TULSA DISTRICT, CORPS OF ENGINEERS
BIOLOGICAL ASSESSMENT
WICHITA RIVER BASIN REEVALUATION OF THE AUTHORIZED RED RIVER CHLORIDE CONTROL PROJECT
TEXAS-OKLAHOMA

May 2001

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PRIOR STUDIES

Studies to control naturally-occurring salt emissions in the Arkansas and Red River Basins began in 1957 when Congress directed the U.S. Public Health Service to locate the major sources of salt emissions in those basins. In the Red River Basin (upper Red River and Wichita River), ten major sources were located and identified as Areas V, VI, VII, VIII, IX, X, XI, XIII, XIV, and XV. A survey report was completed in 1966 that recommended chloride control plans at the salt sources on the Wichita River portion (Part I) which includes Areas VII, VIII, and X. Part I was authorized by Congress in 1966 and pre-construction planning was initiated in 1968. The remaining areas in the Red River Basin (Part II) were the subject of a second survey report completed in 1966 which recommended chloride control plans at five of the remaining six salt source areas. Area XI was not recommended for further studies. Part II; including experimental work at Jonah Creek (Area XIII), was authorized for construction in 1970. Detailed studies for the three areas in the Wichita River Basin were completed in 1972. In 1974, the Water Resources Development Act provided special authorization to construct control measures at Area VIII on the Wichita River. In 1976, General Design Memorandum No. 25 was submitted recommending control measures for the Wichita and Red River areas. Area XV and the North Pease River portion of Area IX were not considered economically feasible at the time and were recommended for future development. A Final Environmental Statement (FES) for the project dated May 18, 1977, was prepared, distributed for agency and public review, and filed with the Environmental Protection Agency (EPA). Construction at Area VIII began in 1977.

A draft Supplement to the FES (SFES) dated April 27, 1995, was prepared and released for public review and comment. The draft supplement addressed changes in the authorized project since the FES was filed in 1977 as well as new environmental concerns and issues identified by commenting agencies. The SFES was finalized in August 1996 but was never released for public review as a result of objections by resource agencies. As a result of natural resource agency concerns, the scope of the project has been modified to consider completion of the remaining features of the Wichita River Basin portion of the authorized project. Since 1998 the District has been conducting studies to reevaluate the project, its key assumptions, and benefits.

As part of the National Environmental Policy Act and Endangered Species Act compliance process, the Tulsa District furnished the U. S. Fish and Wildlife Service (USFWS) a biological assessment (BA) for the authorized project on September 3, 1991. The USFWS provided the District a draft biological opinion (BO) on October 8, 1993; a revised draft on March 28, 1994; and the final BO on July 7, 1994. Both the BA and BO addressed impacts on the endangered interior least tern (*Sterna antillarum),* the endangered whooping crane (*Grus americana*), and the threatened bald eagle (*Haliaeetus leucocephalus*). The NEPA process for the SFES which contained the September 3, 1991, BA and the July 7, 1994, BO was never completed. Also, the scope of the authorized project has changed to focus only on completion of the remaining Wichita River Basin chloride control features. Consequently, a new SFES and a Section 7 consultation are required for the Wichita River portion of the authorized Red River Chloride Control Project to assure compliance with NEPA and the Endangered Species Act.

DESCRIPTION OF THE PROJECT

The proposed revised project consists of evaluating alternatives for controlling chloride emissions in the Wichita River Basin only. The plan would involve continued operation of the previously constructed Area VIII collection facility, a modified Truscott Brine Lake, and evaluation of alternatives for control and disposal of chlorides from Areas VII and X.

The study area will encompass all of the Wichita River from the brine collection facilities downstream to the Wichita River's confluence with the Red River and the upper Red River from its confluence with the Wichita River downstream to Lake Texoma. A map delineating the project study area is shown in Figure 1.

Study reaches to be evaluated include Reach 10 (North and Middle Wichita), Reach 11 (South Wichita), Reach 9 (Wichita River and Lakes Kemp and Diversion), Reach 8 (Wichita River to its confluence with the Red River), Reach 6 (Red River to Lake Texoma), and Reach 5 (Lake Texoma). This area constitutes a major change from the authorized project in that Reaches 7, 13, 14, and 15 (Elm Creek, the North Fork of the Red River, the Prairie Dog Town Fork of the Red River, the Pease River, and the Red River upstream from its confluence with the Wichita River) would be unaffected by implementation of the re-evaluated project.

Areas VII, VIII, and X (Wichita River Basin)

The Wichita River is a south bank tributary of the Red River at about river mile 907. The long, narrow basin drains a subhumid area of 3,485 square miles in north central Texas. The stream is formed by the North, Middle, and South Forks which originate in rolling hills and proceed easterly into the rolling prairie lands of north central Texas. These streams develop from small intermittent gullies in the upper reaches to well-defined streams with narrow, high bank floodplains bordered by high bluffs in the lower reaches of the study areas. The drainage area above Lake Kemp Dam at river mile 126.7 is 2,100 square miles and between Lake Kemp and Wichita Falls at the mouth of Holliday Creek is 1,240 square miles. Average annual rainfall ranges from 21 inches in the western part of the basin to 28 inches in the eastern part of the basin. Average annual land pan evaporation is about 93 inches. Mean annual runoff from the basin above Lake Kemp is 185,400 acre-feet, equivalent to a flow of 256 cfs; however, there have been long periods of low flow and, at times, no flow.

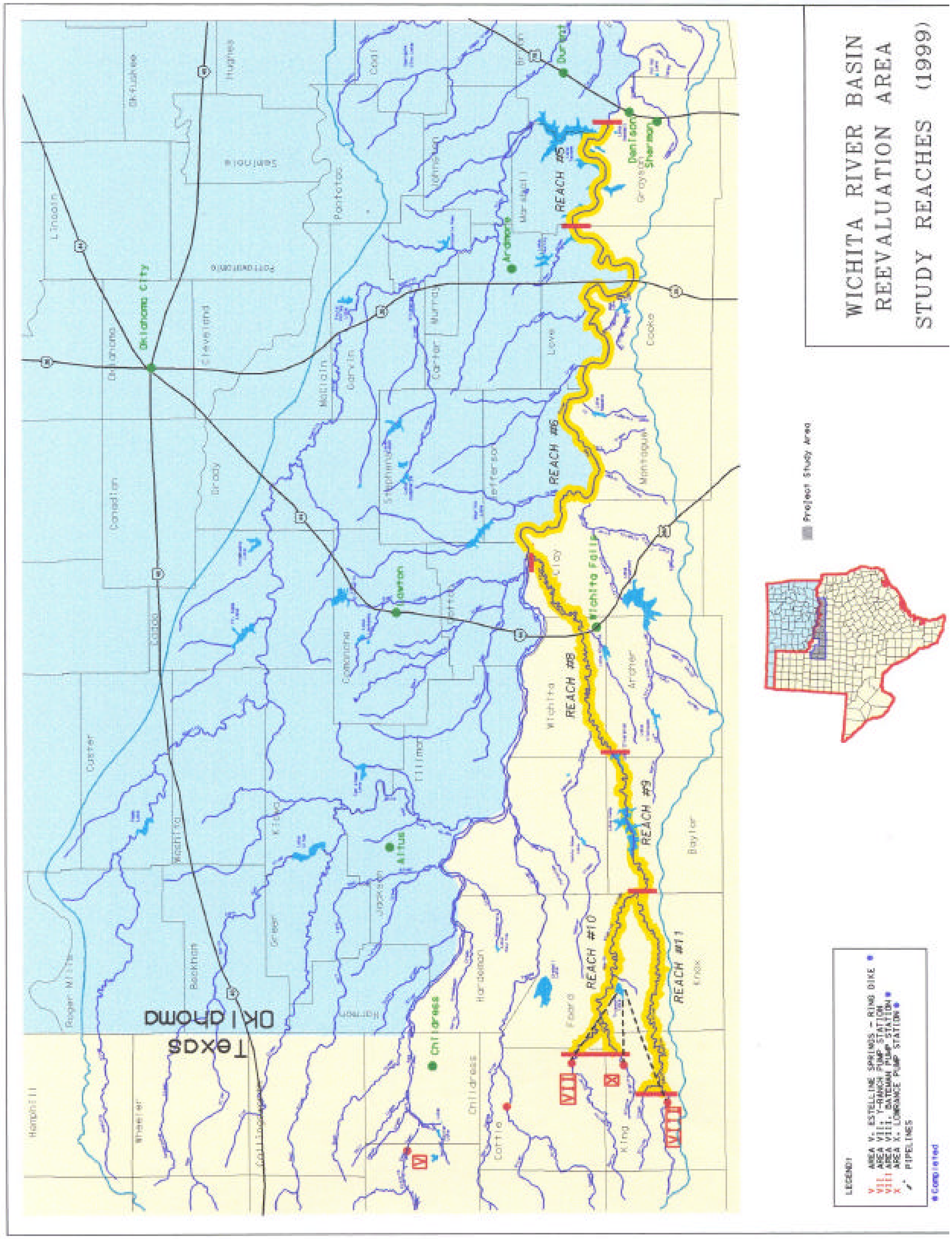
WICHITA RIVER BASIN
REEVALUATION AREA
STUDY REACHES (1999)
Oklahoma
Texas
Oklahoma City
Wichita Falls
REACH #5
REACH #6
REACH #8
REACH #9
REACH #10
REACH #11
Project Study Area

Figure 1.

The total drainage area of the Wichita River in the project area (Areas VII, VIII, and X) is more than 1,240 square miles. The principal streams are the North, Middle, and South Forks of the Wichita River. These three streams are perennial although periods of extreme low flow occur each year. The smaller tributaries are intermittent. Stream flow is extremely erratic and fluctuates from nearly zero to a recorded maximum of 13,000 cfs for the South Fork under flood conditions. The area is the source of more than 496 tons per day of sodium chloride, equivalent to 88% of the total chloride load entering Lake Kemp.

Area VII

Area VII is located at river mile 213 on the North Fork of the Wichita River, about 8 miles southeast of the town of Paducah in Cottle County, Texas. The low flow collection structure would be a 5-foot-high deflatable, fabric weir, with a base width of 80 feet. The weir would extend across the existing stream channel impounding a pool to facilitate pumping. The deflatable weir, with its top at elevation 1539.0, would impound a 14-acre area pool with a capacity of 22 acre-feet.

The North Fork of the Wichita River at river mile 213.0 has a drainage area of 492 square miles. The drainage basin is about 45 miles long and ranges from 7 to 20 miles in width. The weighted slope of the streambed above the dam site is about 17 feet per mile, but near the dam site is about 8 feet per mile. The average flow and chloride load for a 37-year period was computed to be 27 cfs and 244 tons per day, respectively. The brine collected at Area VII would be disposed into a modified Truscott Brine Lake.

Area VIII

Area VIII is located on the South Fork of the Wichita River. The Bateman Low Flow Dam at Area VIII is a deflatable, fabric-type weir 5 feet high and 49 feet long extending across the existing stream channel. It was constructed to impound a pool to facilitate pumping. The brine is currently transported by pipeline to Truscott Brine Lake, which was to be used as a disposal site for brines from both Areas VIII and X. The upper part of the basin is about 12 miles wide but diminishes to about 6 miles near the low flow dam. The average flow and chloride load at this locality was calculated to be 10.2 cfs and 188.6 tons at river mile 91.5. The project is complete and has been operational since 1987.

Area X

The Lowrance Pumping Station is located on the Middle Fork of the Wichita River at river mile 20.5 and is proposed for use as a brine collection structure for Area X. The drainage basin has an area of 60.4 square miles and begins about 9 miles north of Guthrie, 14 miles above the proposed structure. The basin is wedge-shaped in the upper reaches and widens to a width of 6 to 8 miles halfway to the proposed installation. The average flow and chloride load at this locality was calculated to be 8.3 cfs and 57.8 tons per day, respectively. The brine would be collected through the use of a low flow dam with a 5-foot-high inflatable weir, which would also operate identically to the one described for Area VII. The collected brine would be pumped through a pipeline to Truscott Brine Lake for permanent storage. The dam and pump house have been completed, but are not operational.

Truscott Brine Lake

Truscott Brine Lake was designed to receive brine from Areas VIII and X. The dam would have to be modified to receive and store brines from Areas VII, VIII, and X's collection facilities. It is located on Bluff Creek, a south bank tributary of the North Fork of the Wichita River at river mile 3.6. The drainage area of the basin is 26.2 square miles and begins approximately 2 miles west and 1.5 miles south of Truscott. The drainage area extends about 6 miles northeastward to the proposed dam site and ranges in width from 7 miles at the upper end of the basin to about 3 miles at the dam site. The project was constructed and has been collecting brine from Area VIII since 1987.

Area V - Estelline Springs

An experimental project was constructed in 1963 at Estelline Springs (Area V) on the Prairie Dog Town Fork of the Red River to test the application of backhead as a means of suppressing individual springs. The suppressing structure is considered a permanent control installation and is now in operation as an existing chloride control project for Area V. No changes are proposed for Area V, and it would remain operational as completed.

FEDERALLY LISTED SPECIES

By letter dated March 5, 1999, the USFWS identified the Federally listed species likely to be affected by the proposed project. They included the bald eagle, whooping crane, and interior least tern, which are the same species addressed in the previous formal consultation and the 1994 USFWS BO. Since these species have been previously addressed in a BO, this assessment will not reiterate the specific details associated with these species' life histories, collection records, or ranges. This assessment presents only new information with respect to these species and new or revised project data necessary to evaluate impacts of the proposed action on these species.

Whooping Crane

The whooping crane is a migrant through central Oklahoma and Texas during the fall and spring. Recorded sightings confirm this species' presence during migration in the general area. Sightings have been confirmed from the extreme eastern portion of the project area in Texas. Six sightings were from Clay County near Byers, Texas, and the other was from Wichita County near the city of Electra, Texas. Most of the recorded sightings for this species are in relation to the Great Salt Plains Reservoir in north central Oklahoma and the Washita National Wildlife Refuge in southwestern Oklahoma. The Great Salt Plains is recognized as an important whooping crane migration stopover area and supports from 1 to 12 birds during migration periods. Additional bird surveys conducted during 1997-1999 at Truscott Lake and the Area VIII collection facility found no sightings of whooping cranes.

Interior Least Tern

The interior least tern occurs along major rivers in Oklahoma and Texas as a summer resident and migrant. They occur in association with riverine habitats primarily on unvegetated sandbars or shorelines. A review of available literature suggests that this species occur as a migrant within the general project area. The interior least tern has been recently observed at the Truscott Brine Lake (personal communication, Lisa Wrinkle).

The USFWS Recovery Plan for the species reports populations ranging from 16 to 50 individuals for the years 1985-1988 along the Prairie Dog Town Fork of the Red River, Texas. Review of a compilation of surveys for least terns in west Texas shows numerous sightings for the species along the Prairie Dog Town Fork of the Red River (above Reach 6) during surveys conducted from 1984-1985. Additional sightings were found for species in Wichita County near the town of Burkburnett, Texas; Wilbarger County near Highway 283; and on the Pease River in Cottle County, Texas.

Investigations conducted by the USFWS during the summer of 1991 found additional sightings of least terns along the Red River, from Burneyville, Oklahoma, upstream to the Red River's confluence with the North Fork of the Red River. Kirsch (1999) reported the estimated numbers of interior lest terns on the Prairie Dog Town Fork of the Red River from 1984-1995. For these years, the numbers ranged from a low of 12 to a high of 50. Investigations conducted along the Red River below Lake Texoma in cooperation with the Tulsa District and the USFWS (July 9-11, 1991) located additional populations of least terns. The District has been monitoring this population as part of the Section 7 Consultation Process addressing the impacts on least terns of operating Lake Texoma. Tern numbers recorded for 240 miles of the Red River below Lake Texoma ranged from a total of 731 adults in 1999 to 631 adults for the 2000 breeding season. On May 22-24, 1991, personnel from the Tulsa District conducted a survey for interior least tern at Area VI, Crowell Brine Dam, the Pease River below Crowell Brine Dam, and the Area X collection facility, the existing Truscott Brine Lake, and the Bateman Pumping Facility. No least terns were sighted in the noted areas, and most areas appeared to be void of habitat typically suited for this species.

Bald Eagle

The bald eagle is a winter migrant throughout the State of Oklahoma and a winter resident along major rivers and around impoundments. The total winter population along the Red River is unknown, but eagles are likely present along the 140-mile stretch of the Red River from Lake Texoma to the Red River’s confluence with the Wichita River. Data provided by the USFWS in the previous BO place the wintering population of eagles in Oklahoma between 516 and 1,167. Estimates of eagle use on the Red River are difficult to obtain because few surveys are made of this remote area. Annual midwinter surveys at Lake Texoma and Waurika Lake indicate that eagles use the upper Red River. From 1984-1992, bird numbers have averaged 54.5 at Lake Texoma and 4.9 at Waurika Lake. No bald eagles have been sighted during the intensive bird count surveys completed during 1977-1999 at Truscott Lake and the Area VIII collection facilities. The USFWS has determined that this species has recovered to the point that it should be removed from the list of threatened and endangered species. The bald eagle is currently classified as AD,T (proposed for delisting); however, the delisting process has not been completed and the bald eagle remains on the list and will be addressed.

NEW/REVISED DATA

Bird Surveys

The Tulsa District has been monitoring Truscott Brine Lake to address the potential for selenium (Se) concentration. As part of this monitoring effort, the District funded extensive bird use surveys at Truscott Lake and the Area VIII collection facilities for estimation of bird use and subsequent determination of potential impacts to avian species related to Se. A copy of this study entitled "Avian Community Dynamics at Truscott Brine Lake" is included in Appendix B. Texas Tech University personnel conducted intensive bird counts during the spring and winter of 1997, 1998, and January 1999. Limited numbers of least terns were found to occur at Truscott during periods of spring and fall migration. No nesting least terns were observed at the lake. On May 31, 1997, one was observed catching fish near the western portion the lake. On April 27, 1998, one was observed flying near the southwest portion of the lake and three were observed flying. On July 30, 1998, one was observed feeding and two flying. On August 26, 1998, one was observed loafing, and on August 27, 1998, three were observed flying. No evidence of nests or nesting has been observed at the lake.

Flow Data

In addition to reducing chlorides in the Wichita River and to a lesser extent in the Red River, some reduction in average annual flow would also occur. The District reanalyzed the impacts of constructing only Wichita River Basin Chloride Control facilities on Reach 6 of the Red River. The results of this analysis are shown in Tables 1 and 2. This analysis represents a conservative estimate based on the worst drought periods and the lowest flows for the period of record (1937-1998) at the Gainesville gauge (hydrologic reach 6) and the period of record (1938-1998) at the Terral gauge (hydrologic reach 7) on the Red River. The modified flows and stages show the maximum impacts the proposed project would have on stream flows during these critical periods. This analysis also assumes 26.47% return flow from irrigation with increased irrigation due to improved water quality in the Wichita River. Irrigation water withdrawals for Reach 8 are assumed to be taken from Lake Kemp storage while withdrawals for Reaches 6 and 7 are taken directly from the Red River. The irrigation season is assumed to be May through September.

TABLE 1

PREDICTED LOSS OF STREAM FLOW
WITH WICHITA RIVER CHLORIDE CONTROL COMPONENTS
REACH 6 (GAINESVILLE GAUGE)

Natural Year	Natural Date	Natural Flows (cfs)	Natural Stage (feet)	Modified Reduction (feet)	Modified Stage (feet)	Modified Flow (cfs)	Percent Reduction (%)
1940	Nov 01, 1939-Mar 24,1940	46	6.86	0.00	6.86	46.0	0
1955	Aug 19, 1954-Mar 14, 1955	93	7.12	0.00	7.12	93.0	0
1956	Jul 29-Sep 22	89	7.09	0.00	7.09	89.4	0
1963	Jul 22-Oct 15	90	7.11	0.00	7.11	90.0	0
1964	Jun 29-Sep 15	110	7.20	0.00	7.20	110.4	0
1965	Jul 16-Sep 15	173	7.44	0.00	7.44	173.6	0
1970	Jun 21-Aug 08	136	7.31	0.00	7.31	136.0	0
1970	Jun 21-Sep 10	173	7.44	0.00	7.44	173.6	0
1971	Jun 30-Jul 22	105	7.18	0.00	7.18	105.4	0
1971	Jun 30-Aug 11	150	7.36	0.00	7.36	150.4	0
1972	Jul 21-Oct 20	104	7.17	0.00	7.17	104.0	0
1980	Jul 06-Sep 23	182	7.47	0.00	7.47	182.6	0
1981	Jul 14-Oct 05	151	7.36	0.00	7.36	151.0	0
1983	Jul 31-Oct 06	75	7.04	0.00	7.04	75.0	0
1984	Jul 10-Sep 24	130	7.30	0.00	7.30	130.4	0
1998	Jul 25-Aug 02	90	7.11	0.00	7.11	90.0	0

Table 1 shows that the lowest flow since 1937 at the Gainesville gauge was 46 cfs in 1940. With the chloride control project in only the Wichita River, the project would have resulted in no change in flow during this drought event. Slight increases in flow are seen in several events during the irrigation season. The flow increases are due to projected increased irrigation return flow.

Table 2 shows the worst drought periods and the lowest flows for the period of record (1938-1998) at the Terral gage on the Red River. The modified flows and stages show the maximum impacts of the chloride control project during these critical periods assuming 26.47% return flow from irrigation. The impacts will be much less severe during all other periods.

TABLE 2

PREDICTED LOSS OF STREAM FLOW
WITH WICHITA RIVER CHLORIDE CONTROL COMPONENTS
REACH 7 (TERRAL GAUGE)

Natural Year	Natural Date	Natural Flows (cfs)	Natural Stage (feet)	Modified Reduction (feet)	Modified Stage (feet)	Modified Flow (cfs)	Percent Reduction (%)
1939	Sep 27, 1938-Jan 06,1939	58	5.46	0.00	5.46	58.0	0
1939	Sep 03-Oct 24	85	5.58	0.00	5.58	85.0	0
1940	Nov 01, 1939-Mar 24, 1940	46	5.41	0.00	5.41	46.0	0
1943	Sep 11-Oct 18	47	5.42	0.00	5.42	47.0	0
1947	Aug 31-Oct 05	67	5.50	0.00	5.50	67.0	0
1948	Sep 05-Oct 04	78	5.55	0.00	5.55	78.0	0
1952	Sep 01-Oct 29	72	5.52	0.00	5.52	72.0	0
1953	Sep 11-Oct 02	72	5.52	0.00	5.52	72.0	0
1954	Sep 05-Nov 25	87	5.59	0.00	5.59	87.0	0
1956	Aug 06-Sep 22	72	5.52	0.00	5.52	72.4	0
1957	Dec 30, 1956-Jan 17, 1957	50	5.43	0.00	5.43	50.0	0
1964	Aug 25-Sep 14	90	5.60	0.00	5.60	90.5	0
1970	Jul 04-Aug 04	105	5.66	0.00	5.66	105.7	0
1971	Oct 29, 1970-May 03, 1971	81	5.56	0.00	5.56	83.5	0
1972	Sep 21-Oct 19	89	5.59	0.00	5.59	89.0	0
1983	Jul 28-Oct 02	95	5.62	0.00	5.62	95.0	0
1998	Jul 22-Oct 21	80	5.56	0.00	5.56	80.0	0

The lowest flow since 1938 at the Terral gauge was 46 cfs in 1940. With the Wichita River Basin Chloride Control facilities in place, the project would have resulted in no change in flows. Slight increases are also seen during the irrigation season during several events.

Similar flow analyses have been developed for all study reaches on the Wichita River and have been previously furnished to the USFWS.

Chloride Concentration Duration Data

Chloride concentration duration curves were recalculated for all study reaches and have been previously furnished to the USFWS. They are also furnished in Appendix A. The revised curve for Reach 6 of the Red River shows that under natural conditions, chlorides in hydrologic reach 6 equal or exceed 990 mg/l 50% of the time. With Areas VII, VIII, and X in place (modified condition), chlorides would equal or exceed 888 mg/l 50% of the time. This represents a reduction of approximately 10.3%. The revised curve for Reach 7 of the Red River shows that under natural conditions, chlorides in hydrologic reach 7 equal or exceed 1183 mg/l 50% of the time. With Areas VII, VII, and X in place (modified condition), chlorides would equal or exceed 1048 mg/l 50% of the time for a reduction of 11.4%. (See Figures 2 and 3.)

GAINESVILLE DURATION TABLE

REACH 6 - RED RIVER

NATURAL

Concentrations	Percent of Time Equalled or Exceeded								
	1%	5%	10%	20%	50%	80%	90%	95%	99%
Chlorides	1905	1650	1536	1354	990	552	357	256	142
Sulfates	1186	917	810	685	495	284	181	133	76
TDS	4725	4070	3750	3374	2504	1440	936	684	378

MODIFIED W/7, 8 & 10

Concentrations	Percent of Time Equalled or Exceeded								
	1%	5%	10%	20%	50%	80%	90%	95%	99%
Chlorides	1692	1471	1372	1210	888	497	317	230	128
Sulfates	1152	867	756	641	463	266	167	124	70
TDS	4294	3710	3430	3083	2297	1319	853	626	342

MODIFIED + 10%

Concentrations	Percent of Time Equalled or Exceeded								
	1%	5%	10%	20%	50%	80%	90%	95%	99%
Chlorides	1861	1618	1509	1331	977	547	349	253	141
Sulfates	1267	954	832	705	509	293	184	136	77
TDS	4723	4081	3773	3391	2527	1451	938	689	376

MODIFIED - 10%

Concentrations	Percent of Time Equalled or Exceeded								
	1%	5%	10%	20%	50%	80%	90%	95%	99%
Chlorides	1523	1324	1235	1089	799	447	285	207	115
Sulfates	1037	780	680	577	417	239	150	112	63
TDS	3865	3339	3087	2775	2067	1187	768	563	308

MODIFIED W/7 & 8

Concentrations	Percent of Time Equalled or Exceeded								
	1%	5%	10%	20%	50%	80%	90%	95%	99%
Chlorides	1720	1493	1394	1228	901	504	323	232	130
Sulfates	1165	880	769	654	472	271	172	127	72
TDS	4370	3764	3480	3134	2330	1337	867	635	348

MODIFIED + 10%

Concentrations	Percent of Time Equalled or Exceeded								
	1%	5%	10%	20%	50%	80%	90%	95%	99%
Chlorides	1892	1642	1533	1351	991	554	355	255	143
Sulfates	1282	968	846	719	519	298	189	140	79
TDS	4807	4140	3828	3447	2563	1471	954	699	383

MODIFIED - 10%

Concentrations	Percent of Time Equalled or Exceeded								
	1%	5%	10%	20%	50%	80%	90%	95%	99%
Chlorides	1548	1344	1255	1105	811	454	291	209	117
Sulfates	1049	792	692	589	425	244	155	114	65
TDS	3933	3388	3132	2821	2097	1203	780	572	313

Figure 2.

TERRAL DURATION TABLE

REACH 7 - RED RIVER

	NATURAL								
	Percent of Time Equalled or Exceeded								
Concentrations	1%	5%	10%	20%	50%	80%	90%	95%	99%
Chlorides	2129	1833	1700	1500	1183	684	442	317	164
Sulfates	1024	907	850	785	632	391	268	191	107
TDS	5290	4576	4258	3845	3053	1824	1192	852	466

	MODIFIED W/7, 8 & 10								
	Percent of Time Equalled or Exceeded								
Concentrations	1%	5%	10%	20%	50%	80%	90%	95%	99%
Chlorides	1870	1607	1496	1329	1048	607	393	282	148
Sulfates	964	848	794	728	591	366	252	179	100
TDS	4507	3955	3655	3344	2716	1667	1116	804	438

	MODIFIED + 10%								
	Percent of Time Equalled or Exceeded								
Concentrations	1%	5%	10%	20%	50%	80%	90%	95%	99%
Chlorides	2057	1768	1646	1462	1153	668	432	310	163
Sulfates	1060	933	873	801	650	403	277	197	110
TDS	4957	4351	4020	3678	2988	1833	1228	884	482

	MODIFIED - 10%								
	Percent of Time Equalled or Exceeded								
Concentrations	1%	5%	10%	20%	50%	80%	90%	95%	99%
Chlorides	1683	1446	1346	1196	943	546	354	254	133
Sulfates	868	763	715	655	532	329	227	161	90
TDS	4056	3560	3289	3009	2444	1500	1005	723	394

	MODIFIED W/7 & 8								
	Percent of Time Equalled or Exceeded								
Concentrations	1%	5%	10%	20%	50%	80%	90%	95%	99%
Chlorides	1900	1636	1520	1350	1065	615	400	286	149
Sulfates	985	864	809	743	602	373	256	182	102
TDS	4591	4021	3724	3396	2754	1695	1135	822	446

	MODIFIED + 10%								
	Percent of Time Equalled or Exceeded								
Concentrations	1%	5%	10%	20%	50%	80%	90%	95%	99%
Chlorides	2090	1800	1672	1485	1172	677	440	315	164
Sulfates	1084	950	890	817	662	410	282	200	112
TDS	5050	4423	4096	3735	3030	1864	1249	904	491

	MODIFIED - 10%								
	Percent of Time Equalled or Exceeded								
Concentrations	1%	5%	10%	20%	50%	80%	90%	95%	99%
Chlorides	1710	1472	1368	1215	959	554	360	257	134
Sulfates	887	778	728	669	542	336	230	164	92
TDS	4132	3619	3351	3056	2479	1525	1022	740	401

Figure 3.

IMPACTS

Construction Activities

Construction activities associated with building the project would be confined to the upper or western portion of the Wichita River Basin, while benefits from the project (improved water quality) would be recognized throughout the Wichita River Basin and to a lesser extent on the Red River from the confluence of the Wichita River downstream to Lake Texoma. Consequently, construction activities associated with completing the collection facilities and pipelines should have no impacts on Federally listed species.

Construction Activities at Truscott Lake

The proposed plan would require modification to the dam at Truscott Lake to create a larger volume brine disposal lake. Based on the avian surveys conducted by Texas Tech University, a small number of least terns utilize Truscott Lake on a limited basis during spring and fall migration periods. Modification of Truscott Brine Lake would not require draining the lake, so the pool would remain intact for migrating least terns. During construction, there would be increased activities in the area of the dam that would probably cause terns to use the upper limits of the reservoir during the period of construction.

Selenium (Se) Levels in Truscott Lake

There was considerable discussion regarding Se levels of concern related to brine disposal lakes for the original Red River Chloride Control Project. Because of the demonstrated sensitivity of aquatic birds to waterborne Se, their potential use of brine disposal lakes, and substantial information regarding impacts on these species, birds were (and continue to be) the focus for an Se related impact evaluation for the project. The District completed a study entitled, "Alternatives for Chloride Control - Wichita River Basin and Truscott Brine Lake, TX", which is included in Appendix A.

The conservative predicted maximum total Se concentration for Truscott Lake water is highest for Alternative 4, which is disposal of brine from Areas VII, VII, and X at Truscott Lake. This concentration, 6.4 ug/l , was estimated to occur after approximately 80 years of project operation. This concentration is within the threshold range for avian reproductive impairment (2-10 ug/l), but closer to the upper end of this range relative to other alternatives. Accordingly, the potential for impacts on breeding birds might still be relatively low for this alternative and limited to sensitive to moderately-sensitive avian species, but the risk of occurrence of these effects is the highest of all evaluated alternatives. As with other alternatives, maximum estimated waterborne concentrations are well below the 34-ug/l threshold for non-reproductive impacts on young and adult birds. Predicted sediment concentrations are highest for this alternative (maximum 2.23 mg/kg) and slightly exceed the conservative lower end of the sediment threshold range used for this evaluation.

Based on methodology and assumptions used for this evaluation of Se-related concerns associated with brine disposal alternatives, it appears reasonable to assume that all alternatives could be implemented without Se-induced impacts on non-breeding birds (e.g., wintering waterfowl) or significant Se-related sediment concerns for these species at Truscott Brine Lake, Texas. Modeled estimates for Se concentrations for all alternatives are below estimated threshold values for non-reproductive impacts. Due to the limited use of Truscott Lake by migrating least terns, there should be no Se related effects on this species.

Land Use Changes

With the project operational and improved water quality, there will be an increase in agriculture production and a noticeable shift in crop yields and cropping patterns on irrigable lands along the Wichita River and a portion of the Red River. As part of the economic reanalysis, many of the assumptions concerning irrigation were reexamined. This included redefining reaches, soil delineation, land availability, irrigation modes, lift zones from the alluvium, and revised leaching fractions for irrigation. The redefinition of land suitable for irrigation resulted in a more narrow set of soil type characteristics suitable for irrigation. The inventory of land available by reach was modified and reduced the number of potential acres to be irrigated. It was determined that for the reevaluation, available irrigable land would be restricted to land currently irrigated (crops or pasture) plus dryland acres which were currently being cropped. These lands would have moderate to low conversion costs and thus would be most likely candidates for irrigation. Under existing conditions, there are 15,000 acres of irrigated cropland. With implementation of the recommended plan there would be an increase to 58, 202 acres of irrigated land. Of this amount, approximately 43,200 acres would be transformed or converted to irrigated lands. Approximately 42 acres of pasture, 3,011 acres of idle farmland, and 40,128 of dryland farmland would be converted to irrigated farmland with the project.

While the number of irrigated acres will increase, the conversion will come from other types of agricultural lands. Most of the irrigation will occur in economic reaches 5 and 7. Approximately 18,699 acres of irrigated land is projected to occur in economic reach 5 (main stem of the Red River downstream from the Clay/Montague County line to the I-35 bridge north of Gainesville) and approximately 39,234 acres are projected to occur in economic reach 7 (Wichita River from Lake Diversion downstream to the mouth of the Wichita River but not above the Wichita County irrigation district canal). Minor amounts are projected to occur in economic reaches 6 and 12. Conversion of existing agricultural land into irrigated agricultural lands should not impact Federally listed threatened and endangered species.

Nutrients and Contaminants

During the environmental issue resolution process for the Red River Chloride Control Project, there were numerous discussions concerning the potential for increased levels of nutrients and herbicides and pesticides associated with increased agriculture and irrigation return flows. A potential indirect impact associated with the project would be the increase of contaminant levels due to the increase of agriculture with the project. As determined from the Texas A&M studies, most of the agricultural changes are expected to occur from the conversion of dryland farming of bermuda grass/hay to irrigated farming of alfalfa. Estimates of present and future concentrations of nitrogen and phosphorus in the Wichita River were developed by Texas A&M (Walker 2001). With the project, the estimated mean discharge of nitrogen concentrations for the Wichita River at the Charlie Gage were projected to increase from 1.42 mg/l to 10.88 mg/l and phosphorous concentrations were projected to increase from 0.42 mg/l to 1.64 mg/l. This increase in nutrient levels could potentially impact algal production in receiving waters and increase the potential for dissolved oxygen variability.

The transformation from dryland farming of bermuda grass and alfalfa to irrigated alfalfa also has the potential to increase levels of agri-chemicals in receiving streams. Presently, both herbicides and pesticides are applied to the dryland crops. With irrigation, only pesticides would be applied to irrigated alfalfa (Texas A&M, 2000). Consequently, with the project, the amount of herbicides available for transport into receiving streams would be less than presently exists. Under existing project conditions, both herbicides and pesticides are applied to existing crops and are potentially transported into receiving streams during rainfall events. With the project, the amount of herbicide applied to crops should be considerably reduced, but the rates of transport of other contaminants could be increased. This increase would be due to transport by rainfall events as currently exist and irrigation return flows.

FINDINGS

(1) Hydrologic reaches 6 and 7 of the Red River and the study area are within the documented range of migrating whooping cranes, wintering bald eagles, and nesting interior least terns.

(2) There are no recorded or recent sightings of any of the three Federally listed species within the project areas where construction activities are proposed for the collection facilities or pipeline routes. Least terns have been observed using Truscott Lake during spring and fall migration periods.

(3) Construction activities associated with completion of the collection facilities and pipelines for completion of the Wichita River Basin Chloride Control features should have no affect on the interior least tern, whooping crane, or bald eagle since these species do not occur within the construction areas.

(4) Construction activities associated with modification of the dam at Truscott Lake would temporarily increase levels of noise, fugitive dust, and vehicular traffic in the area of the dam. However, most of the sightings of least terns at the project have been near the western and southwestern portion of the lake. Construction activities associated with raising the top of the dam at Truscott Lake, which is located on the east and northeast side of the project, are unlikely to impact the least tern during migration periods.

(5) With the project operational and improved water quality, there should be an increase in agriculture production and a noticeable shift in crop yields and cropping patterns on irrigable lands along the Wichita River and to a lesser extent the Red River. Projected secondary impacts to the Wichita River Basin include land use changes, such as conversion of dry land farming to

irrigated farming and reduced stream flow as a result of irrigation (reference low flow duration curves) in the upper reaches of the Wichita River, and the potential for increases in farming chemicals through irrigation return flows.

(6) Construction and operation of the project will result in improved water quality (reduced chloride concentrations) in the Red River, but to a much lesser degree than in the Wichita River. During the environmental issue resolution process for the Red River Chloride Control Project, the Upper Red River Committee determined "Reaches of Special Concern" for salinity and low flows. The level of concern for Reach 6 was determined to be low for both salinity and flow. With the Wichita River Basin Chloride Control features in place, this level of concern should remain low. As shown in Figure 2, chloride concentrations should remain high enough that few if any impacts would be expected to occur in the fish community within Reach 6 of the Red River.

(7) Construction and operation of the project will significantly impact stream flow within study reaches 8, 9, 10, and 11. While this may result in conditions deleterious to the aquatic community within the severely impacted reaches of the Wichita River, it should not have an impact on any of the three Federally listed threatened and endangered species. Changes in stream flow of the Red River (hydrologic reaches 6 and7) as a result of the project are very minor as shown in Table 1. Predicted changes in low flow conditions for reaches 6 and 7 are very small and probably not of sufficient magnitude to impact the fish community of the Red River. Consequently, construction and operation of the project should not impact the fish community of the Red River, which serves as the source of food for the interior least tern and bald eagle.

(8) Previous concerns were that reduced flows would eliminate least tern-feeding habitat and alter bald eagle roosting sites. The amount of flow reduction expected to occur in hydraulic reaches 6 and 7 should not be of a magnitude or frequency to allow vegetation encroachment on islands within the Red River. Neither would the projected reductions in river stage be of a magnitude to significantly modify channel morphology. The project would have no impact on high flows, which is the primary factor scouring vegetation from islands and changing channel morphology. Consequently, construction and operation of the project should not significantly alter least tern or bald eagle habitat within hydrologic reaches 6 and 7 of the Red River.

(9) Potential project impacts on the whooping crane were previously determined to be: (a) reduction or elimination of suitable roosting habitat due to degradation and vegetation encroachment, (b) continued loss of riverine roosting habitat, and (c) increased disturbance by predators and human activities due to degradation and vegetation encroachment. Since the predicted reduction to flows in hydrologic reaches 6 and 7 are so minor; these impacts should not be expected to occur with operation of the project.

(10) A potential indirect impact associated with construction of the project would be the increase of contaminant levels due to the increase in irrigated agriculture with the project. As determined from Texas A&M studies, most of the agricultural changes are expected to occur from the conversion of dryland farming of bermuda grass/hay and alfalfa to irrigated alfalfa. The associated increase in nutrient levels has the potential to affect algal production in receiving

waters. If dissolved oxygen levels were to drop below levels capable of sustaining fish life in the Red River, it could impact the prey base of least terns and bald eagles.

The transformation from dryland farming of bermuda grass and alfalfa to irrigated alfalfa also has the potential to increase levels of agri-chemicals in receiving streams. Under existing project conditions, both herbicides and pesticides are applied to existing crops and are transported into receiving streams during rainfall events. With the project, the amount of herbicide applied to crops should be considerably reduced. However, pesticides would continue to be applied to irrigated alfalfa. Under existing conditions, the transport of contaminants is due primarily to rainfall events. With irrigation, the rates of transport of contaminants could increase since transport would be influenced by both rainfall events and irrigation return flows. Efforts to model and predict these changes have largely been unsuccessful. However, increases in levels of either pesticides or herbicides could post a threat to bald eagles, least terns, or whooping cranes.

(11) There was considerable discussion regarding Se levels of concern related to brine disposal lakes for the original Red River Chloride Control Project. The District completed a study entitled "Alternatives for Chloride Control – Wichita River Basin and Truscott Brine Lake, TX." Based on methodology and assumptions used for this evaluation of Se-related concerns associated with brine disposal alternatives, it appears reasonable to assume that all alternatives could be implemented without Se-induced impacts on non-breeding birds (e.g., wintering waterfowl) or significant Se-related sediment concerns for these species at Truscott Brine Lake. Due to the limited use of Truscott Lake by migrating least terns, there should be no Se-related effects on this species.

CONCLUSIONS

With irrigation, the potential exists for increases in levels of nutrients and pesticides, while levels of herbicides may decrease (nitrogen to increase from 1.42 mg/l to 10.88 mg/l and phosphorus from 0.42 mg/l to 1.64 mg/l). The exact amounts and implications of these potential changes in water quality on threatened and endangered species is not known and would be difficult to ascertain. Based upon the best available information and assessment of the known impacts of the project, it is the District's opinion that construction and operation of the Wichita River portion of the authorized Red River Chloride Control Project has the potential to increase levels of nutrients and pesticides, which could adversely impact least terns, bald eagles, and whooping cranes.

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Walker, C. H. 2001. Hasty Estimates of Changes in Average Annual Values for Nitrogen and Phosphorous in the Wichita River Below Wichita Falls Due to Proposed Expansion of Irrigated Alfalfa Related to Wichita Red River Chloride Control Project. Memorandum to James C. Randolph, Tulsa District, Corps of Engineers. 8.

APPENDICES

APPENDIX A

ALTERNATIVES FOR CHLORIDE CONTROL – WICHITA RIVER BASIN AND TRUSCOTT BRINE LAKE, TX:

Summarized Evaluation of the Potential for Selenium-Related Impacts on Wildlife

ALTERNATIVES FOR CHLORIDE CONTROL - WICHITA RIVER BASIN AND TRUSCOTT BRINE LAKE, TX:

SUMMARIZED EVALUATION OF THE POTENTIAL FOR SELENIUM-RELATED IMPACTS ON WILDLIFE

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SUMMARIZED EVALUATION OF THE POTENTIAL FOR SELENIUM-RELATED IMPACTS ON WILDLIFE

1. INTRODUCTION AND OBJECTIVES

The purpose of this summary is to provide an overview of methodology and findings for evaluation of potential selenium- (Se) related impacts on wildlife associated with chloride control alternatives under consideration for the Wichita River Basin, Texas. These alternatives involve a variety of options for brine collection at identified chloride source areas and ultimate disposal at Truscott Brine Lake, Texas. A complete overview of Se concerns associated with the Red River Chloride Control Project as originally formulated, a Se literature review, and a detailed description of evaluation methodology is provided in a previous Tulsa District report on this subject (USACE 1993). While much of the focus for the previous evaluation was proposed Crowell Brine Lake, Texas, similar methodology has been applied in this evaluation for Truscott Lake. The 1993 document should therefore be reviewed for an understanding of Se-related concerns associated with the project and methods used to evaluate potential Se-related impacts. The 1993 document is frequently cited for much of the information used in this evaluation.

Original Se evaluations for chloride control project features were, out of necessity, based on extremely limited field data. Given this scarcity of data, the complexity of Se behavior in the environment, and a desire for environmental protection, a very conservative modeling approach was employed for initial Se evaluations. Since that time, considerable data have been collected at brine source areas as well as at Truscott Lake, permitting a more realistic though still somewhat conservative site-specific evaluation of Se-related concerns. Additionally, important information concerning Se-related risk assessment has been added to the scientific literature since original Se evaluations for the project. The purpose of this summary is to provide an updated methodology using expanded field data and literature findings and apply it to evaluation of Truscott Lake brine disposal alternatives.

Finally, despite additional field and literature data, considerable uncertainty still exists with respect to physical, chemical, and biological processes affecting Se dynamics in aquatic systems and their implications for application to this project. It is likely that this uncertainly in the Wichita Basin can only be reduced with continued monitoring and site-specific data collection as the project progresses. Accordingly, it is also the intent of this summary to provide an identification of these areas of uncertainties for use in risk management decisions for the project.

2. ALTERNATIVES

Brine disposal alternatives for Truscott Lake for this evaluation include four potential scenarios. One alternative is the existing condition (brine collection at Area VIII employing an outlet end-of-pipeline spray field for increasing evaporation). The other three involve brine collection at additional source areas, transport via pipeline, and ultimate disposal at Truscott Brine Lake. Features of these source areas as well as Truscott Lake are described in USACE (1993).

For purposes of this evaluation, alternatives for evaluation are identified as follows:

Alternative 1: Area VIII only with 1 outlet spray field (current condition);
Alternative 2: Areas VIII, VII-2 ((-2) indicates spray fields on both ends);
Alternative 3: Areas VIII, X-2;
Alternative 4: Areas VIII, VII-2, X-2.

Design pump rates used in this evaluation for Areas VIII, VII, and X were 5.7, 8.2, and 4.2 cubic feet per second (cfs), respectively. Required Truscott Lake pool elevations, areas, and volumes for all alternatives are provided in Table 1.

TABLE 1

ELEVATION / AREA / CAPACITY TABLE FOR TRUSCOTT ALTERNATIVES
Starting Elevation: 1470 (current)

Years	Elevation, Area, Capacity	Area/# Spray Fields			
		Alt. 1	Alt. 2	Alt. 3	Alt. 4
		VIII-1	VIII, VII-2	VIII, X-2	VII, VIII, X-2
5	Elev. (ft)	1463.73	1468.69	1466.31	1472.43
	Area (m^2)	5.77E+06	6.96E+06	6.37E+06	7.67E+06
	Vol (m^3)	3.70E+07	4.67E+07	4.18E+07	5.50E+07
	Z (m)	6.41E+00	6.71E+00	6.56E+00	7.17E+00
	SSV (mm/yr)	7.91E+00	6.56E+00	7.17E+00	5.95E+00
10	Elev. (ft)	1462.6	1473.11	1466.63	1478.63
	Area (m^2)	5.52E+06	7.79E+06	6.45E+06	8.72E+06
	Vol (m^3)	3.51E+07	5.66E+07	4.24E+07	7.05E+07
	Z (m)	6.36E+00	7.27E+00	6.57E+00	8.08E+00
	SSV (mm/yr)	8.27E+00	5.86E+00	7.08E+00	5.23E+00
15	Elev. (ft)	1463.8	1475.46	1469.17	1482.64
	Area (m^2)	5.79E+06	8.19E+06	7.08E+06	9.47E+06
	Vol (m^3)	3.72E+07	6.25E+07	4.78E+07	8.16E+07
	Z (m)	6.42E+00	7.63E+00	6.75E+00	8.62E+00
	SSV (mm/yr)	7.88E+00	5.57E+00	6.45E+00	4.82E+00
20	Elev. (ft)	1462.1	1476.5	1467.86	1484.53
	Area (m^2)	5.41E+06	8.36E+06	6.76E+06	9.85E+06
	Vol (m^3)	3.43E+07	6.50E+07	4.50E+07	8.71E+07
	Z (m)	6.34E+00	7.78E+00	6.66E+00	8.84E+00
	SSV (mm/yr)	8.44E+00	5.46E+00	6.75E+00	4.63E+00
25	Elev. (ft)	1463.51	1477.75	1469.64	1486.76
	Area (m^2)	5.73E+06	8.58E+06	7.18E+06	1.03E+07
	Vol (m^3)	3.67E+07	6.84E+07	4.86E+07	9.42E+07
	Z (m)	6.40E+00	7.97E+00	6.77E+00	9.15E+00
	SSV (mm/yr)	7.97E+00	5.32E+00	6.36E+00	4.43E+00
30	Elev. (ft)	1464.68	1479.64	1470.48	1489.14
	Area (m^2)	6.00E+06	8.90E+06	7.37E+06	1.08E+07
	Vol (m^3)	3.88E+07	7.32E+07	5.06E+07	1.02E+08
	Z (m)	6.47E+00	8.22E+00	6.87E+00	9.44E+00
	SSV (mm/yr)	7.61E+00	5.13E+00	6.19E+00	4.23E+00

Table 1 (Continued)

Years	Elevation, Area, Capacity	Area/# Spray Fields			
		Alt. 1	Alt. 2	Alt. 3	Alt. 4
		VIII-1	VIII, VII-2	VIII, X-2	VII, VIII, X-2
35	Elev. (ft)	1467.7	1482.62	1473.34	1492.64
	Area (m^2)	6.71E+06	9.47E+06	7.82E+06	1.15E+07
	Vol (m^3)	4.46E+07	8.16E+07	5.71E+07	1.14E+08
	Z (m)	6.65E+00	8.62E+00	7.30E+00	9.91E+00
	SSV (mm/yr)	6.80E+00	4.82E+00	5.84E+00	3.97E+00
40	Elev. (ft)	1463.35	1479.65	1469.35	1489.97
	Area (m^2)	5.74E+06	8.91E+06	7.13E+06	1.10E+07
	Vol (m^3)	3.67E+07	7.34E+07	4.82E+07	1.05E+08
	Z (m)	6.39E+00	8.24E+00	6.76E+00	9.55E+00
	SSV (mm/yr)	7.95E+00	5.12E+00	6.40E+00	4.15E+00
45	Elev. (ft)	1464.56	1480.59	1470.63	1491.17
	Area (m^2)	5.98E+06	9.08E+06	7.38E+06	1.12E+07
	Vol (m^3)	3.86E+07	7.59E+07	5.09E+07	1.08E+08
	Z (m)	6.45E+00	8.36E+00	6.90E+00	9.64E+00
	SSV (mm/yr)	7.63E+00	5.03E+00	6.18E+00	4.08E+00
50	Elev. (ft)	1464.51	1480.63	1470.61	1491.35
	Area (m^2)	5.95E+06	9.08E+06	7.38E+06	1.12E+07
	Vol (m^3)	3.84E+07	7.59E+07	5.09E+07	1.09E+08
	Z (m)	6.45E+00	8.36E+00	6.90E+00	9.73E+00
	SSV (mm/yr)	7.67E+00	5.03E+00	6.18E+00	4.08E+00
55	Elev. (ft)	1464.61	1482.05	1471.13	1492.89
	Area (m^2)	5.98E+06	9.38E+06	7.46E+06	1.15E+07
	Vol (m^3)	3.86E+07	8.01E+07	5.20E+07	1.15E+08
	Z (m)	6.45E+00	8.54E+00	6.97E+00	1.00E+01
	SSV (mm/yr)	7.63E+00	4.87E+00	6.12E+00	3.97E+00
60	Elev. (ft)	1464.68	1481.11	1471.16	1492.16
	Area (m^2)	6.00E+06	9.18E+06	7.48E+06	1.14E+07
	Vol (m^3)	3.88E+07	7.73E+07	5.22E+07	1.12E+08
	Z (m)	6.47E+00	8.42E+00	6.98E+00	9.82E+00
	SSV (mm/yr)	7.61E+00	4.97E+00	6.10E+00	4.00E+00

Table 1 (Continued)

Years	Elevation, Area, Capacity	Area/# Spray Fields			
		Alt. 1	Alt. 2	Alt. 3	Alt. 4
		VIII-1	VIII, VII-2	VIII, X-2	VII, VIII, X-2
65	Elev. (ft)	1467.06	1484.49	1473.1	1495.21
	Area (m^2)	6.56E+06	9.85E+06	7.79E+06	1.20E+07
	Vol (m^3)	4.34E+07	8.71E+07	5.66E+07	1.23E+08
	Z (m)	6.62E+00	8.84E+00	7.27E+00	1.03E+01
	SSV (mm/yr)	6.96E+00	4.63E+00	5.86E+00	3.80E+00
70	Elev. (ft)	1469.08	1485.43	1475.19	1496.4
	Area (m^2)	7.06E+06	1.00E+07	8.14E+06	1.22E+07
	Vol (m^3)	4.76E+07	8.99E+07	6.17E+07	1.27E+08
	Z (m)	6.74E+00	8.99E+00	7.58E+00	1.04E+01
	SSV (mm/yr)	6.47E+00	4.56E+00	5.61E+00	3.74E+00
75	Elev. (ft)	1468.65	1486.83	1474.6	1497.45
	Area (m^2)	6.96E+06	1.03E+07	8.04E+06	1.24E+07
	Vol (m^3)	4.67E+07	9.42E+07	6.03E+07	1.31E+08
	Z (m)	6.71E+00	9.15E+00	7.50E+00	1.06E+01
	SSV (mm/yr)	6.56E+00	4.43E+00	5.68E+00	3.68E+00
80	Elev. (ft)	1465.09	1482.24	1471.45	1493.09
	Area (m^2)	6.09E+06	9.39E+06	7.53E+06	1.16E+07
	Vol (m^3)	3.95E+07	8.04E+07	5.29E+07	1.15E+08
	Z (m)	6.49E+00	8.56E+00	7.03E+00	9.91E+00
	SSV (mm/yr)	7.49E+00	4.86E+00	6.06E+00	3.93E+00
85	Elev. (ft)	1465.06	1483.87	1471.87	1494.47
	Area (m^2)	6.09E+06	9.73E+06	7.59E+06	1.18E+07
	Vol (m^3)	3.95E+07	8.54E+07	5.38E+07	1.20E+08
	Z (m)	6.49E+00	8.78E+00	7.09E+00	1.02E+01
	SSV (mm/yr)	7.49E+00	4.69E+00	6.01E+00	3.87E+00
90	Elev. (ft)	1467.82	1485.7	1474.54	1496.5
	Area (m^2)	6.74E+06	1.01E+07	8.02E+06	1.22E+07
	Vol (m^3)	4.48E+07	9.08E+07	6.00E+07	1.28E+08
	Z (m)	6.65E+00	8.99E+00	7.48E+00	1.05E+01
	SSV (mm/yr)	6.77E+00	4.52E+00	5.69E+00	3.74E+00

Table 1 (Continued)

Years	Elevation, Area, Capacity	Area/# Spray Fields			
		Alt. 1	Alt. 2	Alt. 3	Alt. 4
		VIII-1	VIII, VII-2	VIII, X-2	VII, VIII, X-2
95	Elev. (ft)	1467.92	1486.24	1474.39	1496.77
	Area (m^2)	6.76E+06	1.02E+07	8.00E+06	1.23E+07
	Vol (m^3)	4.50E+07	9.23E+07	5.98E+07	1.29E+08
	Z (m)	6.66E+00	9.05E+00	7.48E+00	1.05E+01
	SSV (mm/yr)	6.75E+00	4.47E+00	5.71E+00	3.71E+00
100	Elev. (ft)	1470.4	1488.23	1476.59	1498.7
	Area (m^2)	7.28E+06	1.06E+07	8.38E+06	1.27E+07
	Vol (m^3)	4.95E+07	9.87E+07	6.53E+07	1.36E+08
	Z (m)	6.80E+00	9.31E+00	7.79E+00	1.07E+01
	SSV (mm/yr)	6.27E+00	4.31E+00	5.45E+00	3.59E+00

Z = average depth
SSV = sediment settling velocity

3. SUMMARY OF FIELD DATA

Water quality data collected as part of the Tulsa District's Wichita River Basin monitoring program include Se data for brine source areas as well as for Truscott Brine Lake. Limited Se data were collected at brine source areas VIII and VII by the Tulsa District as part of initial evaluations for Crowell Lake in 1992. As part of a long-term monitoring effort, monthly water sample collection and Se analyses by the U.S. Geological Survey (USGS) under contract to the Tulsa District was initiated at all potential brine collection areas in the basin beginning in November 1996. This monitoring effort continues to the present. Total and dissolved Se concentrations measured at Areas VIII, VII, and X to date are included in Table 2.

TABLE 2

BRINE SOURCE AREA SELENIUM DATA

Area VIII – Bateman Pump Station South Fork Wichita (07311782)				Area VII – Y Ranch North Fork Wichita (07311600)				Area X - Lowrance Middle Fork Wichita (07311630)			
Date	**cfs**	**Total Se (ug/l)**	**Diss Se (ug/l)**	**Date**	**cfs**	**Total Se (ug/l)**	**Diss Se (ug/l)**	**Date**	**cfs**	**Total Se (ug/l)**	**Diss Se (ug/l)**
Collected by COE				Collected by COE				Collected by USGS			
7/21/1992		<20	<20	6/29/1992	176	<10	<10	11/6/1996	6.1	10	12
8/18/1992		6.6	<1	7/14/1992	24	<10	<10	11/20/1996	4.8	17	13
10/20/1992		4	3	7/29/1992	18	8	7	1/23/1997	5.8	13	15
				8/19/1992	19	5.4	6.6	3/6/1997	7.5	13	12
				9/16/1992	18	7.9	8.3	3/26/1997	5.8	11	12
				9/30/1992	21	8	8	4/23/1997	5.8	12	13
				10/21/1992	20	8	8	5/15/1997	7	16	12
				11/4/1992	23	9	8	6/5/1997	6.3	12	15
				MEAN	**40**	**8**	**8**	6/26/1997	7.5	12	12
				GEOMEAN	**27**	**8**	**8**	7/30/1997	4.8	14	12
								8/13/1997	4.9	12	14
								9/7/1997	5.1	13	16
								MEAN	**6.0**	**12.9**	**13.2**
								GEOMEAN	**5.9**	**12.8**	**13.1**
Collected by USGS				Collected by USGS				Collected by USGS			
11/5/1996	9.2	1	2	11/5/1996	19	9	12	11/5/1997	11	12	14
12/4/1996	6.3	2	2	11/19/1996	19	15	11	12/10/1997	10	13	15
1/30/1997	4.6	1	1	1/22/1997	11	14	15	1/14/1998	7.1	16	13
3/13/1997	6.8	1	1	3/6/1997	9.1	10	12	2/11/1998	5.3	13	15
4/2/1997	6.9	1	1	3/26/1997	12	9	13	3/26/1998	7.3	14	14
5/1/1997	12	1	1	4/23/1997	23	8	8	4/22/1998	4.8	15	12
5/14/1997	6.4	1	1	5/7/1997	25	9	9	5/6/1998	6.5	12	13
6/4/1997	12	2	2	5/21/1997	28	11	10	6/3/1998	5.4	15	16
6/25/1997	11	2	2	6/11/1997	22	10	10	6/17/1998	6	11	12
8/7/1997		1	2	7/29/1997	20	12	12	7/15/1998	6	14	13
9/4/1997	6.6	1	1	9/6/1997	21	<1	11	9/2/1998	5	10	12
9/8/1997	6.6	1	1	**MEAN**	**19**	**9.8**	**11.2**	**MEAN**	**6.8**	**13.2**	**13.5**
MEAN	**8.0**	**1.3**	**1.4**	**GEOMEAN**	**18**	**8.5**	**11.0**	**GEOMEAN**	**6.5**	**13.1**	**13.5**
GEOMEAN	**7.7**	**1.2**	**1.3**								

Table 2 (Continued)

Area VIII – Bateman Pump Station South Fork Wichita (07311782)				**Area VII -- Y Ranch** North Fork Wichita (07311600)				**Area X -- Lowrance** Middle Fork Wichita (07311630)			
Date	**cfs**	**Total Se (ug/l)**	**Diss Se (ug/l)**	**Date**	**cfs**	**Total Se (ug/l)**	**Diss Se (ug/l)**	**Date**	**cfs**	**Total Se (ug/l)**	**Diss Se (ug/l)**
Collected by USGS				Collected by USGS				Collected by USGS			
11/4/1997	6.7	2	2	11/4/1997	28	15	15	12/29/1998	4.8	15	14
12/9/1997	6.7	2	2	12/9/1997	27	13	14	1/20/1999	4.9	11	17
1/13/1998	6.3	2	2	1/13/1998	17	17	13	2/23/1999	5.6	11	11
2/10/1998	10	2	2	2/10/1998	15	16	15	3/16/1999	5.7	9	12
3/17/1998	6.6	3	4	3/25/1998	23	11	12	4/21/1999	4.9	6	8
4/21/1998	6.8	1	1	4/21/1998	16	15	11	5/18/1999	5.4	9	8
5/5/1998	6.8	1	1	5/5/1998	13	11	14	6/9/1999	5.3	9	6
6/2/1998	6.7	<1	<1	6/2/1998	14	14	10	6/30/1999	6.3	7	6
6/16/1998	6.6	<1	<1	6/16/1998	17	12	11	7/21/1999	7.8	4	4
7/14/1998	6.6	<1	<1	7/14/1998	12	11	10	7/28/1999	7.1	6	4
8/11/1998	6	<1	<1	8/11/1998	13	10	10	8/11/1999	5.4	5	6
9/1/1998	6.9	<1	<1	9/1/1998	16	9	10	9/15/1999	4.8	6	4
MEAN	**6.9**	**1.5**	**1.6**	**MEAN**	**18**	**12.8**	**12.1**	**MEAN**	**5.7**	**8.2**	**8.3**
GEOMEAN	**6.8**	**1.4**	**1.4**	**GEOMEAN**	**17**	**12.6**	**11.9**	**GEOMEAN**	**5.6**	**7.6**	**7.4**
Collected by USGS				Collected by USGS				Collected by USGS			
12/29/1998	10	<4	<4	12/28/1998	12	12	12	10/26/1999	5	6	3
1/21/1999	6.8	4	7	1/21/1999	10	10	14	11/26/1999	5.4	15	12
2/24/1999	5.7	4	6	2/24/1999	15	7	9	1/4/2000	7.6	14	13
3/17/1999	6.8	<2	2	3/16/1999	15	10	9	1/20/2000	6.6	8	12
4/22/1999	0.24	<4	<4	4/22/1999	14	7	7	2/29/2000	6.1	15	13
5/18/1999	6.5	6	1	5/20/1999	18	7	5	4/3/2000	6.8	16	8
6/10/1999	1.8	3	5	6/10/1999	12	6	5	4/20/2000	6.4	13	
6/24/1999	7.2	<1	4	6/24/1999	21	2	4	5/18/2000	5.9	10	6
7/22/1999	7	13	<10	7/22/1999	17	3	3	6/14/2000	6.2	7	
8/12/1999	1.7	<1	9	8/12/1999	15	3	4	7/18/2000	6.1		
9/15/1999	6.4	8	26	8/24/1999	11	6	5	**MEAN**	**6.2**	**11.6**	**9.6**
MEAN	**5.5**	**4.5**	**7.1**	9/13/1999	12	4	2	**GEOMEAN**	**6.2**	**10.9**	**8.6**
GEOMEAN	**4.0**	**3.5**	**5.1**	**MEAN**	**14**	**6.4**	**6.6**				
				GEOMEAN	**14**	**5.7**	**5.7**				

Table 2 (Continued)

Area VIII – Bateman Pump Station South Fork Wichita (07311782)				Area VII – Y Ranch North Fork Wichita (07311600)				Area X - Lowrance Middle Fork Wichita (07311630)			
Date	**cfs**	**Total Se (ug/l)**	**Diss Se (ug/l)**	**Date**	**cfs**	**Total Se (ug/l)**	**Diss Se (ug/l)**	**Date**	**cfs**	**Total Se (ug/l)**	**Diss Se (ug/l)**
Collected by USGS				Collected by USGS							
10/6/1999	6.3	<4	<4	10/19/1999	11	4	2				
11/12/1999	6.7	4	4	11/4/1999	11	6	4				
1/3/2000	2.4	3	3	12/28/1999	11	10	8				
1/19/2000	4.5	<4	<4	1/20/2000	11	8	10				
2/28/2000	2.7	<10	5	2/9/2000	9.6	12	7				
3/13/2000	4.4	14	<12	4/6/2000	15	7	6				
5/2/2000	3	<5		4/18/2000	24	10					
5/15/2000	1.2	<10	<24	5/18/2000	26	9	5				
6/27/2000	4.6	<26		7/5/2000	26	5					
MEAN	**4.0**	**5.7**	**5.4**	7/24/2000	26						
GEOMEAN	**3.6**	**4.9**	**4.7**	**MEAN**	**17**	**7.9**	**6.0**				
				GEOMEAN	**16**	**7.5**	**5.4**				
OVERALL MEAN		**3.0**	**3.5**	**OVERALL MEAN**		**9.2**	**9.1**	**OVERALL MEANS**		**11.4**	**11.3**
OVERALL GEOMEAN		**2.1**	**2.3**	**OVERALL GEOMEAN**		**8.2**	**8.3**	**OVERALL GEOMEANS**		**10.8**	**10.5**
OVERALL MEDIAN		**2.0**	**2.0**	**OVERALL MEDIAN**		**9.0**	**10.0**	**OVERALL MEDIANS**		**12**	**12**
Detection limit used in mean calculations with exception of excessively high values (<10 to <26).				Detection limit used in mean calculations							

In addition to initial 1992 data, total selenium analyses for Truscott Brine Lake waters were conducted as part of an extensive baseline Se monitoring program for a number of environmental matrices conducted by the Tulsa District during 1997 and 1998. Water sampling occurred over a range of seasons at four sampling sites ranging from Truscott Dam to the extreme upper end of the impoundment. Water samples were collected in both surface and near-bottom waters and analyzed for total Se. Primary field samples and quality control duplicates were analyzed by the USGS National Water Quality Laboratory, Arvada, Colorado. Quality assurance replicates were analyzed by an independent laboratory (Environmental Trace Substances Laboratory, Rolla, Missouri).

Selenium data for all Truscott Lake water analyses are presented in Table 3. While a total Se concentration of 2 ug/l was measured across the lake in October 1992 as the pool was filling, total Se concentrations in all field samples collected during 1997 and 1998 (once the lake reached a somewhat stable pool) were below analytical detection limits (ranging from 0.5 to 1 ug/l). The last samples collected (September 2, 1998) indicated that waterborne total Se concentrations were still less than the 0.5 ug/l detection limit after approximately 11 years of project operation. Sediment sample total Se concentrations measured during the same time period ranged from <0.4 to 0.58 mg/Kg total Se (dry weight).

Brine pumping from Area VIII to Truscott Lake began in May 1987. The impoundment slowly filled until reaching a somewhat stable pool in approximately 1996. Annual pool elevations, volumes, surface areas, and brine volumes pumped from Area VIII to Truscott Lake are presented in Table 4.

TABLE 3

TRUSCOTT LAKE SELENIUM DATA (WATER)

Date	Time	Depth	Total Se (ug/l)	Duplicate	QA (ETSL)
		Site 1 (Near Dam)			
7/22/1992		S	<10		
7/22/1992		B	<10		
8/19/1992		S	<1		
8/19/1992		B	<1		
10/21/1992		S	2		
10/21/1992		B	2		
Analyses for 1992 samples conducted by Eureka Laboratories, Inc., Sacramento, CA					
2/26/1997	1000	S	<1	<1	<0.5
2/26/1997	1000	B	<1		
3/25/1997	1330	S	<1		
3/25/1997	1330	B	<1		
4/23/1997	910	S	<1		
4/23/1997	910	B	<1		
6/10/1997	1337	S	<1		
6/10/1997	1337	B	<1		
7/14/1997	1355	S	<1	<1	<0.5
7/14/1997	1355	B	<1		
8/26/1997	1313	S	<1	<1	2.2
8/26/1997	1313	B	<1		
10/22/1997	1030	S	<1		
10/22/1997	1030	B	<1		
12/15/1997	1430	S	<1		
12/15/1997	1430	B	<1		
1/26/1998	1400	S	<1		
1/26/1998	1400	B	<1		
4/30/1998	1125	S	<1		
4/30/1998	1130	B	<1		
7/7/1998	931	S	<1		
7/7/1998	931	B	<1		
9/2/1998	1315	S	<0.5 (ETSL)	0.6 (ETSL)	
9/2/1998	1315	B	<0.5 (ETSL)		
		Site 2 (Mid-Lake)			
7/22/1992		S	<10		
7/22/1992		B	<20		
8/19/1992		S	<1		
8/19/1992		B	<1		
10/21/1992		S	2		
10/21/1992		B	2		
Analyses for 1992 samples conducted by Eureka Laboratories, Inc., Sacramento, CA					

Table 3 (Continued)

Date	Time	Depth	Total Se (ug/l)	Duplicate	QA (ETSL)
2/26/1997	1035	S	<1		
2/26/1997	1035	B	<1		
3/25/1997	1410	S	<1	<1	<0.5
3/25/1997	1410	B	<1		
4/23/1997	955	S	<1		
4/23/1997	955	B	<1		
6/10/1997	1410	S	<1		
6/10/1997	1410	B	<1		
7/14/1997	1415	S	<1		
7/14/1997	1415	B	<1		
8/26/1997	1405	S	<1		
8/26/1997	1405	B	<1		
10/22/1997	1040	S	<1		
10/22/1997	1040	B	<1		
12/15/1997	1447	S	<1	<1	1
12/15/1997	1447	B	<1		
1/26/1998	1440	S	<1		
1/26/1998	1440	B	<1		
4/30/1998	1150	B	<1		
7/7/1998	959	S	<1		
7/7/1998	959	B	<1		
9/2/1998	1340	S	<0.5 (ETSL)		
9/2/1998	1340	B	<0.5 (ETSL)		
		Site 3 (Upper End)			
7/22/1992		S	<20		
8/19/1992		S	<1		
10/21/1992		S	2		
Analyses for 1992 samples conducted by Eureka Laboratories, Inc., Sacramento, CA					
2/26/1997	1055	S	<1		
3/25/1997	1440	S	<1		
4/23/1997	1020	S	<1	<1	<0.5
6/10/1997	1437	S	<1	<1	<0.5
7/14/1997	1445	S	<1		
8/26/1997	1445	S	<1		
10/22/1997	1055	S	<1	<1	<1
12/15/1997	1520	S	<1		
1/26/1998	1500	S	<1	<1	<1
4/30/1998	1205	S	<1	<1	<0.5
7/7/1998	1045	S	<1		
9/2/1998	1355	S	<0.5 (ETSL)		

Table 3 (Continued)

Date	Time	Depth	Total Se (ug/l)	Duplicate	QA (ETSL)
		Site 4 (Extreme Upper End)			
6/10/1997	1500	S	<1		
7/14/1997	1456	S	<1		
12/15/1997	1540	S	<1		
1/26/1998	1515	S	<1		
4/30/1998	1215	S	<1		
7/7/1998	1055	S	<1		
9/2/1998	1405	S	<0.5 (ETSL)		

S = surface sample (0.5 m depth)
B = bottom sample (1 m from bottom)
Duplicate = duplicate sample analyzed by primary laboratory (USGS)
QA = quality assurance sample analyzed by separate laboratory (ETSL)
ETSL = Environmental Trace Substance Laboratory, Rolla, MO.

TABLE 4

TRUSCOTT LAKE POOL AND PUMPED BRINE DATA

Date	Pool Elevation (feet)	Volume (m^3)	Area (m^2)	Annual Pumped (L)	Total Pumped (L)
10/1/1984	1423.8*	1.51E+06	8.01E+05	0	0
10/1/1985	1424.8*	1.75E+06	8.90E+05	0	0
10/1/1986	1435.50	3.18E+06	1.33E+06	0	0
10/1/1987	1445.38	1.31E+07	2.92E+06	2956985222	2956985222
10/1/1988	1448.03	1.56E+07	3.37E+06	5890531680	8847516902
10/1/1989	1452.09	2.02E+07	3.98E+06	4580428090	13427944992
10/1/1990	1457.76	2.77E+07	4.68E+06	4082045933	17509990925
10/1/1991	1460.00	3.10E+07	4.97E+06	4812348499	22322339424
10/1/1992	1466.11	4.14E+07	6.32E+06	6803409888	29125749312
10/1/1993	1468.15	4.55E+07	6.82E+06	5361309043	34487058355
10/1/1994	1468.30	4.59E+07	6.86E+06	5810346432	40297404787
10/1/1995	1471.49	5.29E+07	7.53E+06	5387215046	45684619833
10/1/1996	1470.00	4.73E+07	7.10E+06	6394155685	52078775518
10/1/1997	1471.00	4.95E+07	7.28E+06	6058138525	58136914043
10/1/1998	1471.00	4.95E+07	7.28E+06	5396800615	63533714658

* Estimated
Note: 1987 pumped volume data for May through September.

4. POST-IMPOUNDMENT MASS BALANCE ESTIMATE

An estimate of Se mass delivered to Truscott Lake since impoundment, calculation of "conservative substance" (i.e., worst case) concentration estimates, and comparison with latest measured lake water concentrations were employed as an initial means of gaining an understanding of mass balance for the system. This analysis involved mass load estimation using actual pumped brine volumes (not design averages), actual rainfall data, and Se concentration information collected to date at the Area VIII pump station. This analysis and its results are described below.

An estimate of the long-term average total Se concentration in brines collected and delivered to Truscott Lake was obtained using 1996 through 2000 monitoring data collected at the Area VIII pump station by the USGS (Table 2). This estimation was somewhat complicated by the presence of censored (below analytical reporting limit) data for a number of sampling events. In most instances, reporting limits were reasonably close to detected values for other months. Therefore, in most cases, the reporting limit was substituted for censored values in concentration calculations. In a few cases, reporting limits were extremely high (10 to 26 ug/l). In these cases (May and June 2000), these values were eliminated from calculations. For several months with no data, it was necessary to estimate concentrations based on those obtained from previous and succeeding months. All values used in calculations are shown in Table 5.

Monthly Se concentration values were averaged to obtain an estimated long-term average of 2.9 ug/l total Se for Area VIII brines (Table 5). As an alternate means of evaluation, concentration values were multiplied by actual monthly pumped volumes to obtain an estimated monthly mass of Se pumped from the collection area (Table 5). This mass was totaled (50.1 Kg) and divided by the total volume pumped during this 40-month period (1.8E10 liters) to obtain a very similar average concentration estimate of 2.8 ug/l. Owing to the use of averaged concentration data for other source areas in the modeling exercise (see below), an estimate of 2.9 ug/l total Se was used for Area VIII brines.

TABLE 5

BATEMAN (AREA VIII) LOAD CALCULATIONS FOR SE DATA PERIOD OF RECORD

Year	Month	Gallons Pumped	CFS	L Pumped	Kg/L Se*	inst. CFS*	Kg Se	Kg/d Se
1996	Nov	175377000	9.05	663801945	1.00E-09	9.2	6.64E-01	2.21E-02
	Dec	169111000	8.44	640085135	2.00E-09	6.3	1.28E+00	4.13E-02
1997	Jan	150196000	7.50	568491860	1.00E-09	4.6	5.68E-01	1.83E-02
	Feb	114156000	6.09	432080460	**1.00E-09**		4.32E-01	1.49E-02
	Mar	123173000	6.15	466209805	1.00E-09	6.8	4.66E-01	1.50E-02
	Apr	133454000	6.88	505123390	1.00E-09	6.9	5.05E-01	1.68E-02
	May	184755000	9.22	699297675	1.00E-09	**9.2**	6.99E-01	2.26E-02
	Jun	164949000	8.51	624331965	2.00E-09	12	1.25E+00	4.16E-02
	Jul							
	Aug	109290000	5.46	413662650	1.00E-09		4.14E-01	1.33E-02
	Sept	60485000	3.12	228935725	1.00E-09	6.6	2.29E-01	7.63E-03
	Oct	109930000	5.49	416085050	**1.50E-09**		6.24E-01	2.01E-02
	Nov	124644000	6.43	471777540	2.00E-09	6.7	9.44E-01	3.15E-02
	Dec	161279000	8.05	610441015	2.00E-09	6.7	1.22E+00	3.94E-02
1998	Jan	141447000	7.06	535376895	2.00E-09	6.3	1.07E+00	3.45E-02
	Feb	142733000	7.62	540244405	2.00E-09	10	1.08E+00	3.73E-02
	Mar	107979000	5.39	408700515	3.00E-09	6.6	1.23E+00	3.96E-02
	Apr	133927000	6.91	506913695	1.00E-09	6.8	5.07E-01	1.69E-02
	May	106890000	5.34	404578650	1.00E-09	6.8	4.05E-01	1.31E-02
	June	112529000	5.80	425922265	**1.00E-09**	6.6	4.26E-01	1.42E-02
	July	83279000	4.16	315211015	**1.00E-09**	6.6	3.15E-01	1.02E-02
	Aug	107817000	5.38	408087345	**1.00E-09**	6	4.08E-01	1.32E-02
	Sept	93385000	4.82	353462225	**1.00E-09**	6.9	3.53E-01	1.18E-02
	Oct	122344000	6.11	463072040	**2.00E-09**		9.26E-01	2.99E-02
	Nov	125864000	6.49	476395240	**2.00E-09**		9.53E-01	3.18E-02
	Dec	125072000	6.24	473397520	**4.00E-09**	10	1.89E+00	6.11E-02
1999	Jan	129539000	6.47	490305115	4.00E-09	6.8	1.96E+00	6.33E-02
	Feb	88762000	4.74	335964170	4.00E-09	5.7	1.34E+00	4.63E-02
	Mar	137661000	6.87	521046885	**2.00E-09**	6.8	1.04E+00	3.36E-02
	Apr	97796000	5.04	370157860	**4.00E-09**	0.24	1.48E+00	4.94E-02
	May	102496000	5.12	387947360	6.00E-09	6.5	2.33E+00	7.51E-02
	Jun	81101000	4.18	306967285	2.00E-09	**4.5**	6.14E-01	2.05E-02
	Jul	128851000	6.43	487701035	1.30E-08	7	6.34E+00	2.05E-01
	Aug	132034000	6.59	499748690	1.00E-09	1.7	5.00E-01	1.61E-02
	Sept	81004000	4.18	306600140	8.00E-09	6.4	2.45E+00	8.18E-02
	Oct	123621000	6.17	467905485	**4.00E-09**	6.3	1.87E+00	6.04E-02
	Nov	118948000	6.14	450218180	**4.00E-09**	6.7	1.80E+00	6.00E-02
	Dec	112172000	5.60	424571020	**3.00E-09**		1.27E+00	4.11E-02

Table 5 (Continued)

Year	Month	Gallons Pumped	CFS	L Pumped	Kg/L Se*	inst. CFS*	Kg Se	Kg/d Se
2000	Jan	52700000	2.63	199469500	3.00E-09	**3.5**	5.98E-01	1.93E-02
	Feb	74101000	3.95	280472285	**5.00E-09**	2.7	1.40E+00	4.84E-02
	Mar	118293000	5.90	447739005	1.40E-08	4.4	6.27E+00	2.02E-01
	Apr	91989000	4.74	348178365				
	May	74621000	3.72	282440485	*****			
	Jun	93528000	4.82	354003480	*****			
	Jul	30794000	1.54	116555290				
Sum							5.01E+01	
Averages			**6.04**		**2.89E-09**	**6.38**	**1.25E+00**	**4.10E-02**

* Data collected by USGS.
***** Data exist, but extremely high detection limits (up to 26 ug/l) preclude use.
Bold type indicates estimated values (usually detection limit used for censored data).

In addition to that resulting from pumped brines from Area VIII, a relatively minor amount of Se loading to Truscott Lake occurs via local runoff from the lake's 26.2-square-mile drainage area. Selenium loading via runoff can be estimated by assuming that 4.7% of rainfall over the entire drainage area reaches the impoundment (based on Crowell Lake estimates and similar watersheds), and that the concentration of total Se in runoff waters is approximately 0.4 ug/l. This concentration is reduced from the estimate of 1 ug/l originally used in initial Crowell Lake estimates (USACE 1993), but is more likely at the upper end of the range of "background" concentrations in freshwater environments and is the approximate median background concentration in California streams (Skorupa et al. 1996). For initial mass balance estimates, actual rainfall data (Table 6) were used to estimate runoff loads since Truscott Lake impoundment.

TABLE 6

ESTIMATED RUNOFF SE LOADS: 1984 TO 1998

Year	**Rain (inches.)**	**Inflow (L)** [1]	**Kg Se** [2]	**Kg/d Se**
1984	22.24	1801933283	0.721	0.002
1985	24.45	1980992301	0.792	0.002
1986	30.07	2436336953	0.975	0.003
1987	32.03	2595140425	1.038	0.003
1988	21.54	1745217757	0.698	0.002
1989	24.87	2015021617	0.806	0.002
1990	30.78	2493862700	0.998	0.003
1991	30.83	2497913809	0.999	0.003
1992	35.04	2839017187	1.136	0.003
1993	32.22	2610534640	1.044	0.003
1994	19.40	1571830292	0.629	0.002
1995	38.34	3106390381	1.243	0.003
1996	17.34	1404924601	0.562	0.002
1997	33.69	2729637244	1.092	0.003
1998	20.14	1631786705	0.653	0.002
Sum	412.98	33460539896	13.38	
Average	27.532	2230702660	0.892	0.002
		(6.11E6 L/d)		

(1) Based on 26.2 square-mile drainage, assuming 4.7% rainfall reaches lake.
(2) Assumes Se concentration of 0.4 ug/l in runoff.

For purposes of both initial mass balance estimates and modeling exercises, atmospheric deposition of Se to Truscott Lake was assumed to be insignificant. It is unlikely that wind-blown surface soils in the area would contain significant concentrations of Se, and industrial facilities with a potential for Se discharge are absent from the area. Total mass delivered to Truscott Lake from impoundment (1984) through initiation of pumping (May 1987) to the latest Truscott lake water Se analyses (September 1998) was therefore estimated as follows:

Runoff: (33,460,539,896 liters)(4E-10 Kg/l Se) = 13.38 Kg Se (Table 6)
Pumped: (63,533,714,658 liters)(2.89E-9 Kg/l Se) = 183.61 Kg Se (Table 4)
Total: 13.38 Kg + 183.61 Kg = **197 Kg**

In September 1998, Truscott Lake possessed a pool volume of approximately 4.95E10 liters (Table 4). Therefore, if Se were to be considered as totally conserved (no mass loss from water column), lake water total Se concentration in September 1998 could be estimated as:

197 Kg Se / 4.95E10 liters = **4 ug/l**

On September 2, 1998 (latest Truscott Lake water analysis), total Se concentrations across Truscott Lake (end-to-end, surface, and bottom waters) were reported as <0.5 ug/l. Values similarly below detection limits (0.5 to 1 ug/l) were consistently measured across sampling dates (spanning a range of seasons) and sites throughout 1997 and 1998 (Table 3). It can therefore be demonstrated that somewhere in excess of 87% of Se mass estimated to have been delivered to Truscott Lake during the 14-year period between impoundment and September 1998 could not be accounted for in total waterborne Se analyses.

5. SELENIUM LOAD ESTIMATION FOR ALTERNATIVES

For this evaluation, it was necessary to estimate Se mass loads for each of the alternatives under consideration. These loads were then used in modeling exercises for estimation of long-term water and sediment Se concentrations for all alternatives.

Loads resulting from local inflow (runoff) were estimated using the 30-year average annual rainfall (24 inches), a 26.2-square-mile watershed for Truscott Lake, the assumption that 4.7% of rainfall reaches the lake as runoff, and an assumed Se concentration in runoff waters of 0.4 ug/l. The resulting load is 0.002 Kg/day and was used as an estimate for local inflow load for evaluation of all alternatives.

Selenium load for brine inputs from Area VIII was estimated using an average total Se concentration of 2.9 ug/l (derived as described above) and the average design pumping rate of 5.7 cfs (13,947,034 l/day). The resulting estimated load is 0.040 Kg/day and was used for evaluation of all alternatives.

Loads for other brine collection areas were similarly derived using average total Se concentrations (Table 2) and design pump rates. Selenium concentrations at these areas are somewhat higher than those at Area VIII, and censored concentration data were largely absent for these areas. For Area VII, a design pump rate of 8.2 cfs (20,064,154 l/day) and average Se concentration of 9.2 ug/l (Table 2) yielded an average daily load of 0.185 Kg/day. For Area X, a design pump rate of 4.2 cfs (10,276,762 l/day) and an average total Se concentration of 11.4 ug/l (Table 2) yielded an average daily load of 0.117 Kg/day. These estimated loads were used in evaluations involving these areas.

Total Se loads for alternatives analyses were obtained by summing loads for local runoff and appropriate source areas. Using this approach, the following average daily Se loads (Kg/day) were obtained and used as model input in alternative evaluation:

Alternative 1:	0.042
Alternative 2:	0.227
Alternative 3:	0.159
Alternative 4:	0.344

If alternative 1 (existing condition) is used as a reference, alternatives 2, 3, and 4 would result in estimated 440, 279, and 719% increases, respectively, in Se load over current conditions. It is also of interest to note the estimated average inflow total Se concentrations of these alternatives. If total mixing of all Se inputs as described above is assumed, resulting average inflow concentrations for alternatives 1 through 4 would be 2.2, 5.8, 5.4, and 6.9 ug/l total Se, respectively.

6. PREDICTIVE MODELING EVALUATION OF ALTERNATIVES

Water quality modeling was employed as a means of obtaining reasonable estimates of temporal changes in Se concentration in water and sediments in Truscott Lake for project alternatives listed above. The modeling approach was very similar to that employed in initial Se evaluations for project features (USACE 1993) using the Simplified Lake and Stream Analysis (SLSA) model (Hydroqual, Inc. 1981, 1982). Detailed description of model characteristics, assumptions, input parameters, and uncertainties are provided in USACE (1993) and should be thoroughly reviewed for an understanding of this approach. As noted in the 1993 document, considerable uncertainties regarding Se dynamics in brine disposal lakes for the project necessitated a very conservative initial modeling approach to Se prediction. While many uncertainties remain, additional field data collected at Truscott Lake permit a reevaluation of model input parameter values to more closely match observed field data. Details for this reanalysis and their impacts on alternatives evaluation are provided in this section.

When applied to Se simulation for the approximate 10-year period from initiation of brine input (May 1987) to September 1998 (most recent Truscott lake data), input parameters used for initial Se predictions significantly overestimate total waterborne Se concentrations and underestimate sediment Se levels. Predicted values using original input values for this time period are 2.8 ug/l and 0.06 mg/Kg (dry wt) total Se for water and sediments, respectively. These compare to measured values of <0.5 ug/l for water (Table 3) and sediment concentrations ranging from 0.1 to 0.49 mg/Kg total Se (1998 data). The conservative nature of this approach for estimation of waterborne Se concentrations, which was recognized and discussed in USACE (1993), is apparent in these comparisons. It is also apparent that the original model substantially underestimated Se concentrations in sediments.

In an effort to more closely simulate observed conditions at Truscott Lake for alternative comparisons, SLSA model input was varied until predicted values for both water and sediment were reasonably close to 1998 reported Se concentration for these matrices. For this exercise, the actual volume of pumped brine (not design average) from project initiation to September 1998 was used in load estimation (Table 4). The resulting estimated Se load over this period was 0.049 Kg/day. For the sake of continued conservatism, it was then determined that the model should be adjusted to predict an approximate waterborne total Se concentration of 0.6 ug/l for the "calibration" time period – a concentration slightly higher than the latest reported detection limit of 0.5 ug/l (Table 3). The degree of conservatism would be dependent upon how close actual concentrations are to this detection limit. Finally, a related goal of model adjustment was to more closely simulate observed sediment concentrations as sediments have been noted to be a major sink for Se in lakes (Bowie et al. 1996).

Processes reflected by SLSA model input data originally employed in Se predictive analysis (Table 2 of USACE 1993) were evaluated for potential explanation of Se mass loss in Truscott Lake as described in Section 4 above. Two processes attributed to significant Se mass loss from the water column in other systems include volatilization and sediment adsorption (see detailed discussion and citations in USACE, 1993). These two processes therefore became the focus for model input adjustment. While relative contribution of these processes is currently unknown, an attempt was made to adjust input values to provide reasonable agreement with field findings while maintaining consistency with reports from the Se literature.

Volatilization of methylated Se compounds has been demonstrated to be a significant source of Se mass loss in a number of systems (see discussion in USACE 1993). Cooke and Bruland (1987) reported that outgassing of Se may have been substantial in Kesterson Reservoir and estimated that roughly 30% of Se introduced to the system was volatilized to the atmosphere. Similarly, Thompson-Eagle and Frankenberger (1990) reported a 35% loss of the total Se inventory of pond water from Kesterson reservoir after 43 days of incubation. Biomethylation and volatilization of Se have been shown to vary considerably with Se species, concentrations, and overall aquatic productivity. From a mass removal standpoint, volatilization may be a more significant process in wetlands (Zhang and Moore 1997) relative to lakes (Bowie et al. 1996).

Owing to considerable uncertainty regarding the importance of this process and a desire for initial conservatism, original 1993 water column and sediment volatilization rate coefficients (day^{-1}) used in brine lake Se simulations were set extremely low (2E-6 day^{-1}). These values were three to four orders of magnitude lower than the few that could be found reported in the literature (0.003 to 0.053 day^{-1}; Calderone et al. 1990). For Truscott Lake simulations for this analysis, volatilization rate constants were varied to more realistically reflect both recent literature findings for lakes and to account for a fraction of observed Se mass loss. In one of the few modeling exercises described in the literature, Bowie et al. (1996) estimated net volatilization losses of less than 5% of Se loading to Hyco Reservoir, North Carolina. They reported that similar minor losses probably occur in most lakes. Accordingly, both (water and sediment) volatilization rate constants were varied to approximate 5% or less (depending on alternative) mass loss from the system over a 100-year period. The resulting rates (2E-5 day^{-1}) were still two to three orders of magnitude lower than those found in the literature but were thought to reasonably account for some Se mass loss from the system while still providing a measure of conservatism. These values were therefore used in all SLSA modeling exercises for this evaluation.

Changes in water column and sediment partition coefficients (l/Kg) were next evaluated for providing model simulations more closely matching observed field conditions. Through iterative simulation, water column and sediment partition coefficients of 500 and 350 l/Kg, respectively, resulted in a predicted waterborne total Se concentration of approximately 0.6 ug/l in Truscott Lake for a simulation period from impoundment to September 1998. This was very close to the prediction goal as described above. Predicted total Se in Truscott Lake sediments was 0.19 mg/Kg dry weight - a value very much within the range of 0.1 to 0.49 mg/Kg reported for 1998 sediment sampling and a much closer estimate of sediment Se predictions than that obtained using previous partition coefficients. Based on this evaluation, water column and sediment partition coefficients of 500 and 350 l/Kg were retained for use in Truscott Lake alternatives evaluation. Use of these values improved simulation accuracy of the model by increasing predicted flux of Se to sediments – a process reported to be of major importance in lakes (Bowie et al. 1986).

With the exception of coefficients described above and alternative-specific parameters, all input parameters used in original Se simulations (Table 2, USACE 1993) were used in SLSA model analysis of alternatives for this evaluation. Simulations were conducted for separate 5-year intervals over a total time span of 100 years. Discrete simulations were conducted to mitigate the influence of significantly changing pool volumes and surface areas during initial years of project operation for some alternatives. Input parameters dependent upon pool morphometry, including water volume, sedimentation rates, and water depth (Table 1), were varied to match anticipated conditions for each alternative.

7.0 MODELING RESULTS

Predicted total Se concentrations in Truscott Lake water and sediments for all alternatives for this evaluation are provided in Table 7, Figure 1, and Table 8, Figure 2, respectively.

For water, maximum concentrations (ug/l) and operational time to occurrence are as follows:

Alternative 1:	0.9	(40 years)
Alternative 2:	4.5	(65 years)
Alternative 3:	3.2	(50 years)
Alternative 4:	6.4	(80 years)

Similarly, estimated maximum total Se concentrations in sediments (mg/Kg dry wt) and operational time to occurrence are:

Alternative 1:	0.30	(90 years)
Alternative 2:	1.57	(65 years)
Alternative 3:	1.11	(55 years)
Alternative 4:	2.23	(85 years)

These values were used in alternatives evaluation relative to Se concerns.

TABLE 7

ESTIMATED LAKEWATER TOTAL SE CONCENTRATIONS (ug/l) FOR WICHITA BASIN ALTERNATIVES*

ALT 1: Area VIII - 1 spray field
ALT 2: Areas VIII-1, VII-2
ALT 3: Areas VIII-1, X-2
ALT 4: Areas VIII-1, VII-2,X-2

Years	Alternative 1	Alternative 2	Alternative 3	Alternative 4
5	0.3	1.4	1.1	2.0
10	0.5	2.2	1.9	3.0
15	0.7	3.3	2.2	3.8
20	0.8	3.2	2.6	4.3
25	0.8	3.5	2.7	4.8
30	0.8	3.7	2.9	5.0
35	0.8	3.8	2.9	5.2
40	**0.9**	4.1	3.1	5.8
45	0.9	4.2	3.1	5.8
50	0.9	4.3	**3.2**	5.9
55	0.9	4.3	3.2	6.0
60	0.9	4.4	3.2	6.2
65	0.9	**4.5**	3.2	6.2
70	0.9	4.3	3.2	6.2
75	0.9	4.3	3.2	6.2
80	0.9	4.4	3.2	**6.4**
85	0.9	4.4	3.2	6.4
90	0.9	4.4	3.0	6.4
95	0.9	4.4	3.2	6.4
100	0.9	4.3	3.2	6.3
MAX	**0.9**	**4.5**	**3.2**	**6.4**

* SLSA Model Output

Figure 1. Estimated Lakewater Total Se Concentrations

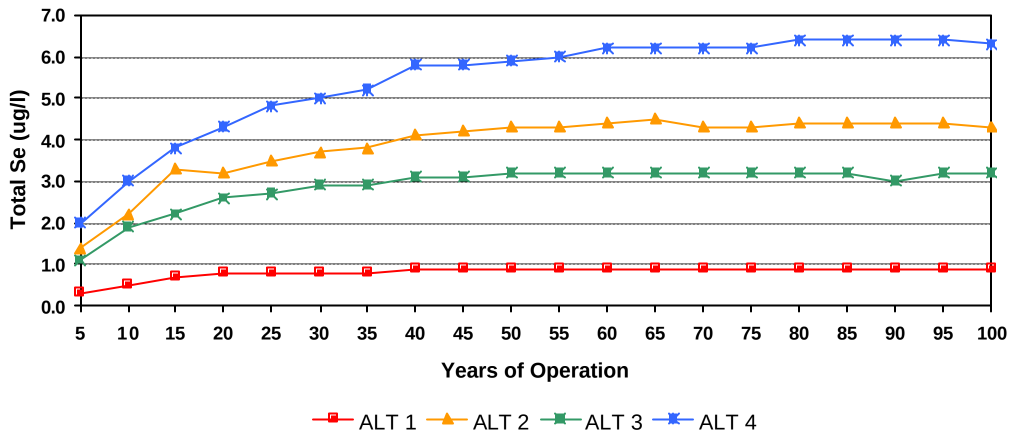


TABLE 8

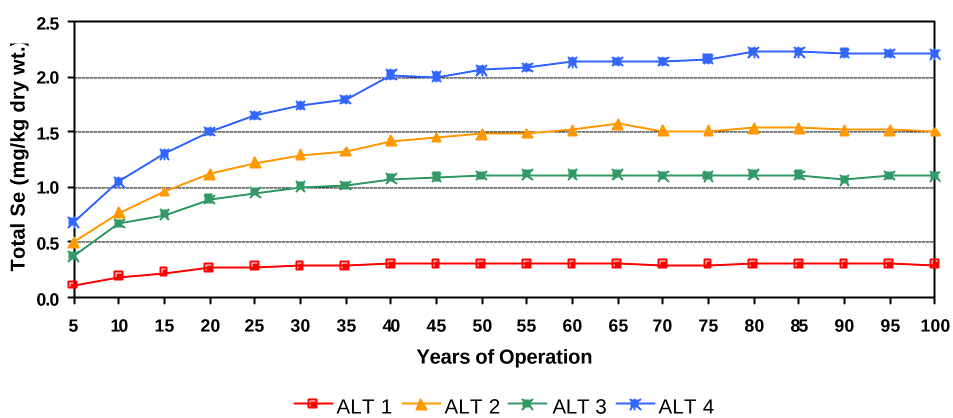
ESTIMATED SEDIMENT TOTAL SE CONCENTRATIONS (MG/KG DRY WT) FOR WICHITA BASIN ALTERNATIVES*

ALT 1: Area VIII - 1 spray field
ALT 2: Areas VIII-1, VII-2
ALT 3: Areas VIII-1, X-2
ALT 4: Areas VIII-1, VII-2,X-2

Years	Alternative 1	Alternative 2	Alternative 3	Alternative 4
5	0.108	0.497	0.376	0.680
10	0.184	0.765	0.668	1.046
15	0.224	0.960	0.749	1.298
20	0.261	1.117	0.889	1.505
25	0.274	1.222	0.946	1.648
30	0.283	1.290	1.005	1.739
35	0.283	1.322	1.012	1.794
40	0.300	1.418	1.077	2.015
45	0.300	1.448	1.088	1.997
50	0.301	1.479	1.105	2.060
55	0.301	1.488	**1.110**	2.084
60	0.301	1.518	1.110	2.136
65	0.298	**1.570**	1.109	2.137
70	0.296	1.509	1.097	2.138
75	0.296	1.508	1.100	2.158
80	0.301	1.536	1.109	2.222
85	0.301	1.533	1.107	**2.226**
90	**0.303**	1.518	1.060	2.212
95	0.298	1.515	1.102	2.210
100	0.295	1.506	1.097	2.203
MAX	**0.303**	**1.570**	**1.110**	**2.226**

* SLSA Model Output

Figure 2. Estimated Sediment Total Se Concentrations



8.0 THRESHOLD LEVELS OF CONCERN

Considerable discussion regarding Se levels of concern related to brine disposal lakes for the original Red River Chloride Control Project is provided in USACE (1993). As noted in this document, project impoundments are designed solely for disposal of collected brines. As such, primary environmental concerns center around potential impacts on semi-aquatic organisms tied to these systems via food chain dynamics, and not maintenance of diverse communities of exclusively aquatic species (e.g., fish). Owing to a demonstrated sensitivity of aquatic birds to waterborne Se, their potential use of brine disposal lakes, and substantial information regarding impacts on these species, birds were (and continue to be) the focus for Se-related impact evaluation for the project. This focus should be carefully considered in threshold evaluation.

Owing to two distinct categories of Se-related impacts on aquatic birds, it was necessary to distinguish between Se criteria for: (1) potential reproductive impairment of birds nesting at the project area, and (2) potential detrimental impacts on adult and juvenile birds nesting at sites removed from the project (e.g., wintering waterfowl). In the 1993 evaluation for Crowell Lake, a total waterborne Se concentration of 10 ug/l was used as a threshold value protective of avian embryotoxicity. For impacts on adult and juvenile birds in the absence of reproductive concerns, a threshold value of 34 ug/l was proposed. Finally, a sediment concern threshold level of 4 mg/Kg (dry weight) was used in this evaluation. Literature citations supporting these criteria are provided in USACE (1993) and should be reviewed for an understanding of issues related to threshold estimation for this study.

Subsequent to the USACE (1993) report, a significant amount of literature has provided additional information on threshold levels for Se in the environment and their application to risk evaluation. Principal among these are Lemly (1993, 1995, 1996), Skorupa et al. (1996), and Heinz (1996). In addition, Se concentrations in a number of environmental matrices from field case studies where Se toxicity has been observed have been reported by Skorupa et al. (1996) and Skorupa (1998). Collectively, these publications have provided additional information for establishment of Se toxicity thresholds in the aquatic environment and have generally resulted in a gradual lowering of concentrations reported to be toxic to fish and wildlife.

One area of apparent consensus among Se researchers is that waterborne Se concentration in and of itself is a poor predictor of impact on fish and wildlife and that water (as well as sediment) data should be evaluated along with Se concentrations in food chain organisms and fish and wildlife tissues for conclusions regarding Se impacts (Lemly 1996). For ultimate assessment of bird-related impacts, avian eggs are believed to be the best biotic matrix for risk/impact assessment though considerable between-species variability in embryo sensitivity exists (Lemly 1993, Skorupa et al. 1996). Complexities involved with using water-based criteria for impact prediction have even resulted in proposed methods for deriving site-specific water quality criteria for Se (e.g., Van Derveer and Canton 1997, Lemly 1998). Important considerations in deriving site-specific crieria appear to be Se speciation, sediment organic content, and application to lotic versus lentic systems (Van Derveer and Canton 1997). The current USEPA chronic criteria for Se (as well as the State of Texas chronic water quality standard) is 5 ug/l.

Despite the complexities and uncertainties involved, it was still necessary to derive water and sediment criteria for use in pre-construction evaluation of brine disposal alternatives and projected impacts on birds. While site-specific monitoring of both biotic and abiotic environmental matrices would undoubtedly reduce this uncertainty upon project implementation, pre-construction evaluation of alternatives made this assessment necessary. Given the complexities and uncertainties involved, a range of threshold values appearing in the literature was chosen for comparison to predicted values in alternatives analysis.

Though not confined exclusively to impacts on birds, Lemly (1995) assigned a "low hazard" (defined as ". . . periodic or ephemeral toxic threat that could marginally affect the reproductive success of some sensitive species, but most species will be unaffected.") rating to dissolved (0.45 um filtered) Se concentrations of 2 to 3 ug/l based on an extensive literature review. Later, Lemly (1996) recommended that waterborne Se concentrations of 2 ug/l or greater (total recoverable basis in 0.45-um filtered samples) be considered "highly hazardous" to the health and long-term survival of fish and wildlife. Though originally based on dissolved concentrations (totals might be slightly higher) and not confined exclusively to birds, a total Se concentration of 2 ug/l was used as the lower value for the threshold range for this evaluation.

Given conservatism associated with both predicted Se values for this assessment as well as the 2 ug/l threshold, this lower end might be considered as "ultraconservative" for purposes of this evaluation. In studies relating Se concentrations in water to bioaccumulation of Se in bird eggs, Skorupa and Ohlendorf (1991) proposed 10 ug/l waterborne Se as protective of avian embryotoxicity under most conditions. This was the concentration used in the 1993 evaluation and was retained as the upper limit of the threshold range for this evaluation. Consequently, a range of 2 to 10 ug/l was used as a minimum threshold total waterborne Se value range for impacts on breeding birds associated with alternatives evaluation.

The threshold concentration of 34 ug/l total Se for impacts on non-breeding birds was originally based on recommended dietary exposure for non-breeding birds and empirically-derived regression equations for prey accumulation of Se (see USACE 1993). Nothing could be found in the recent literature to justify modification of this threshold and it was therefore retained for use in alternatives evaluation.

Currently, there is no well developed empirical basis for assessing fish and wildlife risk as a function of sediment Se concentration (Skorupa et al. 1996, Van Derveer and Canton 1997). Sediment concentrations are particularly important in systems where the benthic detrital food web may influence Se transfer (Van Derveer and Canton 1997). Lemly (1995) characterized sediment Se concentrations of 2-3 mg/Kg dry weight as "low hazard" (an assessment again not entirely based on bird data). Skorupa et al. (1996) cited unpublished data, which suggested egg Se concentrations exceeded embryotoxicity thresholds for sensitive bird species in black-necked stilt eggs at ponds averaging greater than or equal to 1.8 ppm Se in sediments. They also cited studies reporting an approximate background Se concentration of <1.9 mg/Kg in Texas freshwater environments. Based on a review of field data from throughout the United States, Van Derveer and Canton (1997) derived a "predicted effect level" of sediment Se concentrations in the range of 2.5 mg/Kg and an "observed effect level" in the range of 4.0 mg/Kg. They also cited sediment total organic carbon (TOC) concentrations as important considerations in these evaluations. Finally, a 4 mg/Kg concern threshold was proposed by Lemly and Smith (1987) and was the value used in the original Crowell Lake evaluation (USACE 1993). Accordingly, an approximate minimum threshold range of 2 to 4 mg/Kg dry weight Se in sediments was used in this assessment of alternatives. Again, the lower end of the range (around 2 mg/Kg) might be considered "ultraconservative" for purposes of this evaluation.

9. COMPARISON OF ALTERNATIVES

Predicted values for total Se in Truscott Lake water (Table 7) and sediments (Table 8) for the four brine disposal alternatives were compared to threshold ranges described above for estimation of potential impacts on birds. This analysis permitted both impact estimation and a comparison of alternatives relative to selenium concerns.

Predicted waterborne Se concentrations for Alternative 1 (current operational condition) are extremely low, near analytical detection limits, and below threshold values for Se-related impacts on birds. Under this scenario, the maximum estimated concentration, 0.9 ug/l, would be predicted to occur after approximately 40 years of project operation (Table 7). A maximum sediment concentration of 0.303 mg/Kg was predicted after approximately 90 years of project operation (Table 8) – a value that is likewise well below the threshold range for protection of fish and wildlife. Based on the methodology and assumptions used for this assessment, Se-related concerns would not be expected to occur with this alternative.

Alternatives 2 and 3 have similar predicted maximum Se concentrations in water of 4.5 and 3.2 ug/l, respectively (Table 7). For alternative 2, the maximum concentration would be predicted after approximately 65 years of project operation. Estimated time to maximum concentration for alternative 3 is approximately 50 years. Predicted waterborne Se concentrations for both alternatives are within, but near the lower end of the threshold range for impacts on breeding birds (2 – 10 ug/l), indicating that reproductive impacts on some avian species (particularly sensitive species) breeding at Truscott lake might be possible. Estimated water concentrations for both alternatives are well below the threshold range for impacts on young and adult birds in the absence of reproductive concerns. Likewise, estimated maximum sediment Se concentrations for both alternatives are in the 1 to 1.6 mg/Kg range (Table 8) and therefore below the impacts threshold range for sediments.

Predicted maximum total Se concentration for Truscott Lake water is highest for Alternative 4. This concentration, 6.4 ug/l, was estimated to occur after approximately 80 years of project operation (Table 7). This concentration is within the threshold range for avian reproductive impairment (2 – 10 ug/l), but closer to the upper end of this range relative to other alternatives. Accordingly, the potential for impacts on breeding birds might still be relatively low for this alternative and limited to sensitive to moderately-sensitive avian species, but the risk of occurrence of these effects is the highest of all evaluated alternatives. As with other alternatives, maximum estimated waterborne concentrations are well below the 34 ug/l threshold for non-reproductive impacts on young and adult birds. Predicted sediment concentrations are highest for this alternative (maximum of 2.23 mg/Kg) and slightly exceed the conservative lower end of the sediment threshold range used for this evaluation.

10. SUMMARY AND CONCLUSIONS

Based on methodology and assumptions used for this evaluation of Se-related concerns associated with brine disposal alternatives, it appears reasonable to assume that all alternatives could be implemented without Se-induced impacts on non-breeding birds (e.g., wintering waterfowl) or significant Se-related sediment concerns for these species at Truscott Brine Lake, Texas. Modeled estimates for Se concentrations for all alternatives are below estimated threshold values for non-reproductive impacts.

Estimated concentrations of total Se in Truscott Lake waters for all alternatives involving increased brine flows to the impoundment from additional collection areas are within a range of threshold values which indicate at least a potential for reproductive impacts on sensitive species of semi-aquatic bird species nesting at Truscott Lake. Alternatives involving collection and disposal of additional brines from either Area VII or X result in predicted waterborne Se concentrations near the conservative end of a range of threshold values indicating the potential for avian reproductive impacts. Addition of brines from both areas (Alternative 4) results in an estimated total Se concentration in water closer to the upper end of a threshold range indicative of the potential for these effects. In addition, this alternative results in estimated sediment Se concentrations near the lower end of a threshold range for potential impacts. Given the assumed conservative nature of the approach used, it would seem that the potential for Se-related impacts predicted by this evaluation is not excessive and is low enough that any of the alternatives could reasonably be implemented, provided that an adequate Se monitoring program accompanies project implementation. This monitoring program should include a number of environmental matrices, including water, sediment, vegetation, avian food items (e.g., fish, invertebrates), and eggs of appropriate (i.e., sedentary, semi-aquatic) bird species.

It must be noted that considerable uncertainty exists regarding environmental dynamics of Se and associated impacts on wildlife. These areas of uncertainty and their impacts on Se evaluations for this project are addressed in original Se evaluations (USACE 1993) and should be reviewed for an understanding of these issues. Given the site-specific nature of many of these issues, it is likely that these uncertainties can only be significantly reduced by continued monitoring in the Wichita River Basin as the project progresses. A monitoring program designed to reduce these uncertainties is recommended for implementation of any alternative.

11. REFERENCES

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APPENDIX B

AVIAN COMMUNITY DYNAMICS AT TRUSCOTT BRINE LAKE
FINAL REPORT

Avian Community Dynamics at Truscott Brine Lake

Lisa Wrinkle and C. Brad Dabbert
Texas Tech University

Final Report

Prepared For:
U.S. Army Corps of Engineers, Tulsa District

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PROJECT TITLE: Avian Community Dynamics at Truscott Brine Lake and Area VIII

ORGANIZATION: Department of Range, Wildlife, and Fisheries Management
Texas Tech University, Lubbock, TX 79409-2125

DATE OF INITIATION: January 1997

COMPLETION DATE: August 1999

INVESTIGATORS: C. Brad Dabbert, principal investigator and Lisa Wrinkle, research assistant

PURPOSE: Estimation of bird use at Truscott Brine Lake and Area VIII and subsequent determination of potential impacts to avian species related to potential exposure to selenium. As requested by the Tulsa District, we extracted portions of the methods and results sections of a thesis written by Ms. Lisa Wrinkle, to prepare this report.

OBJECTIVES:

1. Assess the composition of both the breeding and nonbreeding bird communities at the sites to determine the potential magnitude of the impact of selenium toxicity on birds

2. Determine what species of birds would be most appropriate for selenium evaluation

3. Determine egg selenium burdens and potential effects on neonatal survival and development of those target species selected in Objective 2.

MATERIALS AND METHODS

Assessing Breeding and Nonbreeding Bird Composition

Breeding Bird Community Composition

Point count surveys were conducted to determine characteristics of the breeding bird communities at the sites. The point count surveys provided information about species richness, diversity, and breeding bird abundance. The surveys were conducted, once per month during the last four days of each month in May through August 1997 and April through August 1998. Point locations were established at every 1,000-m interval around Truscott Brine Lake for a total of 20 points. Only one point per area was established for Area VIII and the freshwater ponds due to their small size. Each point was marked by placing a ten-foot PVC-pipe pole into the ground at the land/water interface. When the water level fluctuated, a point was defined as the location where the land and water met to form a straight line with the PVC pipe and the center of the lake. The actual point count surveys were conducted in accordance with standard methods previously described by Ralph et al. (1995). Briefly, points were divided between the last four days of the month in order to survey at every point within the first three hours after sunrise. All birds heard or seen for an infinite distance from the point were recorded. Identification of unknown birds after the count was limited to 10 minutes.

Analysis of the point count survey data included the determination of species richness, which was defined as the number of species found in a sample of individuals. Total species richness at each site was determined using point count survey data, winter inventory data, and incidental sightings. In addition, diversity (eveness of the distribution of individuals among species) was calculated using a heterogeneity index, specifically a modification of Simpson's index. The index was calculated by the following formula: D = 1-L, where L = S $[n_i (n_I-1) / N (N- 1)]$ and n_i = the number of individuals of a particular species, N = the total number of individuals. The index varies from 0 to 1 with values closer to 1 representing more diverse sites (Morrison et al. 1992). Lastly, point count survey data were used to calculate the average abundance of individual species at each study site. It was assumed that all species had the same detectability across all habitats within a site. We calculated the mean number of detections of a species at a point from the 4 (1997) or 5 (1998) monthly visits within a field season. The average abundance of a species at Truscott Brine Lake was then calculated as the mean number of the 20 point means. As a consequence of having only one point each at Area VIII and the freshwater ponds, the mean number of detections of a species at the site was calculated rather than average abundance.

Nonbreeding Bird Community Composition

The wintering bird community at the sites was also characterized. Density was determined using optical field of view sampling conducted once per month during the last week of each month in November-February (1997-1998 season) and October-November (1998 season). The sampling consisted of standing at a strategically placed point around the site and estimating the number of birds present using binoculars or a spotting scope. At each point, the number of birds in the first field of view of the binoculars was counted. Then, the number of fields of view at that point were counted and multiplied by the number of birds in the first field of view to estimate the number of birds present. During the counts, emphasis was placed on identifying waterfowl and other birds occupying the water. Four categories including ducks, American coots, geese, and grebes were established. When birds could not be identified as being either a duck or an American coot, both groups were combined into a fifth group noted as "combination." At each site, monthly absolute density of birds in each of the five categories was estimated by adding the individual point totals together. Also, the monthly total density of all birds counted per sight per season, regardless of category, was estimated.

Preliminary Assessment of Target Species to be Studied

Because of selenium's biomagnification properties, two levels in the aquatic food chain (piscivorous and insectivorous birds) were examined to determine differences in dietary selenium concentrations between trophic levels. Intensive nest searching for sedentary, aquatic and semi-aquatic bird species was conducted at the sites. The goal was to find species actively involved in aquatic environments through feeding practices because these would be most appropriate for selenium evaluations. As a result of these searches, such birds were sighted (e.g., grebes); however, they were not observed nesting at any of the sites. Consequently, the two piscivorous species chosen for investigation were the only semi-aquatic, piscivorous bird species nesting in groups of more than one or two pairs at the sites. They were the great blue heron *(Ardea herodias)* and the double-crested cormorant *(Phalacrocorax auritus*). While these species were not the most appropriate for selenium evaluation due to their non-sedentary behaviors, they were the only species present. In fact, these two species were only available at one of the three sites, Truscott Brine Lake. During the study, no birds were observed nesting at Area VIII despite intensive nest searching, and only the insectivorous species was found nesting at the largest freshwater pond. The insectivorous species chosen for this study was the red winged blackbird *(Agelaius phoeniceus)*. It was chosen because of its dependence on aquatic-based foods during the breeding season and its preference for nesting in wetland areas. The three above-mentioned species were considered the target species for this study.

Nest Searching and Egg Collection

Nest searching and egg collection were conducted from May 20 to June 11, 1997 and from April 19 to June 14, 1998 to determine egg selenium levels found in the three target species. Nests of the red-winged blackbirds were located by searching in cattail (*Typha spp.*) and decadent juniper stands around the perimeter of the sites. In addition, nests of double-crested cormorants and great blue herons were located by searching the rookeries contained within the site. Once active nests were identified, they were mapped using a global positioning system (GPS) and marked a safe distance away to avoid predator attraction.

Egg collection began when egg laying was initiated. One egg per nest was randomly collected then wrapped in protective plastic and placed in a styrofoam cup to prevent damage or breakage. Eggs were then placed on ice for transport back to the lab for immediate processing. External contamination of egg samples was prevented by wearing latex gloves and washing the egg exterior with distilled water and a soft brush. Egg length, width, and total weight to the nearest 0.01 (cm or g) were determined after cleaning. Subsequently eggs were cut at the air sac end using a circular motion to remove a small piece of the eggshell. Egg contents were emptied into sterile jars and weighed to the nearest 0.0 1 gram. Eggshell weight was determined by subtraction. Jars were secured using a tamper proof seal and stored at –20 °C until analysis. Samples were sent to the Environmental Trace Substances Laboratory in Rolla, Missouri for analysis. Acid digestion and atomic absorption were used to determine total selenium content of samples. The samples were freeze-dried first to obtain dry-weight measurements (Hartman 1997).

Monitoring Reproductive Success

After egg collection, nests and remaining eggs were monitored throughout the nesting period to determine reproductive success. Each nest was checked at least every four days, and the number of eggs and nestlings in each nest was recorded. Nestlings were carefully examined for malformations characteristic of selenium toxicity such as abnormal eye size, twisted feet and legs, missing appendages, and deformed bills (Ohlendorf et al. 1986b). Monitoring continued until all of the nestlings had fledged. A successful nest was considered to be one from which at least one nestling fledged. Nest success was calculated using the Mayfield Method (Mayfleld 1975). The lengths of incubation and nestling periods were assumed to be as follows for the three target species: red-winged blackbird = 11 and 13 days, great blue heron = 28 and 58 days, double-crested cormorant = 27 and 39 days, respectively (Ehrlich et al. 1988). A z-statistic was computed and used to determine differences in daily survival estimates between 1997 and 1998 within a species for both incubation and nestling periods at Truscott Brine Lake. The z-statistic was also used to determine differences in daily survival estimates of red-winged blackbirds between the freshwater pond and Truscott

Brine Lake for both periods (Johnson 1979). Initial analysis showed no differences in daily survival estimates between years for birds at Truscott Brine Lake. Therefore, data were pooled within a species across the two years, and a z-statistic was used to test for differences in daily survival estimates among the three target species.

RESULTS

Assessing Breeding and Nonbreeding Bird Composition

Breeding Bird Community Composition Results

Total species richness at Truscott Brine Lake for both 1997 and 1998 combined was 113 species representing 31 families. One federally and state endangered species was recorded at the lake in both 1997 and 1998, the interior least tern *(Sterna antillarum athalassos).* The average abundance of the interior least tern was 0.0 125 mean number of birds per point in 1997 and 0.14 mean number of birds per point in 1998. No tern nests were found; however, terns were observed feeding at the lake on two different occasions. Total species richness at Area VIII and the freshwater ponds was 37 and 57 representing 17 and 26 families, respectively. Monthly species richness at Truscott Brine Lake ranged from 31 to 52 with peaks during April and May. Species richness at the freshwater ponds ranged from 12 to 22 with peaks during July and August. Species richness at Area VIII peaked during May and June, and the number of species ranged from 7 to 13. Yearly species richness increased from 1997 to 1998 at all three sites.

Diversity at Area VIII peaked in May of 1997 and in July of 1998. Freshwater Pond I (the largest pond) had peak diversity in July of 1997 and April of 1998. In contrast, diversity at Freshwater Pond 2 peaked during May of 1998. Yearly diversity was similar between 1997 and 1998 at Truscott Brine Lake and Area VIII. However, diversity at Freshwater Pond I was lower in 1998 than in 1997.

Average abundance (mean number of birds per point) of individual species at Truscott Brine Lake ranged from 0.0125 to 5.325 in 1997 and from 0.01 to 4.84 in 1998. At Area VIII, mean number of detections in 1997 ranged from 0.25 to 3.25 and in 1998 from 0.2 to 6.4. Mean number of detections at Freshwater Pond 1 ranged from 0.33 to 9.67 in 1997 and 0.2 to 56.8 in 1998. Freshwater Pond 2, evaluated only in 1998, had a mean number of detections ranging from 0.2 to 21.8.

Eight species had an average abundance above one at Truscott Brine Lake in 1997. They included cattle egret *(Bubulcus ibis*) (5.325), mourning dove *(Zenaida macroura)* (2.275), mallard *(Anas platyrhynch*os) (1.9625), red-winged blackbird (1.7), double-crested cormorant (1.475), Bewick's wren *(Thryomanes bewickii)* (1.3625), northern mockingbird *(Mimus polyglottos)* (1. 2375), and great egret *(Casmerodius albus)* (1.05). In 1998, eleven species at the lake had an average abundance higher than one. They included mallard (4.84), blue-winged teal *(Anas discors)* (3.76), cattle egret (3.41), red-winged blackbird (3.32), mourning dove (3.03), double-crested cormorant (2.11), tree swallow *(Tachycineta bicolor)* (1.7), great egret (1.59), snowy egret *(Egretta thula)* (1.4 1), Bewick's wren (1.24), and northern mockingbird (1.23).

The five most abundant species at Area VIII in 1997, beginning with the most abundant, were mourning dove, Bewick's wren, scissor-tailed flycatcher *(Tyrannus forficatus),* northern mockingbird, and ash- throated flycatcher *(Myiarchus cinerascens).* In 1998, the five most abundant species were turkey vulture *(Cathartes aura),* mourning dove, great-tailed grackle *(Quiscalus mexicanus*), Bewick's wren, and scissor-tailed flycatcher. In 1997, at Freshwater Pond 1, mourning dove, red-winged blackbirds, blue-winged teal, lark sparrows *(Chondestes grammacus)* and northern bobwhite *(Colinus virginianus)* were the most abundant species. In 1998, tree swallows, mourning dove, blue-winged teal, red-winged blackbirds, and ruddy ducks *(Oxyura jamaicensis)* had the highest abundance estimates. At Freshwater Pond 2, only evaluated in1998, the most abundant species included mourning dove, blue-winged teall, red-winged blackbirds, mallards, and white-faced ibis *(Plegadis chihi).*

Nonbreeding Bird Community Composition Results

Monthly absolute density (birds/ha) for each of the five categories of birds was estimated for each site. The highest density for ducks, American coots, combination, and grebes during the 1997-1998 season occurred in the month of November at Truscott Brine Lake. The highest density for geese occurred during December. During the 1998-1999 season, again November exhibited the highest density for ducks, American coots, and grebes. Goose densities were highest in November as well. Peak density for ducks at Area VIII took place during January of the 1997-1998 season and November of the 1998-1999 season. Geese and American coots were not seen during the winter counts at Area VIII. Ducks and coots were at their highest densities during the month of November at Freshwater Pond 1, during the 1997-1998 season. Peak densities for geese occurred during December. In the 1998-1999 season, American coot and grebe densities reached the highest point in November, and duck densities were similar throughout the sampling period. Freshwater Pond 2 had the highest duck densities during December and October in 1997-1998 and 1998-1999, respectively. Truscott Brine Lake exhibited the greatest estimated density of birds with the highest densities occurring in November of both seasons.

Nest Searching and Egg Collection Results

During the 1997 field season, a total of 7 great blue heron, 6 double-crested cormorant, and 12 red-winged blackbird nests was monitored at Truscott Brine Lake. Eight red-winged blackbird nests were monitored at the freshwater pond in 1997. During the 1998 field season, a total of 8 great blue heron, 11 double-crested cormorant, and 5 red-winged blackbird nests was monitored at the lake. Seven red-winged blackbird nests were monitored at the freshwater pond in 1998.

Mean egg weight of great blue heron eggs in 1997 was 61.44 grams and 69.03 grains in 1998. Double-crested cormorant eggs had a mean total egg weight of 43.33 g and 45.24 g in 1997 and 1998, respectively. At Truscott Brine Lake, red-winged blackbird total egg weights averaged 3.64 g in 1997 and 3.78 g in 1998. Red-winged blackbird total egg weights at the freshwater pond averaged 3.82 g in 1997 and 4.12 g in 1998.

Egg selenium levels of great blue herons found at Truscott Brine Lake ranged from 3.0 ppm to 18 ppm in 1997 and from 1.9 ppm to 8.8 ppm in 1998. Double-crested cormorant egg selenium levels ranged from 2.4 ppm to 18 ppm in 1997 and from 2.5 ppm to 9.4 ppm in 1998. Red-winged blackbird egg selenium levels from Truscott Brine Lake ranged from 2.1 ppm to 3.2 ppm in 1997 and from 2.3 ppm to 3.2 ppm in 1998. Egg selenium levels of red-winged blackbirds collected at the freshwater pond ranged from 2.0 ppm to 3.0 ppm in 1997 and from 2.0 ppm to 3.0 ppm again in 1998. All ranges are presented on a dry weight basis. Geometric mean egg selenium levels in 1997 were great blue heron = 5.8 ppm (dry weight), double-crested cormorant = 5.4 ppm, red-winged blackbirds at the lake = 2.8 ppm, red-winged blackbirds at the pond = 2.5 ppm. Geometric means in 1998 were as follows, herons = 3.7 ppm, cormorants = 4.9 ppm, redwings at the lake = 2.7 ppm, and redwings at the pond = 2.7 ppm. Of the 15 great blue heron eggs collected at Truscott Brine Lake over the two years of the study, 13% had selenium levels exceeding the threshold value of 10 ppm (dry weight) in eggs, and 8% of the 17 double-crested cormorant eggs exceeded the threshold. No red-winged blackbird eggs (n= 17) collected at Truscott Brine Lake had selenium levels exceeding the threshold value.

Reproductive Success Results

Nest success for the three target species was calculated for both 1997 and 1998. About 15% and 20% of great blue heron nests beginning incubation were expected to survive through the end of the nestling period in 1997 and 1998, respectively. In 1997, approximately 3% of double-crested cormorant nests were expected to survive. In 1998, the percentage increased to 61%. Nest survival of red-winged blackbirds at Truscott Brine Lake decreased from 39% in 1997 to only 4% in 1998. In contrast, nests of blackbirds at the freshwater pond had about 2% survival in 1997, but 17% survival in 1998. Daily survival estimates of piscivorous birds during incubation were higher (P <0.05) than insectivorous birds ($Z=2.60$). Daily survival estimates of double-crested cormorants and great blue herons during the nestling period were not different ($P < 0.05$) ($Z=0.611$). The red-winged blackbird's daily survival estimate during the nestling period was not compared to the others because the estimate was 1.00. No variance existed for this estimate; and therefore, the z-statistic could not be properly calculated.

Table 1.1: Taxonomical total species list at Truscott Brine Lake
for 1997 and 1998 combined.
(includes point count survey (P), winter inventory (W), and incidental sighting (1) data)

Taxonomical Class	Method Used to Sight Species
Accipitridae	
Mississippi Kite (Ictinia mississippiensis)	P
Northern Harrier (Circus cyaneus)	W
Osprey (Pandion haliaetus)	P,I
Red-tailed Hawk (Buteo jamaicensis)	P
Swainson's Hawk (Buteo swainsoni)	P
Alcedinidae	
Belted Kingfisher (Ceryle alcyon)	P
Anatidae	
American Wigeon (Anas americana)	W
Blue-winged Teal (Anas discors)	P,W
Bufflehead (Bucephala albeola)	W
Canada Goose (Branta canadensis)	W
Canvasback (Aythya valisineria)	P,W
Common Goldeneye (Bucephala clangula)	W
Gadwall (Anas strepera)	P,W
Greater Scaup (Aythya marila)	W
Greater White-fronted Goose (Anser albifrons)	W
Green-winged Teal (Anas crecca)	P,W
Hooded Merganser (Lophodytes cucullatus)	W
Lesser Scaup (Aythya affinis)	W
Mallard (Anas platyrhynchos)	P,W
Mute Swan (Cygnus olor)	P
Northern Pintail (Anas acuta)	W
Northern Shoveler (Anas clypeata)	P,W
Redhead (Aythya americana)	W
Ring-necked Duck (Aythya collaris)	W
Ruddy Duck (Oxyura jamaicensis)	P,W
Apodidae	
Chimney Swift (Chaetura pelagica)	P
Ardeidae	
Black-crowned Night Heron (Nycticorax nycticorax)	P
Cattle Egret (Bubulcus ibis)	P
Great Blue Heron (Ardea herodias)	P
Great Egret (Casmerodius albus)	P
Green-backed Heron (Butorides striatus)	P
Little Blue Heron (Egretta caerulea)	P,I
Snowy Egret (Egretta thula)	P

Table 1.1. Continued.

Taxonomical Class	Method Used to Sight Species
Caprimulgidae	
Common Nighthawk (Chordeiles minor)	P
Cathartidae	
Turkey Vulture (Cathartes aura)	P
Charadriidae	
Plover spp. (Charadrius)	P
Killdeer (Charadrius vociferus)	P
Columbidae	
Mourning Dove (Zenaida macroura)	P
Corvidae	
American Crow (Corvus brachyrhynchos)	P
Blue Jay (Cyanocitta cristata)	P
Cuculidae	
Greater Roadrunner (Geococcyx californianus)	P
Yellow-billed Cuckoo (Coccyzus americanus)	P
Emberizidae	
American Tree Sparrow (Spizella arborea)	P
Blue Grosbeak (Guiraca caerulea)	P,I
Brown-headed Cowbird (Molothrus ater)	P
Cassin's Sparrow (Aimophila cassinii)	P
Chipping Sparrow (Spizella passerina)	P
Common Grackle (Quiscalus quiscula)	I
Dark-eyed Junco (Junco hyemalis)	I
Eastern meadowlark (Sturnella magna)	P
Field Sparrow (Spizella pusilla)	P
Grasshopper Sparrow (Ammodramus savannarum)	P
Great-tailed Grackle (Quiscalus mexicanus)	P
Indigo Bunting (Passerina cyanea)	P
Lark Sparrow (Chondestes grammacus)	P
Northern Cardinal (Cardinalis cardinalis)	P
Northern Oriole (Bullock's) (Icterus galbula)	P
Painted Bunting (Passerina ciris)	P
Red-winged Blackbird (Agelaius phoeniceus)	P
Rufous-crowned Sparrow (Aimophila ruficeps)	P
Savanna Sparrow (Passerculus sandwichensis)	W
Unknown Sparrow spp.	P
Western Meadowlark (Sturnella neglecta)	I
White-crowned Sparrow (Zonotrichia leucophrys)	P

Table 1. 1: Continued.

Taxonomical Class	Method Used to Sight Species
<u>Emberizidae Continued</u>	
White-throated Sparrow (Zonotrichia albicollis)	P
Yellow Warbler (Dendroica petechia)	P
Yellow-headed Blackbird (Xanthocephalus xanthocephalus)	P
<u>Falconidae</u>	
American Kestrel (Falco sparverius)	P,I
<u>Fringillidae</u>	
American Goldfinch (Carduelis tristis)	
<u>Gaviidae</u>	
Common Loon (Gavia immer)	P,I
<u>Hirundinidae</u>	
Barn Swallow (Hirundo rustica)	
Tree Swallow (Tachycineta bicolor	P
<u>Laniidae</u>	
Loggerhead Shrike (Lanius ludovicianus)	I
<u>Laridae</u>	
Black Tern (Childonias niger)	
Laughing Gull (Larus atricilla)	P
Least Tern (Sterna antillarum)	P
<u>Mimidae</u>	
Northern Mockingbird (Mimus polyglottos)	P
<u>Pelecanidae</u>	
American White Pelican (Pelecanus erythrorhynchos)	P,I
<u>Phalacrocoracidae</u>	
Double-crested Cormorant (Phalacrocorax auritus)	P
<u>Phasianidae</u>	
Chukar (Alectoris chukar)	1*
Northern Bobwhite (Colinus virginianus)	P
Ring-necked Pheasant (Phasianus colchicus)	1*
Wild Turkey (Meleagris gallopavo)	P

NOTE: 1* = The USACE released these two species at the lake

Table 1.1: Continued.

Taxonomical Class	Method Used to Sight Species
<u>Picidae</u>	
Downy Woodpecker (Picoides pubescens)	
Golden-fronted Woodpecker (Melanerpes aurifrons)	P
Ladder-backed Woodpecker (Picoides scalaris)	P
Northern Flicker (Colaptes auratus)	P
Red-bellied Woodpecker (Melanerpes carolinus)	I
<u>Podicipedidae</u>	
Eared Grebe (Podiceps nigricollis)	P
Homed Grebe (Podiceps auritus)	I
Pied-billed Grebe (Podilymbus podiceps)	P
Western Grebe (Aechmophorus occidentalis)	P
<u>Rallidae</u>	
American Coot(Fulica americana)	P,W
Recurvirostridae	
American Avocet (Recurvirostra americana)	P
Black-necked Stilt (Himantopus mexicanus)	P,W
<u>Scolopacidae</u>	
Greater Yellowlegs (Tringa melanoleuca)	P,W
Least Sandpiper (Calidris minutilla)	P
Long-billed Curlew (Numenius americanus)	P
Long-billed Dowitcher (Limnodromus scolopaceus)	P
Sanderling (Calidris alba)	P
Spotted Sandpiper (Actitis macularia)	P
Upland Sandpiper (Bartramia longicauda)	P,I
Whimbrel (Numenius phaeopus)	P
<u>Strigidae</u>	
Great Horned Owl (Bubo virginianus)	P,I
<u>Threskiornithidae</u>	
White-faced Ibis (Plegadis chihi)	P
<u>Troglodytidae</u>	
Bewick's Wren (Thryornanes bewickii)	P
Carolina Wren (Thryothorus ludovicianus)	P
<u>Tyrannidae</u>	
Ash-throated Flycatcher (Myiarchus cinerascens)	P
Eastern Kingbird (Tyrannus tyrannus)	P
Eastern Phoebe (Sayornis phoebe)	P
Great-crested Flycatcher (Myiarchus crinitus)	P
Scissor-tailed Flycatcher (Tyrannus forficatus)	P
Western Kingbird (Tyrannus verticalis)	P

Table 1.2: Taxonomical total species list at Area VIll
for 1997 and 1998 combined.
(includes point count survey (P), winter inventory (W), and incidental sighting (1) data)

Taxonomical Class	Method Used to Sight Species
Alcedinidae	
Belted Kingfisher (Ceryle alcyon)	P
Anatidae	
American Wigeon (Anas americana)	W
Blue-winged Teal (Anas discors)	W,I
Common Goldeneye (Bucephala clangula)	W
Lesser Scaup (Aythya affinis)	W
Northern Shoveler (Anas clypeata)	W
Ring-necked Duck (Aythya collaris)	W,I
Ruddy Duck (Oxyura jamaicensis)	W
Ardeidae	
Great Blue Heron (Ardea herodias)	P
Green-backed Heron (Butorides striatus)	P
Snowy Egret (Egretta thula)	P
Caprimulgidae	
Common Nighthawk (Chordeiles minor)	P
Cathartidae	
Turkey Vulture (Cathartes aura)	P
Charadriidae	
Killdeer (Charadrius vociferus)	
Columbidae	
Mourning Dove (Zenaida macroura)	
Emberizidae	
American Tree Sparrow (Spizella arborea)	P
Brown-headed Cowbird (Molothrus ater)	P
Dark-eyed Junco (Junco hyemalis)	I
Eastern meadowlark (Sturnella magna)	P
Great-tailed Grackle (Quiscalus mexicanus)	P
Indigo Bunting (Passerina cyanea)	I
Lark Sparrow (Chondestes grammacus)	P
Northern Cardinal (Cardinalis cardinalis)	P
Northern Oriole (Bullock's) (Icterus galbula)	P
Red-winged Blackbird (Agelaius phoeniceus)	P
Unknown Sparrow spp.	P
Mimidae	
Northern Mockingbird (Mimus polyglottos)	P

Table 1.2: Continued.

Taxonomical Class	Method Used to Sight Species
<u>Paridae</u>	
Tufted Titmouse (Parus bicolor)	P
<u>Phalacrocoracidae</u>	
Double-crested Cormorant (Phalacrocorax auritus)	
<u>Phasianidae</u>	
Northern Bobwhite (Colinus virginianus)	P
<u>Picidae</u>	
Golden-fronted Woodpecker (Melanerpes aurifrons)	P
<u>Podicipedidae</u>	
Eared Grebe (Podiceps nigricollis)	W
<u>Scolopacidae</u>	
Greater Yellowlegs (Tringa melanoleuca)	P
<u>Troglodytidae</u>	
Bewick's Wren (Thryornanes bewickii)	P
<u>Tyrannidae</u>	
Ash-throated Flycatcher (Myiarchus cinerascens)	P
Scissor-tailed Flycatcher (Tyrannus forficatus)	P

Table 1.3: Taxonomical total species list at the freshwater ponds
for 1997 and 1998 combined.
(includes point count survey (P), winter inventory (W), and incidental sighting (I) data)

Taxonomical Class	Method Used to Sight Species
Accipitridae	
Osprey (Pandion haliaetus)	I
Alcedinidae	
Belted Kingfisher (Ceryle alcyon)	P
Anatidae	
American Wigeon (Anas americana)	W
Blue-winged Teal (Anas discors)	P,W
Bufflehead (Bucephala albeola)	W
Canada Goose (Branta canadensis)	W
Canvasback (Aythya vallsineria)	W
Gadwall (Anas strepera)	W
Green-winged Teal (Anas crecca)	P,W
Hooded Merganser (Lophodytes cucullatus)	W
Lesser Scaup (Aythya affinis)	W
Mallard (Anas platyrhynchos)	P,W
Mute Swan (Cygnus olor)	I
Northern Pintail (Anas acuta)	W
Northern Shoveler (Anas clypeata)	W
Redhead (Aythya americana)	W
Ring-necked Duck (Aythya collaris)	W
Ruddy Duck (Oxyura jamaicensis)	P,W
Ardeidae	
Black-crowned Night Heron (Nycticorax nycticorax)	P
Cattle Egret (Bubulcus ibis)	P
Great Blue Heron (Ardea herodias)	P
Great Egret (Casmerodius albus)	P
Green-backed Heron (Butorides striatus)	P
Little Blue Heron (Egretta caerulea)	P
Snowy Egret (Egretta thula)	P
Caprimulgidae	
Common Nighthawk (Chordeiles minor)	P
Cathartidae	
Turkey Vulture (Cathartes aura)	P
Charadriidae	
Killdeer (Charadrius vociferus)	P
Columbidae	
Mourning Dove (Zenaida macroura)	P

Table 1.3: Continued.

Taxonomical Class	Method Used to Sight Species
Corvidae	
American Crow (Corvus brachyrhynchos)	P
Cuculidae	
Greater Roadrunner (Geococcyx californianus)	P
Yellow-billed Cuckoo (Coccyzus americanus)	P
Emberizidae	
American Tree Sparrow (Spizella arborea)	I
Brown-headed Cowbird (Molothrus ater)	P
Cassin's Sparrow (Aimophila cassinii)	P
Chipping Sparrow (Spizella passerina)	I
Common Grackle (Quiscalus quiscula)	I
Eastern meadowlark (Sturnella magna)	P
Great-tailed Grackle (Quiscalus mexicanus)	P
Lark Sparrow (Chondestes grammacus)	P
Northern Cardinal (Cardinalis cardinalis)	P
Northern Oriole (Bullock's) (Icterus galbula)	I
Red-winged Blackbird (Agelaius phoeniceus)	P
Yellow-headed Blackbird (Xanthocephalus xanthocephalus)	P
Yellow-rumped Warbler (Dendroica coronata)	P
Hirundinidae	
Tree Swallow (Tachycineta bicolor)	P
Laniidae	
Loggerhead Shrike (Lanius ludovicianus)	I
Laridae	
Laughing Gull (Larus atricilla)	I
Mimidae	
Northern Mockingbird (Mimus polyglottos)	P

Table 1.3: Continued.

Taxonomical Class	Method Used to Sight Species
Pelecanidae	
American White Pelican (Pelecanus erythrorhynchos)	
Phalacrocoracidae	
Double-crested Cormorant (Phalacrocorax auritus)	P
Phasianidae	
Northern Bobwhite (Colinus virginianus)	P
Picidae	
Ladder-backed Woodpecker (Picoides scalaris)	P
Podicipedidae	
Eared Grebe (Podiceps nigricollis)	P
Pied-billed Grebe (Podilymbus podiceps)	P
Rallidae	
American Coot (Fulica americana)	P,W
Recurvirostridae	
American Avocet (Recurvirostra americana)	P
Black-necked Stilt (Himantopus mexicanus)	P
Scolopacidae	
Greater Yellowlegs (Tringa melanoleuca)	P
Spotted Sandpiper (Actitis macularia)	P
Threskiornithidae	
White-faced Ibis (Plegadis chihi)	P
Troglodytidae	
Bewick's Wren (Thryomanes bewickii)	P
Tyrannidae	
Ash-throated Flycatcher (Myiarchus cinerascens)	P
Scissor-tailed Flycatcher (Tyrannus forficatus)	P

Table 1.4. Monthly species richness estimated from point count survey data at three sites in the Texas rolling plains for both 1997 and 1998.

Site	April[a]	May[b]	June	July	August
Truscott Brine Lake					
1997	NA	40	31	35	37
1998	52	45	39	44	43
Freshwater Ponds					
1997	NA	NA	12	17	12
1998	17	20	20	22	21
Area VIII					
1997	NA	9	10	7	7
1998	11	13	9	9	10

[a] = Point Count Surveys were not conducted in April 1997
[b] = Point Count Surveys were not conducted at the Freshwater Ponds in May 1997

Table 1.5. Monthly diversity estimates calculated from point count survey data at four sites in the Texas rolling plains for both 1997 and 1998.

Site	April[a]	May[b]	June	July	August
Truscott Brine Lake					
1997	NA	0.9403	0.9449	0.8272	0.8853
1998	0.9399	0.9443	0.9433	0.9167	0.8479
Freshwater Pond 1					
1997	NA	NA	0.8739	0.9096	0.8032
1998	0.8966	0.8626	0.2076	0.6267	0.5905
Freshwater Pond 2[c]					
1997	NA	NA	NA	NA	NA
1998	0.9000	0.9109	0.88822	0.5157	0.7925
Area VIll					
1997	NA	0.9053	0.9033	0.8497	0.8462
1998	0.9239	0.9032	0.8581	0.9191	0.7230

[a] = Diversity was not calculated in April 1997
[b] = Diversity was not calculated for Freshwater Pond 1 in May 1997
[c] = Diversity was not calculated for Freshwater Pond 2 in 1997

Table 1.6. Average abundance estimates from point count survey data for Truscott Brine Lake in 1997.

Species	Average Abundance	Species	Average Abundance
American Coot	0.05	Mourning Dove	2.275
American Crow	0.6375	Mute Swan	0.0125
Ash-throated Flycatcher	0.25	Northern Bobwhite	0.8
Belted Kingfisher	0.075	Northern Cardinal	0.9
Bewick's Wren	1,3625	Northern Mockingbird	1.2375
Black-crowned Night Heron	0.0375	Northern Oriole (Bullock's)	0.025
Blue-winged Teal	0.6	Northern Shoveler	0.025
Brown-headed Cowbird	0.375	Painted Bunting	0.0125
Cassin's Sparrow	0.0125	Pied-billed Grebe	0.175
Cattle Egret	5.325	Plover Spp.	0.1125
Chimney Swift	0.0125	Red-winged Blackbird	1.7
Common Loon	0.0375	Scissor-tailed Flycatcher	0.8625
Common Nighthawk	0.5625	Snowy Egret	0.45
Double-crested Cormorant	1.475	Swainson's Hawk	0.025
Eared Grebe	0.2375	Tree Swallow	0.4875
Eastern Kingbird	0.025	Turkey Vulture	0.3875
Eastern Meadowlark	0.9875	Western Kingbird	0.0125
Gadwall	0.3	White-faced Ibis	0.0125
Golden Fronted Woodpecker	0.125	Yellow-billed Cuckoo	0.0375
Grasshopper Sparrow	0.0375	Yellow-headed Blackbird	0.125
Great Blue Heron	0.75		
Great Egret	1.05		
Great Horned Owl	0.0125		
Great-crested Flycatcher	0.0125		
Greater Roadrunner	0.2		
Greater Yellowlegs	0.9125		
Great-tailed Grackle	0.2		
Green-backed Heron	0.15		
Killdeer	- 0.9		
Ladder-backed Woodpecker	0.0125		
Lark Sparrow	0.475		
Laughing Gull	0.05		
Least Tern	0.0125		
Long-billed Curlew	0.05		
Mallard	1.9625		
Mississippi Kite	0.025		
Mourning Dove	2.275		
Mute Swan	0.0125		
Northern Bobwhite	0.8		
Northern Cardinal	0.9		

Table 1.7. Average abundance estimates from point count survey data for Truscott Brine Lake in 1998.

Species	Average Abundance	Species	Average Abundance
American Avocet	0.13	Ladder-backed Woodpecker	0.06
American Coot	0.68	Lark Sparrow	0.71
American Crow	0.32	Laughing Gull	0.86
American Kestrel	0.01	Least Tern	0.14
American Tree Sparrow	0.17	Least Sandpiper	0.6
American White Pelican	0.2	Little Blue Heron	0.24
Ash-throated Flycatcher	0.09	Long-billed Dowitcher	0.11
Barn Swallow	0.03	Mallard	4.84
Belted Kingfisher	0.19	Mourning Dove	3.03
Bewick's Wren	1.24	Northern Bobwhite	0.95
Black-crowned Night Heron	0.02	Northern Cardinal	0.62
Black-necked Stilt	0.14	Northern Flicker	0.01
Blue Grosbeak	0.02	Northern Mockingbird	1.23
Blue Jay	0.04	Northern Oriole (Bullock's)	0.01
Blue-winged Teal	3.76	Northern Shoveler	0.17
Brown-headed Cowbird	0.55	Osprey	0.01
Canvasback	0.03	Painted Bunting	0.02
Carolina Wren	0.02	Pied-billed Grebe	0.25
Cassin's Sparrow	0.28	Red-tailed Hawk	0.01
Cattle Egret	3.41	Red-winged Blackbird	3.32
Chipping Sparrow	0.01	Ruddy Duck	0.01
Common Loon	0.04	Rufous-crowned Sparrow	0.08
Common Nighthawk	0.48	Sanderling	0.19
Double-crested Cormorant	2.11	Scissor-tailed Flycatcher	0.82
Eared Grebe	0.83	Snowy Egret	1.41
Eastern Meadowlark	0.8	Spotted Sandpiper	0.01
Eastern Phoebe	0.01	Swainson's Hawk	0.03
Field Sparrow	0.02	Tree Swallow	1.7
Gadwall	0.01	Turkey Vulture	0.14
Golden Fronted Woodpecker	0.08	Unknown Sparrow Spp.	0.01
Great Blue Heron	0.89	Upland Sandpiper	0.01
Great Egret	1.59	Western Grebe	0.03
Great Horned Owl	0.01	Whimbrel	0.07
Great-crested Flycatcher	0.03	White-crowned Sparrow	0.04
Greater Roadrunner	0.12	White-faced Ibis	0.21
Greater Yellowlegs	0.34	White-throated Sparrow	0.02
Great-tailed Grackle	0.57	Wild Turkey	0.05
Green-backed Heron	0.12	Yellow Warbler	0.01
Green-winged Teal	0.01	Yellow-billed Cuckoo	0.12
Indigo Bunting	0.01		
Killdeer	0.76		

Table 1.8. Average abundance estimates from point count survey data for Area VIII in both 1997 and 1998.

1997		1998	
Species	Average Abundance	Species	Average Abundance
Ash-throated Flycatcher	2.0	American Tree Sparrow	0.4
Belted Kingfisher	0.5	Ash-throated Flycatcher	0.6
Bewick's Wren	2.75	Belted Kingfisher	0.6
Common Nighthawk	1.0	Bewick's Wren	3.0
Green-backed Heron	0.75	Brown-headed Cowbird	0.2
Killdeer	0.5	Canyon Wren	0.4
Mourning Dove	3.25	Eastern Meadowlark	0.4
Northern Bobwhite	0.25	Golden-fronted Woodpecker	0.2
Northern Cardinal	1.5	Great Blue Heron	0.6
Northern Mockingbird	2.25	Greater Yellowlegs	0.8
Red-winged Blackbird	1.0	Great-tailed Grackle	3.4
Scissor-tailed Flycatcher	2.5	Green-backed Heron	0.2
Tufted Titmouse	0.5	Killdeer	0.4
Turkey Vulture	0.25	Lark Sparrow	0.2
		Mourning Dove	3.6
		Northern Bobwhite	1.4
		Northern Cardinal	1.4
		Northern Mockingbird	1.6
		Northern Oriole (Bullock's)	0.6
		Scissor-tailed Flycatcher	2.4
		Snowy Egret	0.4
		Turkey Vulture	6.4
		Unknown Sparrow Spp.	0.2

Table 1.9. Average abundance estimates from point count survey data for Freshwater Pond 1 in both 1997 and 1998.

1997		1998	
Species	Average Abundance	Species	Average Abundance
American Crow	0.33	American Avocet	1.6
Ash-throated Flycatcher	0.33	American Coot	3.2
Belted Kingfisher	1.67	Belted Kingfisher	1.2
Bewick's Wren	1.33	Bewick's Wren	0.4
Blue-winged Teal	4.67	Blue-winged Teal	11.2
Brown-headed Cowbird	2.33	Cassin's Sparrow	0.4
Cattle Egret	0.67	Cattle Egret	1.8
Common Nighthawk	0.33	Common Nighthawk	0.2
Double-crested Cormorant	0.67	Double-crested Cormorant	0.4
Eastern Meadowlark	0.67	Eared Grebe	0.2
Great Blue Heron	0.33	Eastern Meadowlark	0.4
Great Egret	0.33	Great Blue Heron	0.2
Great-tailed Grackle	1.33	Great Egret	1.4
Green-backed Heron	0.67	Greater Roadrunner	1.2
Lark Sparrow	3.67	Greater Yellowlegs	0.2
Mallard	0.67	Green-backed Heron	0.2
Mourning Dove	9.67	Green-winged Teal	1.2
Northern Bobwhite	3.0	Killdeer	1.4
Northern Cardinal	1.0	Lark Sparrow	0.4
Northern Mockingbird	1.33	Mallard	0.8
Pied-billed Grebe	0.33	Mourning Dove	18.6
Red-winged Blackbird	6.0	Northern Bobwhite	1.6
Ruddy Duck	0.33	Northern Cardinal	1.0
Scissor-tailed Flycatcher	1.67	Northern Mockingbird	0.4
Tree Swallow	0.67	Pied-billed Grebe	1.0
Yellow-billed Cuckoo	0.33	Red-winged Blackbird	9.6
		Ruddy Duck	3.4
		Scissor-tailed Flycatcher	1.8
		Spotted Sandpiper	0.8
		Tree Swallow	56.8
		Yellow-billed Cuckoo	0.8
		Yellow-headed Blackbird	0.4
		Yellow-rumped Warbler	0.4

Table 1.10. Average abundance estimates from point count survey data for Freshwater Pond 2 in 1998.

Species	Average Abundance
American Crow	0.2
American Coot	0.6
Belted Kingfisher	0.6
Bewick's Wren	2.4
Black-crowned Night Heron	0.4
Black-necked Stilt	0.4
Blue-winged Teal	9.0
Brown-headed Cowbird	0.4
Eared Grebe	0.2
Eastern Meadowlark	0.4
Great Blue Heron	0.2
Great Egret	1.6
Greater Roadrunner	0.4
Greater Yellowlegs	1.0
Great-tailed Grackle	0.8
Green-backed Heron	1.4
Killdeer	2.4
Ladder-backed Woodpecker	0.2
Lark Sparrow	1.4
Little Blue Heron	1.4
Mallard	7.0
Mourning Dove	21.0
Northern Bobwhite	0.8
Northern Cardinal	1.6
Northern Mockingbird	0.6
Pied-billed Grebe	0.2
Red-winged Blackbird	7.6
Scissor-tailed Flycatcher	0.6
Snowy Egret	0.4
Tree Swallow	2.2
Turkey Vulture	1.8
White-faced Ibis	3.0
Yellow-billed Cuckoo	0.2

Table 1.11. Monthly nonbreeding bird densities (birds/ha) at Truscott Brine Lake for both the 1997-1998 and 1998-1999 seasons.

1997-1998 Season:

Month	Ducks	Coots	Combo.	Geese	Grebes
November	0.386	4.376	4.271	0.076	0.018
December	0.113	1.182	2.114	2.647	0.0024
January	0.084	0.837	0.708	2.171	0.015
February	0.190	1.217	0.845	0.205	0.0088

1998-1999 Season:

Month	Ducks	Coots	Geese	Grebes
October	0.837	10.536	0	0.053
November	1.076	12.311	0.0040	0.057

Table 1.12. Monthly nonbreeding bird densities (birds/ha) at Area VIll for both the 1997-1998 and 1998-1999 seasons.

1997-1998 Season:

Month	Ducks	Grebes
November	0	0.8
December	0	0
January	2.8	0
February	1.4	0

1998-1999 Season:

Month	Ducks	Grebes
October	0	0.4
November	2.0	0.4

Table 1.13. Monthly nonbreeding bird densities (birds/ha) at Freshwater Pond 1 for both the 1997-1998 and 1998-1999 seasons.

1997-1998 Season:

Month	Ducks	Coots	Combo.	Geese	Grebes
November	5.37	5.07	0	0	0.049
December	0.195	2.61	1.22	17.80	0.024
January	4.15	1.54	0	0	0
February	1.00	1.85	0	2.71	0.012

1998-1999 Season:

Month	Ducks	Coots	Grebes
October	0.902	1.66	0.049
November	0.854	4.27	0.512

Table 1.14. Monthly nonbreeding bird densities (birds/ha) at Freshwater Pond 2 for both the 1997-1998 and 1998-1999 seasons.

1997-1998 Season:

Month	Ducks	Coots
November	0	0
December	3.0	2.0
January	0.93	2.27
February	2.4	1.6

1998-1999 Season:

Month	Ducks	Coots
October	1.8	0.53
November	1.0	0.93

Table l.15. Monthly total nonbreeding bird densities (birds/ha) at four sites in the Texas Rolling Plains for both the 1997-1998 and 1998-1999 seasons.

Site	October	November	December	January	February
Truscott Brine Lake					
1997-1998	NA[a]	9.127	6.059	3.815	2.465
1998-1999	11.425	13.504	NA[b]	NA[b]	NA[b]
Freshwater Pond 1					
1997-1998	NA[a]	10.488	21.854	5.683	5.683
1998-1999	2.609	5.634	NA[b]	NA[b]	NA[b]
Freshwater Pond 2					
1997-1998	NA[a]	0	5.0	3.2	4.0
1998-1999	2.333	1.933	NA[b]	NA[b]	NA[b]
Area VIII					
1997-1998	NA[a]	0.8	0	2.8	1.4
1998-1999	0.4	2.4	NA[b]	NA[b]	NA[b]

[a] = Nonbreeding bird counts were not conducted in October of the 1997-1998 season.
[b] = Nonbreeding bird counts were conducted only in October and November of the 1998-1999 season.

Table 1.16. Physical measurements of great blue heron eggs collected at Truscott Brine Lake for both 1997 and 1998.

1997

Measurement	Identification Label 1	2	3	4	5	6	7
# eggs/nest	2	2	3	3	4	3	2
Egg Length (cm)	6.3	5.98	6.45	6.24	6.63	6.15	6.24
Egg Width (cm)	4.52	4.43	4.38	4.4	4.62	4.43	4.47
Total Egg Weight (g)	62.79	46.49	60.69	61.3	75.17	61.37	62.29
Jar Weight (g)	117.95	130.86	127.14	129.38	118.88	119.41	119.45
Jar with Contents (g)	174.42	171.42	181.05	184.4	182.33	173.75	174.19
Contents Weight (g)	56.47	40.56	53.91	55.02	63.45	54.34	54.74
Shell Weight (g)	6.32	5.93	6.78	6.28	11.72	7.03	7.55

1998

Measurement	Identification Label A	B	C	D	E	F	G	5
# eggs/nest	4	5	4	4	4	3	4	3
Egg Length (cm)	6.77	6.6	6.51	6.27	6.64	6.67	6.5	6.371
Egg Width (cm)	4.89	4.62	4.52	4.51	4.68	4.57	4.93	4.284
Total Egg Weight (g)	82.66	67.65	64.95	63.02	68.51	67.3	80.52	57.66
Jar Weight (g)	118.61	119.86	126.04	127.99	128.39	125.56	127.19	113.41
Jar with Contents (g)	192.79	178.72	183.53	183.9	187.86	185.32	198.51	165.3
Contents Weight (g)	74.18	58.86	57.49	55.91	59.47	59.76	71.32	51.89
Shell Weight (a)	8.48	8.79	7.46	7.11	9.04	7.54	9.2	5-77

Table 1.17. Physical measurements of double-crested cormorant eggs collected at Truscott Brine Lake in both 1997 and 1998.

1997

	Identification Label					
Measurement	1	2	3	4	5	6
# eggs/nest4	2	4	4	3	4	
Egg Length (cm)	5.96	5.48	5.45	6.24	6.42	5.82
Egg Width (cm)	3.85	3.85	3.74	3.96	3.63	3.78
Total Egg Weight (g)	43.04	42.13	37.12	49.33	43.53	44.83
Jar Weight (g)	90.04	88.72	86.93	88.86	88.63	87.88
Jar with Contents (g)	128.07	124.48	117.54	130.25	126.22	126.56
Contents Weight (g)	38.03	35.76	30.61	41.39	37.59	38.68
Shell Weight (g)	5.01	6.37	6.51	7.94	5.94	6.15

1998

	Identification Label						
Measurement	1	2	3	4	6	G1	G2
# eggs/nest	4	4	4	4	4	2	2
Egg Length (cm)	6.174	6.276	6.16	5.778	6.182	6.34	5.92
Egg Width (cm)	3.784	3.918	3.86	3.852	3.875	3.77	3.73
Total Egg Weight (g)	42.9	51.33	44.54	44.03	48.8	43.62	41.45
Jar Weight (g)	113.34	113.38	112.74	113.1	113.06	118.52	119.6
Jar with Contents (g)	151.49	157.6	150.41	149.08	155.79	155.46	155.85
Contents Weight (g)	38.15	44.22	37.67	35.98	42.73	36.94	36.25
Shell Weight (g)	4.75	7.11	6.87	8.05	6.07	6.68	5.2

Table 1.18. Physical measurements of red-winged blackbird eggs collected at Truscott Brine Lake in both 1997 and 1998.

1997

	Identification Label											
Measurement	1	2	3	4	5	6	7	8	9	10	11	12
eggs/nest	1	4	4	2	4	4	4	4	1	4	1	2
Egg Length (cm)	2.43	2.42	2.6	2.36	2.46	2.46	2.37	2.15	2.33	2.26	2.55	2.49
Egg Width (cm)	1.87	1.73	1.83	1.7	1.68	1.77	1.77	1.62	1.82	1.83	1.8	1.67
Total Egg Weight (g)	4.26	3.68	4.24	3.37	3.41	3.78	3.96	3.12	2.93	3.72	3.67	3.57
Jar Weight (g)	88.01	88.15	88.74	86.99	87.28	88.8	89.4	87.21	87.37	87.75	88.26	131.22
Jar with Contents (g)	91.84	91.33	92.54	89.65	90.41	91.19	92.08	89.79	89.71	91.15	91.52	134.41
Contents Weight (g)	3.83	3.18	3.8	2.66	3.13	2.39	2.68	2.58	2.34	3.4	3.26	3.19
Shell Weight (g)	0.43	0.5	0.44	0.71	0.28	1.39	1.28	0.54	0.59	0.32	0.41	0.38

1998

	Identification Label				
Measurement	A	B	J	K	L
eggs/nest	4	4	3	1	1
Egg Length (cm)	2.38	2.37	2.59	2.41	2.37
Egg Width (cm)	1.85	1.68	1.79	1.77	1.9
Total Egg Weight (g)	4.33	3.47	3.76	2.74	4.59
Jar Weight (g)	121.72	121.62	118.13	119.74	121.99
Jar with Contents (g)	125.76	124.8	120.61	121.91	125.73
Contents Weight (g)	4.04	3.18	2.48	2.17	3.74
Shell Weight (g)	0.29	0.29	1.28	0.57	0.85

Table 1.19. Physical measurements of red-winged blackbird eggs collected at the freshwater pond in both 1997 and 1998.

1997

	Identification Label							
Measurement	1	2	3	4	5	6	7	8
# eggs/nest	2	2	4	1	4	4	4	3
Egg Length (cm)	2.5	2.49	2.49	2.42	2.38	2.55	2.29	2.53
Egg Width (cm)	1.79	1.79	1.82	1.76	1.68	1.91	1.72	1.8
Total Egg Weight (g)	4.28	3.92	3.87	2.36	3.61	4.6	3.67	4.27
Jar Weight (g)	88.08	118.65	119.56	127	120.66	118.56	118.42	130.68
Jar with Contents (g)	91.76	121.74	122.6	128.93	123.93	122.77	121.53	134.39
Contents Weight (g)	3.68	3.09	3.04	1.93	3.27	4.21	3.11	3.71
Shell Weight (g)	0.6	0.83	0.83	0.43	0.34	0.39	0.56	0.56

1998

	Identification Label						
Measurement	C	D	E	F	G	H	I
# eggs/nest	3	4	4	1	2	2	2
Egg Length (cm)	2.39	2.41	2.44	2.57	2.45	2.47	2.8
Egg Width (cm)	1.87	1.86	1.7	1.76	1.84	1.76	1.76
Total Egg Weight (g)	4.4	4.45	3.49	4.16	4.3	3.91	4.13
Jar Weight (g)	121.7	122.07	121.29	122.01	122.52	121.77	121.8
Jar with Contents (g)	125.78	126.19	124.44	125.15	126.14	125.37	125.58
Contents Weight (g)	4.08	4.12	3.15	3.14	3.62	3.6	3.78
Shell Weight (g)	0.32	0.33	0.34	1.02	0.68	0.31	0.35

Table 1.20. Mean egg selenium levels (wet weight) from three species at Truscott Brine Lake, Texas.

Species	Mean Egg Selenium (ppm)	Standard Error
Great Blue Heron	1.079 a [1/]	0.1722
Double-crested Cormorant	1.005 a	0.1851
Red-winged Blackbird	0.4773 b	0.1771

I/ Means followed by the same lower case letter are not different (*P*>0.05).

Table 1.21. Daily survival estimates for three target species monitored in both the 1997 and 1998 breeding seasons.

	Number of Nests	Failures during Incubation	Failures during Nestling	Exposure Days of Incubation	Exposure Days of Nestling	Daily [3] Survival Estimate - Incubation	Daily [3] Survival Estimate - Nestling	Survival for Entire Period
Great Blue Heron [1]								
1997	7	3	1	60.5	122	0.9504 ± 0.0008	0.9918 ± 0.00007	0.1494
1998	8	2	3	83	192.5	0.9759 ± 0.0003	0.9844 ± 0.00008	0.2031
Double-crested Cormorant [1]								
1997	6	2	3	49.5	48	0.9596 ± 0.0008	0.9375	0.0265
1998	11	3	0	163	264	0.9816 ± 0.0001	1.0000 [4]	0.6056
Red-winged Blackbird [1]								
1997	12	7	0	86	53	0.9186 ± 0.0009 [5]	1.0000	0.3930
1998	5	4	0	16	12	0.7500 ± 0.0117	1.0000	0.0422
Red-winged Blackbird [2]								
1997	8	5	2	38	13	0.8684± 0.003	0.8462 ± 0.010	0.0241
1998	7	3	2	52	24	0.9423± 0.001	0.9167 ± 0.003	0.1678

[1] Data for birds monitored at Truscott Brine Lake. [2] Data for birds monitored at the Freshwater Pond.
[3] All comparisons of daily survival estimates between years within a species and a period are not different at $\alpha = 0.05$.
[4] Comparisons were not made when at least one daily survival estimate equaled 1.0000 because a variance could not be established.
[5] All comparisons of red-winged blackbird daily survival estimates between sites within a year are not different at $\alpha = 0.05$.

Table 1.22. Daily survival estimates combined over two years for three target species at Truscott Brine Lake.

Species	Daily Survival Estimate Incubation	Daily Survival Estimate Nestling
Great Blue Heron	0.9652 ± 0.0002a [1/]	0.9873 ± 0.00004a
Double-crested Cormorant	0.9765 ± 0.0001 a	0.9904 ± 0.00003a
Red-winged Blackbird	0.8922 ± 0.0009b	1.0000 [2/]

1/ All comparisons of daily survival estimates between species within a period followed by the same lower case letter are not different at α=0.05.
2/ Daily survival estimate not compared to others within the period because a variance could not be established and therefore a z-statistic could not be properly calculated.

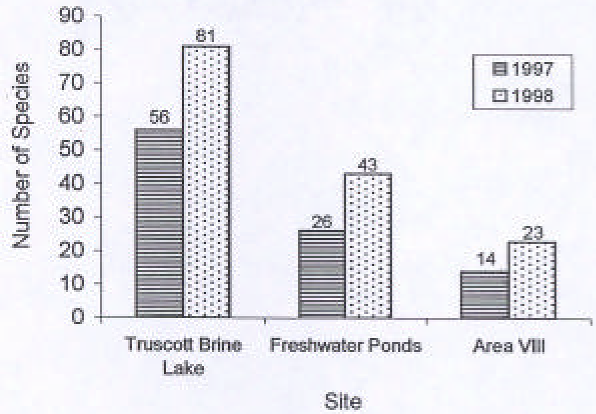

Figure 1.1 Yearly Species Richness from point count survey data at Three Sites in the Texas Rolling Plains

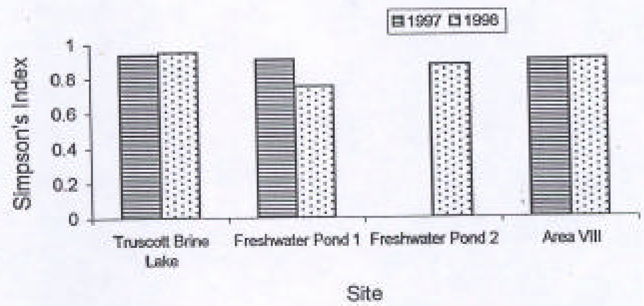

Figure 1.2. Yearly Diversity Calculated from Point Count Survey Data at Four Sites in the Texas Rolling Plains

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The Agriculture Program
THE TEXAS A&M UNIVERSITY SYSTEM

The Blackland Research and Extension Center
April 6, 2001

MEMO

FROM: C. H. Walker

TO: James C. Randolph

SUBJECT: HASTY ESTIMATES OF CHANGES IN AVERAGE ANNUAL VALUES FOR NITROGEN AND PHOSPHOROUS IN THE WICHITA RIVER BELOW WICHITA FALLS DUE TO PROPOSED EXPANSION OF IRRIGATED ALFALFA RELATED TO WICHITA-RED RIVER CHLORIDE CONTROL PROJECT

Attached are some files that document the estimates I have made regarding the impacts of increasing the irrigated area in the Wichita River valley below Lake Kemp from about 12,000 acres of irrigated bermuda hay now to about 57,520 acres of irrigated alalfa in 2015 under Plan 3.

The summary of the results are found in the upper table in the EXCEL worksheet titled "N and P Effects Worksheet." The other files provide supporting documentation for this worksheet.

If we were to make estimates for Plan 5, the only important difference would be that the water yield from the watershed would be decreased by the amount of water pumped from Site X. This would slightly increase the estimates of concentrations of Nitrogen and Phosphorous. If you need this estimate, you can plug in the average Site X water pumpout rates into the upper table in the worksheet titled "N and P effects worksheet."

DISCLAIMERS:

The accuracy of the results is affected by the limited accuracy of the available water quality data. As the charts in the worksheet titled "Historic data on N and P in Wichita River near Charlie" reveal, there is considerable scatter in the correlation of N and P concentrations and water flows at that gage. Yet this gage is the only one in the area for which this kind of correlation provides any meaningful relationship.

The accuracy of the results is also affected by the generalized simplified assumptions made regarding the relationships of the expected nutrient discharges from fields of dry and irrigated bermuda and of irrigated alfalfa and the fate of those discharges as they are transported from the fields to the river.

In general, a mass balance concept has been used. This concept presumes that eventually the nutrients discharged in surface and groundwater from the irrigated fields will all be transported into the river. The effects of local wetlands on this transport regime has not been estimated. A more sophisticated modeling approach **might** predict the timing and frequency of the nitrogen and phosphorous discharges and concentrations more accurately.

The estimates provided are only for average annual conditions. There will be considerable variations from these estimates depending on the fluctuations of water flows, water extractions by the crops, and nutrient discharges during the year. It is certain, for example, that high concentrations during periods of low flows will increase dramatically more than the ratio between future average concentration levels to present average concentration levels would suggest.

Furthermore, it is certain that such a large expansion of irrigated area would cause complete dewatering of the Wichita River near Charlie for significant periods of time when water supplies are low and water extraction rates by alfalfa are highest in June, July, August, and September.

Again, it would take a much more sophisticated modeling approach to develop reasonably reliable estimates of the potential fluctuations water flow and of concentrations of N and P.

BRIEF DESCRIPTION OF PROCEDURES:

1. Water quality data were downloaded from the US Geological Survey's NWIS web sites for gages near the study area in Texas and Oklahoma. These data were examined for evidence of relationships between water flow rates and concentrations of total elemental nitrogen and phosphorous. The original data are in the folder titled "USGS nutrient water quality data". Only the record for the gage on the Wichita River near Charlie revealed a meaningful correlation between flow rates and concentrations of nitrogen and phosphorous for any significant length of time. The charts showing the curves and equations for these relationships for that gage are found in the file titled "Historic data on N and P in the Wichita River near Charlie.xls"
2. The nitrogen and phosphorous correlation equations derived for the gage near Charlie in step 1 were used with the flow records for that gage from October 1967 through December 1998 to estimate daily concentrations and discharges of nitrogen and phosphorous at that gage for that period. These results are found in the file titled "Estimated present disch and conc N and P Wichita River nr Charlie.xls"
3. The current actual irrigated acreage was assumed to be about 12,000 acres of bermuda grass/hay. This latter acreage corresponds approximately with irrigated acre reports from the Texas Water Development Board and the local irrigation district water delivery contracts for recent years. Under current conditions, there is very little irrigation of any grain or row crops

in the area. Table 13 on page 16 of the report titled "Analysis of the Wichita Portion of the Red River Chloride Control Project – Economic Analysis, September 15, 2000 was examined to find the predicted changes in crop acreages for the 5 plans for the years 2005 and 2015. This table (and the supporting narrative) shows that the significant predicted changes are from dry and irrigated pasture (mainly in bermuda) to irrigated alfalfa.

4. The EPIC model, version 8120, was used to simulate the culture of dry and irrigated bermuda hay and alfalfa in the lower Wichita Falls area on a representative soil (Deandale) in the area. This model was run for a 40-year simulation of crop growth and yields, fertilizer applications, erosion rates, water runoff and percolation, and discharges of nitrogen and phosphorous from the surface and through groundwater. A general description of the EPIC model is found at www.brc.tamus.edu/epic/index.html. The relevant output files from these model runs are found in three files for which the phrase "EPIC model results" is included in the titles.
5. The EXCEL worksheet titled "N and P effects worksheet.xls" was created to assemble the summary information from the other files listed above and to compute the changes in nitrogen and phosphorous loadings and concentrations in the Wichita River near Charlie that are estimated to be the result of installing Plan 3 and increasing the irrigated area from about 12,000 acres of bermuda grass/hay to more than 57,500 acres of irrigated alfalfa.

HASTY ESTIMATE OF NUTRIENT CONCENTRATION CHANGES IN WICHITA RIVER BELOW WICHITA FALLS DUE TO PLAN 3 PROPOSED WICHITA RIVER CHLORIDE CONTROL PROJECT

TAMU-BREC CHW:4/6/2001

Estimated Present and Proposed Future Concentrations of Nitrogen and Phosphorous in Wichita River near Charlie

Gage Station	Description For Wichita River near Charlie	Mean Daily Water Flow CFS	Equiv Mean Annual Water Yield M^3/Yr	Est. Mean Discharge N Kg/Yr	Est. Mean Discharge P Kg/Yr
7312700	Plan 1 and 2 (Current) Average 1967-1998	364.66	325872480	464,324	137,334
	Long term historic average N&P concentrations:			**1.42** mg/l	**0.42** mg/l
	Change in watershed water yield due to pumping to Brine Lake - Plan 3	-10.7	-9,561,758		
	Change in water yield and nutrient loads due to change to large area irrig alfalfa		-123,942,780	1,627,737	178,965
	Estimated future average annual water yield and nutrient load	215	192367942	2,092,061	316,299
	Future-with-project average annual N and P concentrations:			**10.88** mg/l	**1.64** mg/l

Dr. McCarls Éstimate of Future Crop Acreages (Table 13, Page 16, Economic Analysis)

Year	Crop	Plan 2 Acres	Plan 3 Acres	Changes
2005	Winter Wheat Dry	15,120	15,010	-110
2015	Winter Wheat Dry	15,120	15,010	-110

2005 Tomatoes Irrigated	18	585	567
2015 Tomatoes Irrigated	18	585	567
2005 Bermuda Irrigated	5,578	5,578	0
2015 Bermuda Irrigated	0	96	96
2005 Alfalfa Dry	60,529	20,511	-40,018
2015 Alfalfa Dry	54,951	20,511	-34,440
2005 Alfalfa Irrigated	9,404	54,601	45,197
2015 Alfalfa Irrigated	14,982	57,520	42,538

Estimate major changes from current situation to Plan 3 Conditions in 2015
(Plan 5 conditions will be similar to Plan 3 Conditions of Nutrient Discharge)

Estimate current condition is that there are about 12,000 acres of irrigated bermuda hay in the valley.
(Approximate estimate from irrigation water delivery contracts in recent years.)

Year	Crop	acres	hectares	P disch Kg/Yr	N disch Kg/Yr	ET M3/Yr
2000	Irrigated Bermuda	12,000	4,856	23,357	539,550	47,006,080
2015	Irrigated Bermuda	0	0	0	0	
2000	Irrigated Alfalfa	0	0	0	0	
2015	Irrigated Alfalfa	57,520	23,278	243,953	2,428,128	294,001,140
	Change from Irr Bermuda to Irr Alfalfa	12,000				
	Change from Dry Bermuda to Irr Alfalfa	45,520				
2000	Dry Bermuda subject to conversion	45,520	18,421	41,631	260,841	123,052,280
2015	Dry Bermuda change to	0	0	0	0	

2000 Total N and P discharges and ET from affected areas	64,988	800,391	170,058,360
2015 Total N and P discharges and ET from affected areas	243,953	2,428,128	294,001,140
Change due to Project	178,965	1,627,737	123,942,780

Nutrient Yield from Dry Bermuda Hay (in Kilograms per Hectare)

P loss in sediment runoff	0.24	N loss in sediment	0.84
P leached to groundwater	0.02	N leached to groundwater	10.27
P labile in water runoff	2	N loss in water runoff	2
		N in lateral flow	1.05
Total P discharged from site	2.26	Total N discharge	14.16
Average annual evapotranspiration:	668 mm		6,680 M^3/hectare

Nutrient Yield from Irrigated Bermuda Hay (in Kilograms per Hectare)

P loss in sediment runoff	0.38	N loss in sediment	2.03
P leached to groundwater	1.43	N leached to groundwater	88.03
P labile in water runoff	3	N loss in water runoff	19.01
		N in lateral flow	2.04
Total P discharged from site	4.81	Total N discharge	111.11
Average Annual Evapotranspiration:	968 mm		9,680 M^3/hectare

NUTRIENT YIELD FROM IRRIGATED ALFALFA (In Kilogram/Hectare)

P loss in sediment runoff	0.69	N loss in sediment	2.29
P leached to groundwater	3.79	N leached to groundwater	82.01
P labile in water runoff	6	N loss in water runoff	19
		N in lateral flow	1.01
Total P discharged from site	10.48	Total N discharge	104.31

Average annual evapotranspiration: 1,263 mm 12,630 M^3/hectare

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April 5, 2000

MEMORANDUM

To: Stan Bevers 940-552-4657
Nikki Dictson 5-4096
John Ellis
Jeremiah Friddell 5-2273
Fran Gelwick 5-4096
Damon Holzer 5-2273
Bruce McCarl
Gretchen Riley 5-2273
Ramish Sivanpillai 5-2273
Raghavan Srinivasan 5-2273
Clive Walker 254-77[illegible]

From: Ron Lacewell

Re: Wichita Chloride Control Evaluation Report

John Ellis and I met with the Corps in Tulsa on March 30 to review the draft report of the Wichita Chloride Control Analysis report. Basically, everything is looking pretty good. There are some parts that some of you are finishing those needs to be incorporated. I appreciate the time and effort from you in bringing this to completion.

However, there are a couple of things we need to do for the final report. Attached are my notes of the meeting and the comments. The folks at Tulsa are reviewing in more detail the printed copies and will respond by April 7. Some of the highlights are:

- Each section will be a separate stand-alone report
- Reports should reference other reports to show the integration
- All reports need a figure of the study area even if it is exactly the same
- It is essential that there be consistency across all the reports
- Need to refine the references with more needed and a list of references at the back, see Fran's report for a good example to follow
- One additional new report will be developed that includes the salinity estimates of TAES along with the economic implications

- Blacklands will still have a separate report that discusses the soils, reach redefinition, land uses over recent years from secondary data, gage stations, etc.
- More is needed on the implications of the project
- Must get individual crops for the 1997 images in Land Use Trends
- Must use normalized prices for Corps evaluations
- Other issues discussed in the attached

Please work with Ms. Zinn in Agricultural Economics and we will put together the final separate reports as well as print. However, what is in the report is each of your responsibilities. Along with you, I would like to get the final submitted very soon and declare this project finished.

Again, thanks for your dedication and hard work. Multidisciplinary research is not an easy task but you have demonstrated that TAES can do it and do it very well. The team approach blending the best of all parts gives us a special ability and we will get better with more experience. I will send the Corps comments when they arrive. In the meantime, please begin to address the points on the attached.

Wichita River Chloride Control Study

Comments and Suggestions from 3/30/00 Meeting
Ellis Lacewell and Corps Representatives

General

- Each task or section will be a separate report and stand-alone. The format will be consistent across all reports and there needs to be references to the other reports when appropriate such as Economics referring to soils and reaches as developed by Blacklands. Agricultural Economics (Ms. Zinn) has the material you provided in the draft report that was submitted. So working with each of you we will print the final reports. Need consistent cover, title page (title of your report but must have the title of the contract as the lead), each do your own acknowledgements, table of contents, list of tables, list of figures, references. Please use Fran Gelwick's style for referencing in the text and for building the list of references. Must have a title for your report and authors. Lastly, each report must have a figure of the study area that will be identical. The Figure 2 in Srini's Land Use Trends is a good example, just find the right place to refer to the study area and insert this map. This is another figure in your report with a number. Your tables and figures will each start with 1 and be numbered consecutively. Appendices are fine. More information is better than less information.

- There is an understanding that the word "pollution" will not be used relative to salinity in the water. Please replace pollution with "natural salt and chloride loads." This is some compromise made by stakeholders, natural resources agencies, etc. Clive be sure to look closely at your section for that is where it came up the first time. Thanks.

- Land Use Changes and the GIS sections are to be combined into one report. I will look to Srini, Damon and John to work through this.

- A major issue relates to land use changes and the implications for habitat. To the extent possible, this needs to be addressed relating to return flow, land cover, etc. One point to consider is that since the study eliminated all the land to the west from conversion to cropland, there is little or no land use implications where the biggest issue rests on wildlife, fishes and habitat. Fran and Clive need to both discuss this briefly. We only allow irrigation and land use conversion where there is already cropland.

- Need to indicate that there is a brush management feasibility study being done on Wichita River that will provide insight on impact of runoff but will not be available until late summer. Where is best place for this-Land Use Trends

- Please work closely with Ms. Zinn and John Ellis. I have asked John to help coordinate and work with figures, GIS, etc.

Land Use and GIS

- For consistency, where hectares are reported, this needs to be modified to reflect acres.
- Incomplete coverage is noted in several places, define what this means and the implications.
- Why are counties with incomplete coverage not in Figure 3 while they are in Table 5? Include in Figure 3.
- Include a graph or figure for Table 7 and Table 8.
- In the section discussing land use trends, need to discuss environmental and habitat implications of these trends (past and likely future)
- As part of the add-on contract we agreed to identify individual crops for the 1997 images. The Corps expects this to be done so need to follow-up using Stan Bevers in Vernon to provide some ground truthing.
- For Table 5, 6, 7 and 8 as well as corresponding figures put in a total value for the region.
- In Land Use Trends, must include a section of implications of the changes due to the completed part of the project. This may need to be developed in cooperation with Fran Gelwick and as mentioned before, we restricted irrigation and land conversions to the east part of the study area hence are not inducing land use change in areas where there is not already irrigation. Clive can also be helpful in crafting this discussion. Very important to the Corps so need to look at carefully. Any potential relation between the trends of land use and completion of parts of the project on the west part of study area? What could this mean to habitat and to the fishes?
- For the GIS section, I did not get any specific suggestions or comments. I am asking John Ellis to work with Damon and Srini to blend Land Use and GIS into one section touching on the needs and issues raised by the Corps at the meeting.

Soils, Reaches, Hydrology

- In the contract, we indicated that there would be an analysis of N, P, and pesticides particularly with regard to return flows and river water quality. Need to address this and as I recall, Clive you were looking at the issue of return flows. Can there be anything on N, P, and pesticides given we are not using EPIC or SWAT? One thing to discuss is the point of no land conversion on the west part of study area and not looking at land that is not dryland cropping or already irrigated which is more in the eastern part. Also, please review the cropping patterns of Bruce to help address if only being one of an expert with all the appropriate hedges, etc.

- Take word Pollution out and replace with natural salt and chloride loads.

- In the graphs and figures, it is critical to include the Irrigation District with canals-part of GIS, etc. Jimmy Banks provided the canals on maps and if need help, the Corps in Tulsa is available.

- Table 6 is all soils. However, it indicates that those used in the Economic Analysis are shaded. They are not shaded in the draft we have. Be sure to get this resolved so in Economic section the soils given (Table 5 of Economics) are also in Table 6 of this section but shaded. Any added discussion of why and how the soils used for economics as derived from this large list would be helpful.

- On page 1, there is a reference to Site VII, VIII, and X. Need a description of where these sites are and show on a figure of the study area.

- Define TDS and CHL in the text in the section on Implications for Project Design and Evaluation. Also, for this section, take a look at the text for there is some of it difficult to interpret. Can there be some rewrite to provide clarity?

- In references to other parts of the study, rather than referring to the scientists, refer to the other reports as the Economic Analysis or the Environmental Assessment.

- Need a reference for material in Table 4.

- Need a list of references and any additional references that are appropriate. See Fran's report for a good example.

- Delete the discussion of Corps assuming wells before and the issue of who drills, etc. This shows up under "Implications for Project Design and Evaluation" for one place and may be also mentioned elsewhere.

- Figures will be included in the text not as an Appendix. After first reference to Figure 1, then it is put into the report text.

- For the hydrological (salinity) implications of the project (the last part of the discussion), I am struggling with how to proceed. My inclination is to develop another report that basically starts with the section "Proposed Hydrological Procedures and Potential Implications." This means that one report on Soils, Reach Definition, Land Use from Secondary Data and Description of gages and the study area are one report and stand alone. Then a new report that evolves from the material starting with the section mentioned above. Included in this report will be the salinity estimates for project and also the economic implications from Bruces model. All the reports will be formally submitted to the Corps and then it is up to them on how to proceed. What we have is our formal report on the salinity estimates and economic implications that will be submitted to which we can refer in the future. Clive is this acceptable to you and to Bruce? This added independent report would have own title and tables and graphs would start from 1. References to the earlier part of your report Clive would be needed.

Environmental Analysis Related to Aquatics

- Fran give us a good title for this.

- Need to begin with purpose of this and it is to provide a basis for analyzing or comparing habitat and populations before and after project. Keep in mind now that we are not allowing irrigation or crop conversions to occur in the western part of the study area, as the land is not appropriate. In your summary it would be appropriate to make some statements on this and draw some conclusions.

- A general comment was to edit or rewrite more where the layman could follow and understand. That is not to say deleting the scientific approach but add comments or discuss so that it can be easily followed by someone like Lacewell. Provide some insights on what does this really mean and what can we infer from what is presented.

- In the graph(s), conductivity needs to be converted to salinity to be consistent with the rest of the report. We asked the Corps to provide the conversion factor so this can be done for this study area. It is appropriate to leave the graph with conductivity but need a companion graph that is presented with salinity.

- In rewriting, edit so that the report is not in first person. Need to discuss but not use "we" and "I" and such. More of the scientific method of writing.

- Rather than refer to Walker's Reaches, include a figure or map with them on it and then give a brief description of each reach. See McCarl's section for some good language to use.

- In reviewing the Corps salinity (conductivity) values for the reaches, what conclusions or inferences can be made about implications for environment, habitat, and fishes? This impacts water quality even in the upper reaches with or without irrigation, as the water is less saline. Can make references to no irrigation or land use changes due to project in upper reaches so little impact on riparian vegetation or whatever to the extend you are comfortable. What is needed is some evaluation or conclusions of impacts of the project where we are using Corps salinity values.

- Can there be any comments or inferences on the impact of reduced flow on survival? Does the GIS show any potholes where the threatened fishes can be expected to survive? What can be said with a level of comfort professionally?

- As I recall, you were finishing a model so need some discussion and how this helps answer questions of the impact of the projection fishes.

Economic Analysis

- The Corps requires that economic analysis be done using Normalized Prices developed by USDA and there is no provision for including any transportation costs. Model is being rerun based on Corps specifications for crop prices.

- Is the seed included in the lint price? Seed is 1.7 pounds per 1.0 pound of lint.

- A set of regional crop enterprise budgets is to be included in an Appendix. Stan Bevers needs to provide the latest copy available.

- Must include a description of the Economic Model and how the crop enterprise budgets are incorporated, components of the model, where functions are described and where data resides, etc.

- That part of the economic implications that comes from Blacklands salinity estimates will be put in the new report that is a combination of Blacklands and Economics.