THE LOWER COLORADO RIVER PESTICIDES STUDY: PESTICIDE AND HEAVY METAL RESIDUES IN SURFACE WATER, SEDIMENTS, AND FISH TISSUE

Study Participants:

- Austin-Travis County Health Department
- Clear Clean Colorado River Association
- Lower Colorado River Authority
- Texas Department of Agriculture
- Texas Department of Health
- Texas Parks and Wildlife Department
- Texas Water Commission

Study Coordinator:

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EXECUTIVE SUMMARY

During the fall of 1987, a cooperative study was undertaken to assess pesticides and heavy metal contamination in the Lower Colorado River from Town Lake in Austin, Texas, to the Gulf of Mexico. The Lower Colorado River Authority, Texas Department of Agriculture, Texas Department of Health, Texas Parks and Wildlife Department, Texas Water Commission, Austin City-County Health Department, and the Clear Clean Colorado River Association provided the financial and/or technical support to evaluate the magnitude of the toxics problem within this river system.

Surface water and sediments were initially scanned for a broad range of pesticides and heavy metals that could enter the river from either urban or rural sources. As the presence of individual compounds was documented during these laboratory analyses, subsequent analyses of fish tissues were directed toward those compounds.

Sampling Locations

Sixteen sampling sites were selected to cover the Colorado River study area, from Town Lake below Tom Miller dam to the tidal influenced river channel in Matagorda County, downstream of the lock structure. An additional station was established on Tres Palacios Creek at the State Highway 35 bridge to evaluate irrigation water that flows into coastal estuaries rather than into the Colorado River.

Sample Periods

Three different surveys of river water quality were conducted during this study. Baseline conditions were documented from December, 1987 through late February, 1988 when no releases were being made from upstream reservoirs and river flow levels reflected local tributary inputs and effluent discharges. Later sampling, when reservoir releases dominated instream flow characteristics, was initiated between April and July 1988 only after stormwater runoff events which affected much of the Lower Colorado watershed. Due to below normal rainfall during the sampling period, only two storm events produced adequate runoff conditions to evaluate toxics transport into the river.

Water & Sediment Quality

During each of the river sampling surveys, no pesticide residues were detected in broad scans for contaminants in the water samples, despite the presence of suspended sediments generated by the runoff events.

During the baseline period, only sediments from Town Lake exhibited any detectable pesticide residues. Sediments from stations at Red Bud Isle and Congress Avenue bridge along Town Lake showed detectable residues of DDT and its breakdown product, DDE. During the July runoff event sampling period, residues of chlordane and DDT, DDE and DDD were detected in sediments throughout the river upstream of Smithville. The Tres Palacios Creek station also had detectable DDE following the storm events. Heavy metal concentrations in sediments exhibited a similar pattern of deposition in the area downstream of Austin and in Tres Palacios Creek, but individual station data were more variable than the pesticide data.

Fish Tissue Data

Fish tissues were analyzed for pesticides and heavy metals detected in water and sediments. Detectable concentrations were higher and more frequent in fishes collected near the Austin urban area. Food and Drug Administration (FDA) Action Levels for chlordane were exceeded in one blue catfish, two gizzard shad, and one common carp, all from Town Lake. This accounts for 15% of the Town Lake samples. FDA Action Levels for DDT/DDE/DDD or mercury were not exceeded by any Town Lake fish. No stations downstream of Longhorn Dam produced fish tissue concentrations approaching FDA Action Levels for chlordane, DDT/DDE/DDD, or mercury.

Conclusions and Recommendations

(1) Study results indicate that persistent chlorinated pesticides, such as chlordane and DDT/DDE/DDD, are present in sediments and fish tissue in Town Lake and along upper stretches of the river. Chlordane levels in some Town Lake fishes were elevated above FDA action levels, and the public health advisory issued by the Austin-Travis County Health Department following previous studies is still in effect.

(2) Agricultural pesticide usage and its impacts could not be adequately evaluated during this study due to the lack of rainfall during the pre-emergent and rapidly growing phases of crop production. Runoff events that were sampled occurred much later than traditional application times for commonly used pesticides.

This objective of the study, to analyze the impact of agricultural use of pesticides on the Colorado River, therefore, could not be adequately accomplished. This potential impact should be further studied in the future during application periods with adequate rainfall.

(3) Because of pesticide concentrations found during this study in Town Lake and earlier findings from the Nationwide Urban Runoff Program, a similar study of Lake Austin should be considered.

INTRODUCTION

Historical Information

In 1982, the City of Austin participation in the Nationwide Urban Runoff Program (NURP) revealed deposits of heavy metals and selected pesticides in Town Lake and Lake Austin sediments. Fish tissue analyses on a limited number of specimens from these lakes revealed that combined DDT, DDD and DDE concentrations in one fish from Town Lake exceeded the FDA Action Level of 5.0 mg/kg (Appendix A). Stormwater runoff samples continued to show pesticides in runoff from tributaries to the two reservoirs.

Public health concerns about pesticide contamination in fishes from Town Lake led to a 1985 survey of fish tissue from a variety of species in this urban reservoir (Appendix B). Observations of diseased and stressed fishes in the Colorado River prompted a similar study of potential contamination downstream of Town Lake (Appendix C). Both of these studies targeted the persistent organochlorine pesticides, chlordane and DDT. FDA Action Levels (i.e. concentrations in edible fish that initiate federal action to remove commercial fish from the market due to public health concerns) were exceeded for chlordane in striped bass (Morone saxatilis), common carp (Cyprinus carpio), and gizzard shad (Dorosoma cepedianum) from Town Lake and in gray redhorse (Moxostoma congestum) from the Colorado River near Webberville (Appendix B and C).

Based on these results, a new study was initiated that would (1) extend the geographical range of studies previously limited to the Austin area further downstream, (2) expand the list of pesticide compounds targeted for analysis, and (3) identify "hot spots" of pesticide and heavy metal contamination for future remedial action.

Cooperative Study Organization

A cooperative group of state resource agencies, local and state health authorities, and public interest organizations organized during 1987 to undertake such a study of the Lower Colorado River. Funds for support of an outside study coordinator were provided jointly by the Clear Clean Colorado River Association, Texas Department of Agriculture, Lower Colorado River Authority, and the Austin City-County Health Department. Field services related to electrofishing of required fish specimens were provided by the Texas Parks and Wildlife Department. Laboratory analyses of water and sediments were provided by certified laboratories at the Texas Department of Agriculture, Texas Department of Health, and Lower Colorado River Authority. Analyses of fish tissues were performed by the Lower Colorado River Authority laboratory. All participating groups provided technical review of this project from formulation of initial work plan through finalization of this document.

DATA COLLECTION AND ANALYSIS

Sampling Locations

Sixteen sample sites along the mainstem Colorado River were used to characterize the river basin downstream of Tom Miller Dam which impounds Lake Austin. One station at the FM 973 bridge downstream of Austin was initially sampled but abandoned during later surveys due to adequate coverage by adjacent stations in Travis County. Station locations are given in Table 1 and illustrated in Figure 1.

An additional sampling station (Station 15) was established on Tres Palacios Creek at the State Highway 35 bridge 5 miles south of the Colorado River to monitor agricultural return flows from farmlands using Colorado River irrigation water. In the narrow river basin near the coast, tributaries emptying into the mainstem are small and localized, so this site appeared to be more representative of pesticide contamination from extensively irrigated croplands.

Sampling Periods

This study was not intended to duplicate routine or periodic monitoring data on toxics distribution throughout the Lower Colorado River basin that is conducted by the U.S. Geological Survey, Texas Water Commission, or Lower Colorado River Authority. In order to characterize pesticide residues currently being transported into the river from adjacent watersheds, the periods of sampling were oriented toward the larger runoff events.

The baseline survey was performed during late December, 1987, a period of low flow. Sediments were sampled for heavy metals analysis during February, 1988. During this period, no reservoir releases were being made to the river through Lake Austin or Town Lake. Therefore, water levels were low at all sampling sites upstream of Bay City, permitting easy access to channel bottom sediments for collection.

Storm events capable of producing runoff from large areas of the lower Colorado River watershed did not occur until late May and the middle of July. During both of these rainfall events, sampling was initiated approximately 24 hours after rain ceased. Turbid water indicating recent runoff contributions was encountered between Longhorn Dam and Webberville in both instances. Town Lake stations were generally clear as reservoir releases pushed the local urban runoff contributions downstream. Turbid conditions usually persisted at all downstream stations during the surveys. Sediment collections made after runoff events incorporated freshly deposited fine materials from shallow areas.

Sample Collection

All water and surface sediment samples during this survey were collected by the study coordinator, Melvin O. Hinson, Jr. Surface grab samples of water for pesticide analyses were collected in pre-cleaned glass bottles provided by the labs conducting the chemical analyses. Surface sediments were placed in wide-mouth glass jars with teflon liners. Samples were placed on ice for preservation. Field collections were conducted over one or two day periods, so samples reached appropriate labs for analysis within 48 hours of collection.

Two methods of analyzing fish tissue are commonly used. One is total fish analysis where the whole body of the fish is analyzed. The other is analysis of the edible portion (fillet) only. This study utilized fillet analysis to specifically address health concerns for those individuals consuming fish from the Colorado River. Fishes used for laboratory pesticide and heavy metal analysis were collected by electrofishing. A field crew comprised of Texas Parks and Wildlife personnel and the study coordinator selected up to five large specimens of a particular fish species from each major trophic group (predator, omnivore, planktivore, and bottom-feeder) after which collection of that species was halted. Attempts to obtain samples of comparable size and number at each site were made, but actual sample composition reflected the local fish community structure.

Fish were kept alive aboard the boat until sampling was complete. Surplus fish were released unharmed. Fish were preserved with ice during transport to the lab. Fishes were weighed and measured (total length). Fillets of edible tissue and livers were removed from the fish with a knife, wrapped in aluminum foil, and placed in plastic freezer bags prior to storage in a freezer.

Laboratory Analyses

The Texas Department of Agriculture pesticides laboratories in Brenham and the Rio Grande Valley performed the pesticide analyses of water and sediment samples collected during the initial low flow baseline survey. Broad scans for organochlorine, carbamate, and organophosphorus residues were conducted on the samples. A list of typical pesticide compounds that would be revealed during such scans can be found in the Table 2. For the purposes of this study, the term "pesticide" refers collectively to insecticides, herbicides, fungicides, etc. Water and sediment samples collected following runoff events were analyzed for pesticides by the Texas Department of Health environmental laboratory in Austin.

All heavy metals analyses were performed by the LCRA environmental laboratory in Austin. Detection limits for pesticide residues and heavy metals at these labs can also be found in the Appendix.

Fish tissue samples were ground, digested, extracted, and processed at the LCRA laboratory. Extractions were completed prior to the six month's holding time limit suggested by EPA. Minimum detection limits for tissue samples varied with the weight of the available sample. Specific procedures followed in analyzing the fish tissue samples are described in Appendix D.

RESULTS AND DISCUSSION

Surface Water Quality

A candidate list of pesticides and heavy metals most likely to be encountered during this study was developed based on (1) detection in previous studies of river water quality and toxics contamination and (2) Texas Department of Agriculture surveys of commonly used pesticides in counties adjacent to the lower Colorado River. Table 2 presents the list of insecticides, herbicides, fungicides, and metals that were targeted for analysis in the initial laboratory screening of environmental media.

Despite the large number of candidate compounds, no pesticide residues above detection limits were observed in surface water samples from any of the 17 sampling stations during the initial baseline survey or from either of the two runoff event surveys.

The lack of positive detection for all candidate pesticides in the baseline and runoff event surveys was unexpected but not surprising. The timing of sample collections, due to late and erratic storm events, did not coincide with traditional pesticide application periods for the major crops in the lower Colorado River basin. Water sampling would be most effective at detecting pesticide transport during active pesticide application periods, coinciding with runoff events.

Sediments

Metal concentrations in sediment were evaluated against 85th percentile values from the Texas Water Commission (TWC) stream monitoring network. That level provides an indication of elevated concentrations. Table 3 presents the results for pesticide residues detected in sediments during the two relevant surveys. During the low flow period, only small quantities of DDT and its breakdown product DDE were found in sediments from the Red Bud Isle and Congress Avenue bridge areas of Town Lake. All sediments at stations downstream of Town Lake were free of detectable pesticide residues. During the July runoff event survey, detectable concentrations of DDT/DDE/DDD were present in sediments at all stations from Tom Miller Dam downstream to Smithville. Tres Palacios Creek sediments also contained low levels of DDE following the July runoff event. Chlordane residues appeared only in sediments from the Congress Avenue bridge (mid-Town Lake) and Smithville. Sediment samples from all other downriver stations were free of detectable pesticide residues.

Table 4 illustrates the changes in sediment concentration of the eight common heavy metals regulated by Texas Surface Water Quality Standards between the river's low flow period and summer flows following runoff events. Of the metals, only lead exceeded the 85th percentile value of 38.0 mg/Kg. Stations 1 and 2 in Town Lake exceeded it during both baseline and post-runoff periods. Station 13, near Wharton, also had an elevated value following runoff sampling. All other metals were below 85th percentile levels. Sediment concentrations of heavy metals increased between surveys in lower Town Lake, the Colorado River at FM 969 bridge near Utley, downstream of Wharton, and at Tres Palacios Creek, perhaps indicating localized deposition of sediments with heavy metals.

During the low flow period, baseline sediment collections uncovered none of the "hot spots" of pesticide or heavy metal contamination that may have been expected based on prior investigations along the lower Colorado River and its mainstream reservoirs. Only the most upstream stations (Red Bud Isle and Congress Avenue bridge) in Town Lake contained detectable levels of DDT and/or DDE. All other downstream sediments had less than detectable levels of pesticide residues. This condition may have been the result of massive river scour and sediment transport resulting from heavy rains in May and June, 1987. Following these storms events, river discharge levels measured at Bastrop peaked at more than 40,000 cfs and exceeded 20,000 cfs from June 3 to June 22 as excess flood storage was released from Lake Travis. Reservoir releases for irrigation are normally less than 2,000 cfs. Sediment accumulations were probably removed and washed out of the river system during that period.

Pesticide and heavy metal accumulations found in post-runoff sampling indicate the potential importance of sediment transport and/or resuspension on the distribution of pesticides and metals in the river system. Only future studies of sediment contamination will reveal the extent of this problem.

Fish Tissue Analyses

Fillets from 86 individual fishes collected from Town Lake in Austin and the Colorado River between Webberville and Bay City were analyzed for selected organic constituents and metals (Tables 5-10). Contaminant concentrations of chlordane, DDT, DDE, DDD, and total mercury were compared to United States Food and Drug Administration (FDA) action levels and Oklahoma State Department of Health (OSDH) warning levels (75% of the FDA action level). Action or warning levels are not available for other substances analyzed. Where FDA criteria were not available, concentrations were compared to whole-fish, 85th percentile values from the Texas Water Commission stream monitoring network. Whole fish tissue data from two minimally impacted

streams, the Devil's River and the Llano River, were also used for comparison. Differences in analytical procedures for metals between these studies and the resulting difference in detection levels limit direct comparisons.

Chlordane concentrations exceeded the FDA action level of 0.300 mg/kg in four of 26 fishes collected from Town Lake (Table 5 and 6). They were two gizzard shad with concentrations of 0.323 and 0.407 mg/kg, a blue catfish (Ictalurus furcatus) with 0.759 mg/kg, and a common carp with 0.417 mg/kg. Two additional fish, both from Town Lake, exceeded the OSDH warning level of 0.225 mg/kg chlordane. They were a channel catfish (Ictalurus punctatus) with a concentration of 0.296 mg/kg and a blue catfish with a concentration of 0.246 mg/kg. None of the 60 fishes analyzed from the river between Webberville and Bay City had concentrations equal to or greater than the FDA or OSDH criteria.

All fish with elevated levels were of species that have a high oil or lipid content relative to the range of species tested. Chlordane, as with other chlorinated hydrocarbons, tends to accumulate in fatty tissues at higher concentrations than in the surrounding water column. Fish can concentrate chlordane by a factor of 1,000 to 3,000 times the ambient water concentration (Dick 1982). Older or larger fishes often demonstrate higher concentrations of chlordane in tissue. This phenomenon may relate to longer exposure or to the general increase in lipid content with size.

Historically, chlordane has been used extensively for termite control, as an insecticide for homes and gardens, and as a control for soil insects. The EPA cancelled some uses of the material in 1978 as a result of serious concerns over its persistence, chronic hazards and its potential to accumulate in the tissue of animals and humans. However, significant commercial use for termite control continued until a complete ban on sales in the United States was initiated in April 1988.

Elevated chlordane levels are often associated with urban and residential runoff, and other studies have generally detected a greater incidence of high chlordane levels downstream of urban areas. Kleinsasser and Linam (1989) observed elevated concentrations in the Trinity River downstream of Fort Worth and Dallas (Table 11). Irwin (1988), who analyzed whole fish rather than fillets, also found a strong association between urban and suburban runoff and chlordane in the Trinity River. In a study on the Kansas River, fish tissue from more than 80% of locations sampled had detectable levels of chlordane (Arruda et al. 1987). Mean chlordane concentrations in the Kansas River increased at or downstream from major urban areas.

By contrast, only trace levels are normally found in minimally impacted areas. Whole fish samples from the Llano and Devils rivers in Texas (Table 12) had concentrations below the detection limit (Texas Water Commission unpublished data). Whole fish would be expected to have slightly higher levels than fillets from the same fish.

DDT, DDE, DDD tissue concentrations were all well below the FDA action level of 5.0 mg/kg (combined total of DDT and its metabolites) and the Oklahoma State Department of Health (OSDH) warning level of 3.750 mg/kg. DDT and its metabolites are persistent and are still found in tissues and sediments despite the fact they have been banned from the United States market since 1972. DDT was also detected in Devils River and Llano River samples (Table 12).

No fishes had mercury concentrations near the FDA action level of 1.0 mg/kg or the OSDH warning level of 0.75 mg/kg. By comparison, mercury was detected in Devils River and Llano River samples. Aside from natural concentrations, mercury sources include fossil fuel combustion; mining and reprocessing of gold, copper, and lead; and the disposal of batteries and fluorescent lamps (Eisler 1987).

Of the other metals, chromium consistently had the highest concentrations. Chromium varied from <0.10 to 2.69 mg/kg in tissue. Six fishes had concentrations greater than 1.0 mg/kg and four exceeded the 85th percentile value of 1.20 mg/kg. Of the latter four fish, one fish was from La Grange and three were from Wharton. More than 93% of the fishes had concentrations less than 1.0 mg/kg. The maximum chromium concentration from whole fish collected from the Devils and Llano rivers was 2.3 mg/kg (Table 12). Fishes rapidly eliminate chromium following exposure. Thus, fishes exposed intermittently to high chromium levels would not experience cumulative chromium uptake (USEPA 1978). In general, fishes tend to accumulate relatively little chromium in edible tissues and chromium is low in toxicity to humans (USEPA 1978).

Chromium is considered an essential trace element in humans (Eisler 1986). The major sources of chromium contamination in aquatic environments are the electroplating and metal finishing industries and publically owned treatment plants (sewage sludge in particular); relatively minor sources are iron and steel foundries, inorganic chemical plants, tanneries, textile manufacturing, and runoff from urban and residential areas (Towill et al. 1978; Ecological Analysts 1981). Chromium in fertilizers may be an important source in soil, water, and some foods (Langard and Norseth 1979). Sediment enrichment has been correlated with fluxes of charcoal from different combustion processes: oil, coal, and wood burning (Moore and Ramamoorthy 1984). Suspended particulates are a major source of transport in aquatic systems.

Arsenic concentrations ranged from <0.18 to 0.41 mg/kg. The latter value was found in a largemouth bass collected near La Grange. However, more than 97% of the values were less than 0.25 mg/kg, and none exceeded the TWC 85th percentile level of 0.7 mg/kg. Arsenic has a relatively low bioaccumulation factor in fish and the biological half-life of arsenic is only seven days in green sunfish (U.S. EPA 1978). The major uses of arsenic are in the production of herbicides, insecticides, desiccants, wood preservatives, and growth stimulants for plants and animals (Eisler 1988a). Arsenic can enter rivers from air pollution (fossil fuel combustion) as well as from pesticides and industrial sources (Irwin 1988).

Lead values ranged from <0.1 to 0.20 mg/kg. The TWC 85th percentile level for lead is 1.7 mg/kg. Lead has a low bioaccumulation factor, and fishes normally accumulate very little of it in edible tissues. According to U.S. EPA (1978), finfishes are probably not a major source of lead in the human diet. Lead concentrations are usually highest near mining, smelting, and refining activities; lead storage battery recycling plants; areas of high vehicular traffic; urban and industrialized areas; and sewage and spoil disposal areas (Eisler 1988b).

CONCLUSIONS AND RECOMMENDATIONS

The Austin-Travis County Health Department issued a health advisory in 1987 advising persons to avoid consuming common carp, shad, and striped bass from Town Lake. That advisory is still in effect (Appendix 5), and based upon the results of the current study, persistent organochlorine pesticides (chlordane and DDT/DDE/DDD) are still present in sediments and fish tissue in Town Lake. Chlordane concentrations in blue catfish, carp, and gizzard shad from Town Lake were elevated above FDA action levels. Although both compounds have been banned, they will undoubtedly continue to show up in further analyses. These results are consistent with those observed in some other watersheds draining urban and suburban areas.

Because of the pesticide concentrations found in Town Lake during this study and earlier findings from the National Urban Runoff Program, a similar study of Lake Austin should be considered.

Agricultural pesticide usage and its short-term impacts could not be adequately evaluated during this study, due to the lack of rainfall during the pre-emergent and rapidly growing phases of crop production. Runoff events that were sampled occurred much later than traditional application times for commonly used pesticides, virtually eliminating the chance of detecting those that are not persistent.

Heavy metal concentrations in tissue were generally near or below detectable levels, though one fish from La Grange and three from Wharton contained chromium concentrations greater than the 85th percentile value for that metal in whole fish samples from Texas (TWC unpublished data). A further evaluation should be conducted into chromium sources in that reach of the river. Lead in sediments showed signs of being slightly elevated in Town Lake, though no fish had elevated concentrations.

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TABLES AND FIGURES

TABLE 1

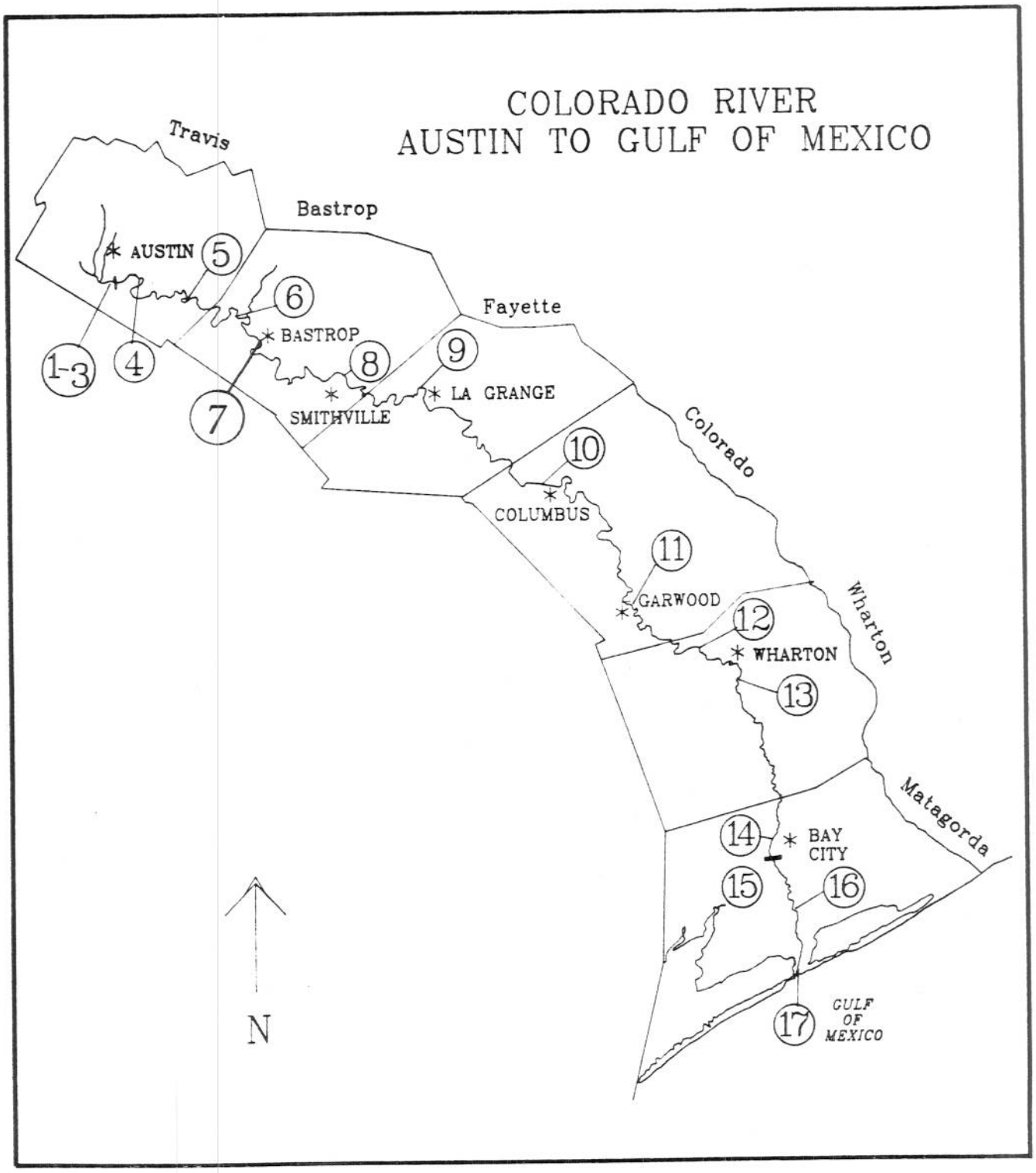
LOWER COLORADO RIVER PESTICIDES STUDY
SAMPLING STATIONS

STATION NO.	COUNTY	SAMPLING LOCATION	TWC/STORET LOCATION NO.
1	Travis	Town Lake - East shore of Red Bud Isle below Tom Miller Dam	1429.0900
2	Travis	Town Lake - North shore at Congress Ave bridge	1429.0855
3	Travis	Town Lake - East shore of main pool near Longhorn Dam	1429.0800
4	Travis	Colorado River - North shore at Bolm Road bridge (private)	1428.0740
4A*	Travis	Colorado River - North shore at FM 973 bridge	1428.0700
5	Travis	Colorado River - North shore near boat ramp in Precinct 1 park	1428.0655
6	Bastrop	Colorado River - North shore at FM 969 bridge	1428.0640
7	Bastrop	Colorado River - North shore near boat ramp in Bastrop City park	1428.6000
8	Bastrop	Colorado River - North shore at US 95 bridge in Smithville	1428.0510
9	Fayette	Colorado River - North shore at boat ramp near SH 71 bridge	1402.0410
10	Colorado	Colorado River - North shore at SH Loop 329 bridge	1402.0300
11	Colorado	Colorado River - North shore at FM 950 bridge near Garwood	1402.0200
12	Wharton	Colorado River - South shore at FM 960 bridge near Glen Flora	1402.0155

TABLE 1 Cont

STATION NO.	COUNTY	SAMPLING LOCATION	TWC/STORET LOCATION NO.
13	Wharton	Colorado River - East shore near boat ramp in Pecan Valley subdivision off FM 1299	1402.0050
14	Matagorda	Colorado River - West shore near boat ramp at SH 35 bridge west of Bay City	1402.0035
15	Matagorda	Tres Palacios Creek - West shore at SH 35 bridge near Blessing	-
16	Matagorda	Colorado River - East shore at FM 521 bridge	1401.0095
17	Matagorda	Colorado River (tidal) - East shore near public boat ramp along FM 2031	1401.0040

* Station abandoned after first sampling survey due to: (1) limitations on number of total analyses and (2) proximity to other stations


COLORADO RIVER
AUSTIN TO GULF OF MEXICO
Travis
Bastrop
Fayette
Colorado
Wharton
Matagorda
AUSTIN
BASTROP
SMITHVILLE
LA GRANGE
COLUMBUS
GARWOOD
WHARTON
BAY CITY
GULF OF MEXICO
1-3
4
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17
N

TABLE 2

CANDIDATE LIST OF PESTICIDES AND HEAVY METALS

INSECTICIDES

Carbaryl (Sevin)
Carbofuron (Furadan)
Terbufos (Counter)
Zolone
Toxaphene
Aldicarb (Temik)
M. Parathion (Metaphos)
Chlorpyrifos (Lorsban/ Dursban)
Aldrin/ Dieldrin
Chlordane
Diazinon (Spectricide)
DDT
Endrin
Heptachlor
Disulfoton (Di-syston)
Dyfonate
Dicrotophos (Bidrin)
Monocrotophos (Azodrin)
Azinophos M. (Futhion)
Acephate (Orthene)
Malathion
E. Parathion (Orthophos)

METALS/TRACE ELEMENTS

Arsenic
Barium
Cadmium
Chromium
Lead
Mercury
Selenium
Silver

HERBICIDES

2,4-D (Demise)
Atrazine (Aatrex)
Picloram (Tordon)
Metolachlor (Dual)
Propenil
2,4,5-T (Weedar)
Dicamba (Banvel)
Propazine (Milog.)
Alachlor (Lasso)
Weedmaster
Trifluralin (Treflan)
Ordram
Prometon
Silvex (Fenoprop)
Grazon

FUNGICIDES/FUMIGANTS

Benomyl (Benlate)
Captan (Orthocide)
Fentin H. (Du-ter)
Tilt
Chlorothalonil (Bravo)
Terrachlor
Iprodione (Rovral)
Maneb (Manzate)
EDB

OTHERS

PCBs
PAHs
Pthalates

TABLE 3

PESTICIDE LEVELS DETECTED IN SEDIMENTS
FROM LOWER COLORADO RIVER STATIONS

STATION NO.	LOW FLOW PERIOD[1] Pesticide Type	Conc. (ug/Kg)	POST-RUNOFF EVENT[2] Pesticide Type	Conc. (ug/Kg)
1	pp',DDE	24	pp',DDE	400
			pp',DDD	52
			pp',DDT	110
			op',DDE	11
			op',DDT	40
2	pp',DDE	31	pp',DDE	60
	pp',DDT	9	pp',DDT	36
			pp',DDD	50
			chlordane	140
3	N.D.		pp',DDE	2
4	N.D.		pp',DDE	3.5
			pp',DDT	5
5	N.D.		pp',DDE	6
6	N.D.		pp',DDE	3
			pp',DDT	20
7	N.D.		pp',DDE	4
8	N.D.		pp',DDE	3
			chlordane	10
9	N.D		N.D.	
10	N.D.		N.D.	
11	N.D.		N.D.	
12	N.D		N.D.	
13	N.D.		N.D.	

TABLE 3 Cont.

STATION NO.	LOW FLOW PERIOD[1] Pesticide Type	Conc. (ug/Kg)	POST-RUNOFF EVENT[2] Pesticide Type	Conc. (ug/Kg)
14	N.D.		N.D.	
15(TPC)	N.D.		pp',DDE	2
16	N.D.		N.D.	
17	N.D.		N.D.	

* N.D. - No detected residues during standard scans

[1] - Low Flow sampling period: 2/28/88

[2] - Post-Runoff Event sampling period: 7/13/88, 7/14/88

TABLE 4

HEAVY METAL LEVELS DETECTED IN SEDIMENTS
FROM COLORADO RIVER STATIONS

STATION NO.	RIVER CONDITION	TOTAL ARSENIC (mg/Kg)	TOTAL BARIUM (mg/Kg)	TOTAL CADMIUM (mg/Kg)	TOTAL CHROMIUM (mg/Kg)	TOTAL LEAD (mg/Kg)	TOTAL MERCURY (mg/Kg)	TOTAL SELENIUM (mg/Kg)	TOTAL SILVER (mg/Kg)
1	Low Flow	6.7	173	<2.3	17.0	65.7	<0.26	<2.3	<2.3
	Post-Runoff	2.86	112	<1.09	9.2	42.0	<0.56	<0.5	<1.09
2	Low Flow	4.0	46.5	<0.9	15.9	48.2	Trace	<0.9	<0.9
	Post-Runoff	2.43	36.4	<0.72	11.6	43.5	<0.48	<0.5	<0.72
3	Low Flow	1.0	12.1	<0.6	2.1	3.5	<0.07	<0.6	<0.6
	Post-Runoff	1.32	21.2	<0.66	3.0	7.61	<0.45	<0.5	<0.66
4	Low Flow	0.8	15.8	<0.6	8.3	12.7	Trace	<0.6	<0.6
	Post-Runoff	0.78	18.5	<0.66	3.7	7.81	<0.49	<0.5	<0.66
5	Low Flow	3.6	158	<2.0	19.7	22.3	<0.19	<2.0	<2.0
	Post-Runoff	1.42	70.9	<0.70	12.2	20.3	<0.49	<0.5	<0.7
6	Low Flow	1.4	46.7	<0.6	5.6	6.1	Trace	<0.6	<0.6
	Post-Runoff	1.52	59.9	<0.72	11.4	13.1	<0.46	<0.5	<0.72
7	Low Flow	2.9	103	1.5	18.8	12.0	Trace	<1.0	<1.0
	Post-Runoff	1.71	63.8	<0.75	11.2	14.4	<0.43	<0.50	<0.75
8	Low Flow	3.3	123	<1.1	15.2	13.2	Trace	<1.1	<1.1
	Post-Runoff	1.65	604	<0.73	11.2	24.4	<0.44	<0.5	<0.73
9	Low Flow	3.0	108	<1.1	12.3	11.2	<0.13	<1.1	<1.1
	Post-Runoff	1.33	43.9	<0.69	3.4	6.22	<0.51	<0.5	<0.69
10	Low Flow	1.9	45.8	<0.7	5.8	5.2	<0.07	<0.7	<0.7
	Post-Runoff	1.79	71.8	<0.68	5.8	12.0	<0.45	<0.5	<0.76
11	Low Flow	2.2	97.1	<0.8	9.9	6.6	Trace	<0.8	<0.8
	Post-Runoff	1.8	92.6	<0.79	7.2	7.68	<0.47	<0.5	<0.79
12	Low Flow	1.5	57.4	<0.6	4.6	5.0	<0.07	<0.6	<0.6
	Post-Runoff	1.45	51.8	<0.61	5.4	5.19	<0.45	<0.5	<0.61
13	Low Flow	1.0	15.3	<0.7	1.4	1.7	<0.06	<0.7	<0.7
	Post-Runoff	1.31	47.9	<0.64	25.4	56.8	<0.46	<0.5	<0.64
14	Low Flow	1.4	54.8	<0.8	4.9	5.2	<0.09	<0.8	<0.8
	Post-Runoff	1.07	38.7	<0.63	2.9	3.8	<0.49	<0.5	<0.63
15	Low Flow	0.9	97.2	<0.7	7.6	6.3	<0.07	<0.7	<0.7
	Post-Runoff	1.93	161	<0.93	10.8	9.5	<0.46	<0.5	<0.93
16	Low Flow	3.0	148	<1.3	17.0	18.2	<0.09	<1.3	<1.3
	Post-Runoff	1.6	73.8	<0.68	4.8	5.56	<0.46	<0.5	<0.68
17	Low Flow	2.0	93.4	<0.9	10.9	10.8	<0.12	<0.9	<0.9
	Post-Runoff	1.7	58.8	<0.61	3.2	5.79	<0.48	<0.5	<0.61

TABLE 5

PESTICIDE AND HEAVY METAL LEVELS IN FISHES
FROM STATION 1 : UPPER TOWN LAKE

FISH TYPE	Total Length (mm)	Total Weight (g)	TISSUE CONCENTRATION (mg/kg) Chlordane	DDD	DDE	DDT	Total Arsenic	Total Chromium	Total Lead	Total Mercury
Largemouth Bass	---	---	<0.040	<0.010	0.059	<0.020	<0.18	<0.10	<0.10	0.26
Largemouth Bass	340	613	<0.076	0.027	0.213	0.046	<0.19	<0.10	<0.10	0.30
Largemouth Bass	370	885	<0.040	0.023	0.174	0.035	<0.20	<0.20	<0.10	0.18
Channel Catfish	457	1453	0.151	0.092	0.227	0.077	<0.20	<0.10	<0.10	0.10
Blue Catfish	547	2837	0.144	0.099	0.274	0.075	<0.20	<0.20	0.13	0.11
Blue Catfish	572	2452	0.759**	0.329	0.740	0.222	<0.20	<0.10	0.16	0.11
Blue Catfish	580	3723	0.246*	0.076	0.231	0.047	<0.20	<0.10	<0.10	<0.10
Gizzard Shad	324	613	<0.041	0.047	0.200	0.120	0.34	<0.10	0.12	<0.10
Gizzard Shad	370	908	<0.040	0.009	0.050	0.018	<0.19	<0.19	0.20	<0.10
Gizzard Shad	368	749	0.323**	0.236	0.655	0.242	<0.20	<0.20	0.16	<0.10
Gray Redhorse	416	1362	<0.040	0.010	0.043	<0.020	0.24	<0.19	0.10	<0.10
Gray Redhorse	423	1158	<0.040	0.016	0.066	<0.020	<0.20	0.50	<0.10	<0.09
Gray Redhorse	412	1203	<0.039	0.015	0.061	<0.020	<0.19	1.00	<0.10	<0.10

* Exceeds Oklahoma State Department of Health warning levels.
** Exceeds United States Food and Drug Administration action levels.

TABLE 6

PESTICIDE AND HEAVY METAL LEVELS IN FISHES
FROM STATION 3 : LOWER TOWN LAKE

FISH TYPE	Total Length (mm)	Total Weight (g)	TISSUE CONCENTRATION (mg/kg) Chlordane	DDD	DDE	DDT	Total Arsenic	Total Chromium	Total Lead	Total Mercury
Largemouth Bass	355	681	<0.040	<0.010	0.052	<0.020	<0.18	<0.10	<0.10	0.15
Largemouth Bass	356	645	0.185	0.064	0.282	0.070	<0.19	<0.10	<0.10	0.16
Largemouth Bass	265	272	<0.053	0.018	0.081	<0.026	<0.20	<0.10	<0.10	0.13
Channel Catfish	290	204	<0.098	0.073	0.187	0.070	0.25	<0.25	<0.12	<0.18
Channel Catfish	449	1052	0.296*	0.086	0.224	0.073	<0.20	<0.20	<0.10	0.13
Yellow Bullhead	260	318	0.121	0.055	0.347	0.053	<0.20	0.40	0.15	0.18
Gizzard Shad	390	1022	0.131	0.065	0.257	0.039	0.21	<0.10	0.18	<0.10
Gizzard Shad	402	1158	0.407**	0.155	0.476	0.128	<0.20	<0.20	<0.10	<0.10
Gizzard Shad	428	1339	0.187	0.195	0.603	0.158	<0.18	<0.10	0.17	<0.10
Common Carp	645	5993	0.095	0.087	0.247	0.026	<0.19	<0.10	<0.10	0.20
Common Carp	738	9080	0.417**	0.313	0.870	0.103	<0.19	<0.19	<0.10	<0.09
Gray Redhorse	349	658	0.153	0.064	0.233	0.032	<0.20	<0.10	0.11	<0.10
Gray Redhorse	366	817	0.217	0.070	0.255	0.036	<0.20	<0.20	<0.10	<0.09
Gray Redhorse	360	781	0.063	0.113	0.243	0.053	<0.20	<0.20	<0.10	<0.10

* Exceeds Oklahoma State Department of Health warning levels.
** Exceeds United States Food and Drug Administration action levels.

TABLE 7

PESTICIDE AND HEAVY METAL LEVELS IN FISHES
FROM STATION 5 : TRAVIS CO. PRECINCT 1 PARK AREA

FISH TYPE	Total Length (mm)	Total Weight (g)	TISSUE CONCENTRATION (mg/kg) Chlordane	DDD	DDE	DDT	Total Arsenic	Total Chromium	Total Lead	Total Mercury
Largemouth Bass	438	1305	<0.040	0.066	0.165	0.046	<0.20	<0.20	<0.20	0.18
Largemouth Bass	277	297	<0.041	0.012	0.065	<0.020	<0.20	<0.20	<0.20	0.17
Largemouth Bass	316	454	0.140	0.060	0.217	0.055	<0.20	<0.20	<0.20	0.11
Guadalupe Bass	392	908	0.084	0.038	0.159	0.029	<0.20	<0.20	<0.20	0.39
Channel Catfish	530	1504	0.056	0.048	0.113	0.034	<0.20	<0.19	<0.19	<0.09
Channel Catfish	466	851	0.150	0.061	0.238	0.039	<0.20	1.04	<0.24	<0.10
Channel Catfish	466	851	0.084	0.034	0.084	0.022	<0.20	<0.19	<0.19	0.10
Channel Catfish	434	851	<0.040	0.021	0.061	<0.020	<0.20	<0.19	<0.19	<0.10
Gizzard Shad	375	596	0.095	0.077	0.119	0.054	0.20	<0.20	<0.20	<0.10
Gizzard Shad	281	249	<0.099	<0.025	0.072	<0.050	<0.20	<0.24	<0.24	<0.09
Gizzard Shad	261	203	0.099	0.071	0.147	0.052	<0.20	<0.20	<0.20	<0.09
Gizzard Shad	310	353	<0.049	0.021	0.050	<0.024	<0.20	<0.20	<0.20	<0.10
Smallmouth Buffalo	520	2357	0.078	0.034	0.117	0.021	<0.20	<0.20	<0.20	0.14
River Carpsucker	411	851	<0.047	0.031	0.100	0.025	<0.19	0.29	<0.19	<0.09
Freshwater Drum	465	1390	0.141	0.055	0.182	0.047	<0.20	<0.20	<0.20	<0.10
Gray Redhorse	446	1107	0.044	0.024	0.113	<0.020	<0.20	<0.20	<0.20	<0.10
Gray Redhorse	468	1419	0.086	0.038	0.163	0.028	<0.20	0.22	<0.20	<0.09
Common Carp	661	4256	0.090	0.048	0.101	<0.020	<0.19	<0.19	<0.19	<0.10
Common Carp	613	3292	0.187	0.067	0.187	0.021	<0.19	<0.19	<0.19	<0.10

* Exceeds Oklahoma State Department of Health warning levels.
** Exceeds United States Food and Drug Administration action levels.

TABLE 8

PESTICIDE AND HEAVY METAL LEVELS IN FISHES
FROM STATION 9 : LA GRANGE AREA

FISH TYPE	Total Length (mm)	Total Weight (g)	TISSUE CONCENTRATION (mg/kg) Chlordane	DDD	DDE	DDT	Total Arsenic	Total Chromium	Total Lead	Total Mercury
Largemouth Bass	509	2327	<0.043	0.021	0.052	<0.021	<0.20	<0.20	<0.20	0.48
Largemouth Bass	425	1362	0.115	0.056	0.114	<0.040	<0.20	2.43	<0.20	0.18
Largemouth Bass	396	1022	<0.044	0.018	0.059	<0.022	0.41	0.64	<0.19	0.21
Channel Catfish	370	511	0.056	0.030	0.068	0.019	<0.20	<0.19	<0.20	<0.09
Channel Catfish	389	624	<0.040	0.019	0.041	<0.020	<0.20	<0.19	<0.19	<0.09
Channel Catfish	373	511	0.051	0.030	0.060	<0.022	<0.20	0.20	<0.20	<0.09
Gizzard Shad	394	738	<0.053	0.033	0.061	<0.026	<0.20	<0.20	<0.20	<0.10
Gizzard Shad	333	511	<0.050	0.019	0.038	<0.025	0.20	0.20	<0.20	<0.09
Gizzard Shad	385	738	0.034	0.027	0.056	<0.019	0.20	<0.20	<0.20	<0.10
Common Carp	432	1163	<0.036	<0.009	<0.009	<0.018	<0.20	<0.20	<0.20	<0.10
Common Carp	605	2979	<0.040	0.009	0.023	<0.020	<0.20	<0.20	<0.20	<0.10
Common Carp	468	1476	<0.039	<0.010	<0.010	<0.019	<0.20	<0.20	<0.20	<0.10

* Exceeds Oklahoma State Department of Health warning levels.
** Exceeds United States Food and Drug Administration action levels.

TABLE 9

PESTICIDE AND HEAVY METAL LEVELS IN FISHES
FROM STATION 13 : WHARTON AREA

FISH TYPE	Total Length (mm)	Total Weight (g)	TISSUE CONCENTRATION (mg/kg) Chlordane	DDD	DDE	DDT	Total Arsenic	Total Chromium	Total Lead	Total Mercury
Channel Catfish	456	965	<0.040	0.016	0.041	<0.020	<0.20	<0.20	<0.20	<0.09
Channel Catfish	460	908	<0.042	0.018	0.047	<0.021	<0.20	<0.19	<0.20	<0.10
Channel Catfish	334	341	<0.060	<0.020	<0.020	<0.030	<0.20	<0.19	<0.20	<0.08
Channel Catfish	314	284	<0.100	<0.030	<0.030	<0.050	<0.20	0.71	<0.20	<0.10
Channel Catfish	335	284	<0.057	<0.014	0.018	<0.028	<0.20	<0.20	<0.20	<0.10
Freshwater Drum	514	2497	0.122	0.050	0.124	0.039	0.22	<0.21	<0.20	<0.09
Freshwater Drum	368	681	<0.040	<0.010	0.022	<0.020	<0.20	<0.19	<0.20	<0.10
Freshwater Drum	275	284	<0.062	<0.016	0.019	<0.031	<0.20	2.69	<0.20	<0.10
Freshwater Drum	555	1305	0.098	0.044	0.098	0.036	<0.19	2.43	<0.19	<0.10
Freshwater Drum	328	454	<0.040	0.010	0.025	<0.020	<0.20	<0.20	<0.20	<0.10
Gizzard Shad	328	132	<0.100	<0.030	0.026	<0.050	0.23	<0.20	<0.20	<0.10
Gray Redhorse	485	1816	0.051	0.019	0.089	0.021	<0.20	1.23	<0.20	<0.09
Gray Redhorse	465	1702	<0.041	0.015	0.078	<0.020	<0.20	<0.20	<0.20	0.20
Gray Redhorse	490	2554	0.076	0.024	0.163	0.045	<0.20	<0.20	<0.20	0.26
River Carpsucker	273	284	<0.100	<0.030	<0.030	<0.050	<0.20	<0.20	<0.20	0.11
River Carpsucker	290	341	<0.051	<0.013	<0.013	<0.025	<0.20	<0.19	<0.20	<0.10

* Exceeds Oklahoma State Department of Health warning levels.
** Exceeds United States Food and Drug Administration action levels.

TABLE 10

PESTICIDE AND HEAVY METAL LEVELS IN FISHES
FROM STATION 14 : BAY CITY AREA

FISH TYPE	Total Length (mm)	Total Weight (g)	TISSUE CONCENTRATION (mg/kg) Chlordane	DDD	DDE	DDT	Total Arsenic	Total Chromium	Total Lead	Total Mercury
Largemouth Bass	365	851	<0.040	<0.010	0.025	<0.020	<0.20	<0.20	<0.20	0.56
Largemouth Bass	316	568	<0.040	0.017	0.054	<0.020	<0.20	<0.20	0.20	0.19
Largemouth Bass	285	328	<0.044	<0.011	<0.011	<0.022	<0.20	<0.20	<0.20	0.34
Channel Catfish	407	596	<0.040	<0.010	<0.010	<0.020	<0.20	<0.20	<0.10	<0.10
Channel Catfish	419	681	<0.040	<0.010	<0.010	<0.020	<0.20	<0.20	<0.10	0.16
Channel Catfish	401	653	<0.040	<0.010	0.016	<0.020	<0.20	<0.20	<0.10	0.13
Smallmouth Buffalo	557	3008	<0.040	0.015	0.048	<0.020	<0.20	<0.20	<0.10	<0.10
Smallmouth Buffalo	397	1135	<0.016	<0.040	0.069	<0.080	<0.20	<0.20	<0.10	0.14
Smallmouth Buffalo	393	1873	<0.162	<0.041	0.114	<0.081	<0.20	<0.20	<0.10	0.19
Gizzard Shad	379	653	0.095	0.056	0.081	<0.044	0.22	<0.20	<0.10	<0.11
Gizzard Shad	368	596	0.140	0.050	0.079	<0.080	<0.20	<0.19	<0.20	<0.08
Gizzard Shad	273	258	0.175	0.052	0.062	<0.094	0.21	<0.19	<0.20	<0.11

* Exceeds Oklahoma State Department of Health warning levels.
** Exceeds United States Food and Drug Administration action levels.

TABLE 11. Results of residue analysis on fillets of fishes collected from the Trinity River and its tributaries (Kleinsasser and Linam 1989). Values with asterisks exceed FDA criteria. (ND = not detected, C = three-fish composite, NA = not analyzed for.)

Station	Species	Chlordane (mg/kg)	DDE (mg/kg)	DDT (mg/kg)	Hg (mg/kg)	Pb (mg/kg)
Bear Creek	Yellow bullhead (C)	ND	ND	ND	0.065	<1.800
Bear Creek	Green sunfish (C)	ND	ND	ND	0.119	<1.600
Below Benbrook Dam	Yellow bullhead (C)	<0.010	<0.005	ND	0.055	<1.700
Below Benbrook Dam	Longear sunfish (C)	ND	ND	ND	0.253	<1.700
Below Benbrook Dam	Largemouth bass	ND	ND	ND	0.324	<1.700
Trinity Park	White crappie	0.050	0.006	ND	0.293	<1.700
Trinity Park	Green sunfish	ND	ND	ND	0.151	<1.700
Trinity Park	Largemouth bass	ND	ND	ND	0.530	<1.600
Purcy Drain	Bluegill sunfish (C)	0.340**	0.040	ND	0.073	<1.700
Purcy Drain	Gizzard shad	0.780**	0.050	ND	0.051	<1.900
Belt Line Road	Smallmouth buffalo	0.032	ND	ND	0.290	<2.800
Belt Line Road	Smallmouth buffalo	0.340**	0.030	0.120	0.360	<3.100
Commerce Street	Smallmouth buffalo	0.700**	0.170	0.080	0.209	<1.600
Commerce Street	Smallmouth buffalo	0.500**	0.100	0.050	0.172	<1.600
Commerce Street	Gizzard shad	0.840**	0.060	0.050	0.096	<1.600
Commerce Street	Gizzard shad	0.800**	0.090	0.100	0.073	<1.600
S. Loop 12	Smallmouth buffalo	0.500**	0.025	0.053	0.200	<2.700
FM 85	Smallmouth buffalo	0.250*	0.060	0.015	0.096	<3.100
FM 85	Freshwater drum	0.120	0.015	0.020	0.240	<1.600
FM 85	Blue catfish	0.080	0.009	ND	0.356	<1.600
FM 85	Gizzard shad	0.090	0.009	ND	0.078	<1.700
State Highway 31	Smallmouth buffalo	0.050	0.020	ND	0.185	<1.600
State Highway 31	Gizzard shad	0.190	0.025	ND	0.049	<1.700
U.S. 287	Blue catfish	0.014	0.010	ND	0.170	<2.200
U.S. 79	Smallmouth buffalo	0.170	0.054	0.016	0.140	<2.600
U.S. 79	Smallmouth buffalo	0.024	0.006	ND	0.046	<1.400
U.S. 79	Blue catfish	0.040	0.017	ND	0.175	<1.400
U.S. 79	Blue catfish	0.020	0.010	ND	0.223	<1.600
State Highway 7	Freshwater drum	ND	ND	ND	0.064	<3.000
State Highway 7	River carpsucker	0.047	0.012	ND	0.078	<3.100
State Highway 7	Flathead catfish	0.086	0.026	0.059	NA	NA
State Highway 21	Flathead catfish	0.077	0.038	0.040	0.340	<2.900
State Highway 21	White bass	0.140	0.050	ND	0.145	<1.600
State Highway 21	White bass	0.290*	0.170	0.060	0.132	<1.300
Elm Fork: Sandy Lake Road	White crappie	ND	ND	ND	NA	NA
Elm Fork: Sandy Lake Road	Longear sunfish	ND	0.006	ND	NA	NA
East Fork: Malloy Bridge	Longear sunfish	0.430**	0.065	0.085	NA	NA
East Fork: Malloy Bridge	Longear sunfish	0.190	0.110	0.070	NA	NA
East Fork: Malloy Bridge	Channel catfish	0.054	0.014	ND	0.120	<2.300
East Fork: Malloy Bridge	Smallmouth buffalo	0.030	0.020	ND	0.181	<1.600
East Fork: Malloy Bridge	Smallmouth buffalo	0.140	0.030	ND	0.209	<1.600

* Exceeds Oklahoma State Department of Health warning level
** Exceeds FDA action level and OSDH warning level

Table 12. Whole fish samples analyzed for selected metals from minimally impacted streams. From Texas Water Commission Stream Monitoring Network Data. Metals values cannot be compared directly to Colorado River data given differences in analytical methods.

Location	Species	Chlordane mg/kg	DDD mg/kg	DDT mg/kg	DDE mg/kg	As mg/kg	Cr mg/kg	Pb mg/kg	Hg mg/kg
Llano River	River carpsucker	< 0.005	0.030	0.090					
	Bluegill	< 0.005	0.022	0.030					
	River carpsucker	< 0.005	< 0.010	< 0.010					
	Redbreast sunfish	< 0.005	< 0.010	< 0.010					
Devils River	Channel catfish					< 0.200	< 0.600	< 0.600	0.140
	Channel catfish	< 0.005	< 0.010	0.020	0.087				
	Channel catfish	< 0.005	< 0.010	< 0.010	0.028	< 0.500	< 1.400	< 1.700	0.150
	Bass (Micropterus sp.)	< 0.010	< 0.010	< 0.010	0.040	< 0.500	< 0.700	< 1.600	0.220
	Bass (Micropterus sp.)	< 0.020	< 0.020	< 0.020	0.040	< 0.400	< 0.900	< 1.600	0.260
	Unspecified	< 0.020	< 0.020	< 0.020	0.170	< 0.400	2.300	< 1.700	0.110

APPENDIX A

1981 NATIONAL URBAN RUNOFF PROGRAM (NURP) STUDY

ANALYSIS OF TOXIC ORGANICS IN FISH TISSUE FROM LAKE AUSTIN
SEPTEMBER 1961

Species Common Name: Scientific Name	Weight (g)	Tail Length (cm)	Organics (µg/kg) in Tissue			
			DDD	DDE	DDT	PCBs
Bluegill Sunfish #3[2]: Lepomis macrochirus	86	16.5	27	250	10	<100
Bluegill Sunfish #4[2]:	66	14.6	20	180	<10	<100
Bluegill Sunfish #5[3]:	102	17.2	73	380	120	<100
Redear Sunfish #3[1]: Lepomis microlophus	160	20.3	280	870	200	<100
Redear Sunfish #4[1]:	185	23.5	24	87	30	<100
Redear Sunfish #5[2]:	76	15.9	85	230	10	<100
Redear Sunfish #6[2]:	59	15.3	20	120	<10	<100
Redear Sunfish #7[3]:	55	15.3	19	84	38	<100
Longnose Gar #1[2]: Lepisosteus osseus	398	58.4	310	2,700	200	<100
Longnose Gar #2[2]:	295	58.4	40	560	<10	<100

[1]Fish taken from ES-1 site.

[2]Fish taken from ES-2 site.

[3]Fish taken from ES-3 site.

From Nationwide Urban Runoff Program
Austin Report

ANALYSIS OF TOXIC ORGANICS IN FISH TISSUE FROM TOWN LAKE
SEPTEMBER 1981

Species Common Name: Scientific Name	Weight (g)	Tail Length (cm)	Organics (µg/kg) in Tissue			
			DDD	DDE	DDT	PCBs
Rio Grande Perch #1[3]: Cichlasoma cyanoguttatum	173	19.1	380	880	260	<100
Rio Grande Perch #2[3]:	172	19.1	1,500[4]	3,600[4]	790[4]	<100
Redbreasted Sunfish #1[1]: Lepomis auritus	236	20.7	160	670	380	<100
Redbreasted Sunfish #2[1]:	194	20.3	140	1,500	46	<100
Redbreasted Sunfish #3[2]:	91	17.2	350	1,400	290	<100
Bluegill Sunfish #1[2]: Lepomis macrochirus	165	-[5]	100	380	150	<100
Bluegill Sunfish #2[3]:	94	15.9	79	490	79	<100
Redear Sunfish #1[3]: Lepomis microlophus	150	20.3	40	380	150	<100
Redear Sunfish #2[3]:	150	19.7	160	560	60	<100
Largemouth Bass: Micropterus salmoides	428	31.8	40	370	40	<100

[1]ES-4 site.

[2]ES-5 site.

[3]ES-6 site.

[4]Sum of the DDT residue concentrations exceed the U.S. Food and Drug Administration cumulative standard of 5,000 µg/kg.

[5]Composite sample of several fish approximately 5 cm in length used in analysis.

From Nationwide Urban Runoff Program
Austin Report

APPENDIX B

1985 AUSTIN-TRAVIS COUNTY HEALTH DEPARTMENT STUDY

TABLE I
PESTICIDE ANALYSIS OF TOWN LAKE
Fish (fillet) 1985

all values expressed in milligrams/kilo = parts per million (ppm)

EPA Allowable levels
1. total DDT & metabolites - 5.0 ppm
2. no other applicable values set

FDA Action levles * (a) .300 ppm *
1. Chlordane - ~~1.0 ppm~~

** Value exceeds tolerance
C Indicates composite test sample

Type	Date Collected	Chlordane	DDT[i]	DDD[ii]	DDE[iii]	Total 1,2,3	Dieldrin	(PCB)
BLACK BASS								
1. EM5-51	2/27	-	0.015	-	0.065	-	-	-
2. C-EM5-52	2/27	0.061	0.025	0.023	0.10	0.15	-	-
3. C-EM5-60	2/27	0.066	0.022	-	0.074	-	-	-
4. C-EM5-67	2/27	0.023	-	-	0.042	-	-	-
5. C-EM5-72	2/27	-	-	-	0.022	-	-	-
6. EM5-74	2/27	0.046	0.014	-	0.059	-	-	-
7. C-EM5-75	2/27	-	-	-	0.028	-	-	-
STRIPPED BASS								
8. EM5-112	4/04	0.520	0.240	0.079	0.450	0.769	0.021	0.185
9. EM5-115	4/04	0.200	0.022	0.025	0.160	0.207	-	0.071
WHITE BASS								
10. EM5-59	2/27	0.23	0.12	0.055	0.19	0.365	0.01	-
SUNFISH *								
WARMOUTH ~~BASS~~								
11. C-EM5-69	2/27	$<$ 0.001	$<$ 0.001	$<$ 0.001	$<$ 0.001	-	$<$ 0.001	-
12. EM5-78	2/27	$<$ 0.001	$<$ 0.001	$<$ 0.001	$<$ 0.001	-	$<$ 0.001	-

* CCC CORRECTIONS TO TABLE

Type	Date Collected	Chlordane	DDT[i]	DDD[ii]	DDE[iii]	Total 1,2,3	Dieldrin	(PCB)
SUNFISH								
13. C-EM5-53	2/27	-	-	-	0.031	-	-	-
14. C-EM5-54	2/27	0.059	-	-	0.043	-	-	-
15. EM5-62	2/27	-	-	-	0.018	-	-	-
16. EM5-63	2/27	-	-	-	0.018	-	-	-
17. C-EM5-70	2/27	-	-	-	0.010	-	-	-
18. C-EM5-71	2/27	-	-	-	0.042	-	-	-
19. C-EM5-76	2/27	0.133	0.025	0.028	0.173	0.226	-	0.052
20. C-EM5-77	2/27	-	-	-	0.025	-	-	-
21. EM5-113	4/04	-	-	-	0.027	-	-	-
22. EM5-61	2/27	0.088	0.045	0.03	00.11	0.185	-	-
23. C-EM5-68	2/27	-	-	-	0.018	-	-	-
CARP								
24. EM5-50	2/27	**1.43	0.20	0.67	1.90	2.77	0.049	0.148
25. EM5-57	2/27	0.52	0.17	0.14	0.57	0.88	0.008	0.15
26. EM5-58	2/27	0.21	0.012	0.043	0.147	0.202	0.014	-
27. EM5-64	2/27	0.259	0.084	0.110	0.440	0.634	-	0.078
28. EM5-65	2/27	0.05	0.012	0.012	0.089	0.113	-	-
29. EM5-116	4/04	0.310	0.048	0.091	0.460	0.599	8.0	0.110
SHAD								
30. EM5-49	2/27	**1.96	0.58	0.59	3.6	4.77	0.04	0.59
31. C-EM5-55	2/27	0.485	0.072	0.060	0.286	0.418	0.034	0.113
32. EM5-56	2/27	0.91	0.37	0.34	1.0	1.81	0.024	-
33. EM5-66	2/27	0.175	0.031	0.021	0.12	0.172	-	-
34. EM5-73	2/27	0.334	0.030	0.023	0.37	0.423	-	0.10
35. EM5-114	4/04	0.570	0.210	0.149	0.860	1.219	0.021	0.350
36. EM5-117	4/04	0.073	0.011	-	0.074	0.085	-	0.071
CATFISH								
37. EM5-118	4/15	0.254	0.049	0.026	0.325	0.400	-	0.100
38. EM5-123	4/23	0.058	-	-	0.068	-	-	0.055

i, dichlorodiphenyltrichloroethane
ii, iii, chemical metabolites of DDT

Philip Zbylot, M.D., M.P.H.
Word Processing: Margie Martinez

APPENDIX C

1986 CLEAR CLEAN COLORADO RIVER ASSOCIATION FISH TISSUE STUDY

CCCA FISH TISSUE RESULTS - COLORADO RIVER, TEXAS

		CONSTITUENT (UG/KG WET WEIGHT)						
Fish Species	Location	Lead	Mercury	Chlordane	DDD	DDE	DDT	Dieldrin
Largemouth Bass	Above Onion Ck	<1000	<50	<25	<25	<25	<25	<50
Largemouth Bass	Below Onion Ck	<1000	<50	<25	<25	<25	<25	<50
Largemouth Bass	Webberville	<1000	<50	<25	<25	<25	<25	<50
Largemouth Bass	Travis Co. Park	<1000	<50	<25	<25	<25	<25	<50
Channel Catfish	Above Onion Ck	<1000	<50	<25	<25	<25	<25	<50
Channel Catfish	Below Onion Ck	<1000	<50	<25	<25	<25	<25	<50
Channel Catfish	Webberville	<1000	<50	40	<25	<25	<25	<50
Gray Redhorse	Above Onion Ck	-	-	370	-	-	-	-
Gray Redhorse	Below Onion Ck	-	-	650	-	-	-	-
Gray Redhorse	Webberville	-	-	40	-	-	-	-
Gray Redhorse	Travis Co. Park	-	-	100	-	-	-	-
Bluegill	Above Onion Ck	-	-	<50	-	-	-	-
Bluegill	Below Onion Ck	-	-	30	-	-	-	-

APPENDIX D

PARTICIPATING LABORATORY ANALYTICAL METHODOLOGY

THE LOWER COLORADO RIVER PESTICIDES STUDY

LCRA PARTICIPATION

LCRA's Environmental Lab received a set of 17 sediment samples on 03/02/88 and another set of 17 on 07/15/88. These samples required acid digestions prior to analysis for eight total metals. Outlined below are the target metals, the instrument used for analysis and their analytical EPA method number:

Metal	Instrument	Method No.
Arsenic	GFAA	EPA 206.2
Barium	ICP	EPA 200.7
Cadmium	ICP	EPA 200.7
Chromium	ICP	EPA 200.7
Lead	GFAA	EPA 239.2
Mercury	CVAA	EPA 245.5
Selenium	GFAA	EPA 270.2
Silver	ICP	EPA 200.7

The Lab received a set of 25 fish tissue samples on 03/29/88 and another set of 61 on 05/23/88. Outlined below are the target parameters, the instrument used for analysis and their analytical EPA method number:

Parameter	Instrument	Method No.
DDD	Tracor GC/HECD	EPA 600/4-81-055
DDE	Tracor GC/HECD	EPA 600/4-81-055
DDT	Tracor GC/HECD	EPA 600/4-81-055
Chlordane	Tracor GC/HECD	EPA 600/4-81-055
Arsenic	GFAA	EPA 206.2
Chromium	ICP	EPA 200.7
Lead	GFAA	EPA 239.2
Mercury	CVAA	EPA 245.5

The fish tissues were extracted within the undocumented 6-month suggested holding time furnished by EPA. The method used for sample preparation was taken from EPA 600/4-81-055. The initial steps involved cutting the fish into small chunks, grinding them in dry ice, and then allowing the dry ice to dissipate for at least 16 hours before continuing.

The metals (Arsenic, Chromium, Lead and Mercury) required the same Acid digestions used for sediments. The organics (DDD,DDE, DDT, and Chlordane) required Hexane extraction while grinding, extract solvent exchange, concentration, micro-filtration, gel permeation (furnished by the Texas Health Department) to remove oils and fats, extract solvent exchange, concentration, florisil column cleanup, extract solvent exchange and concentration.

Analysis of organics was performed on a Tracor 570 Gas Chromatograph (GC) with a 700A Hall Electrolytic Conductivity Detector (HECD) in the Halogen Mode. Confirmation of identified peaks was made by a VG 70-250 Magnetic Sector Gas Chromatograph/Mass Spectrometer (GC/MS).

Analysis of metals was performed on an Applied Research Laboratory 3510 Inductively Coupled Plasma (ICP) and a Hitachi 180-80 Atomic Absorption Spectrophotometer (AA) equipped with a Cold Vapor (CV) analyzer, a Hitachi Graphite Furnace (GF) and Zeeman Background Correction.

Lower Colorado River Study
Texas Dept. of Health Laboratory Participation

1/ Participation

34 water samples analyzed for insecticides and herbicides
17 sediment samples analyzed for insecticides and herbicides

2/ Laboratory Methods

Water

EPA Method 608 - Organochlorine Pesticides and PCB's Federal Register, Vol. 49, No. 209, p. 89,Oct. 26, 1984

Method 509-B, Chlorinated Phenoxy Acid Herbicides, 15th Edition, Standard Mehtods for the Examination of Water and Wastewater, 1980.

Sediment

Organochlorine and Organophosphorous Insecticides in Bottom Sediment, Manual of Analytical Methods for the Analysis of Pesticides in Humans and Environmental Samples, Section 11A, p.1, EPA - 600/8-80-038, June 1980.

Method 509-B, Cholorinated Phenoxy Acid Herbicides, 15th Edition, Standard Methods for the Examination of water and Wastewater, 1980.

3/ Pesticides Measurable by Methods and Detection Limits

	Water (PPB)	Sediment (PPB)*
Aldicarb	5.0	
Aldrin	0.2	1.0
Atrazine	5.0	50.
Azinphos (Methyl)	20.	
Azodrin	20.	
Amiben	5.0	
Alachlor	0.1	
-BHC	0.03	1.0
-BHC	0.03	1.0
Banuel	5.0	
Benefin	1.0	
Bromacil	1.0	20.
Captan	1.0	
Carboxin	20.	
Chlorothalonil (Bravo)	0.02	5.0
Chlordane (CIS)	0.2	3.0
Chlordan (Trans)	0.2	3.0
Chlordane (Total)	0.4	6.0
Dacthal	0.05	3.0
2,4 DCP	5.0	
2,5 DCP	5.0	
Dimethoate	0.2	10.

	Water (PPB)	Sediment (PPB)
Diazinon	0.3	5.0
Dieldrin	0.1	2.0
DEF	0.05	0.6
Dicamba	1.0	10.
Dursban	0.6	10.
Demeton	5.0	50.
PP-DDD	0.15	3.0
PP-DDE	0.10	1.5
PP-DDT	0.15	3.0
OP-DDD	0.15	3.0
OP-DDE	0.10	1.5
OP-DDT	0.15	3.0
DDD (Total)	0.30	6.0
DDE (Total)	0.20	3.0
DDT (Total)	0.30	6.0
Diuron	0.2	5.0
Dibutyl Phthalate	5.0	50.
Diethyl Phthalate	2.0	
Diethylhexyl Phthalate	50.	300.
Dimethyl Phthalate	2.0	50.
Endrin	0.2	3.0
Endrin Aldehyde	0.2	3.0
Endosulfan I	0.2	2.5
Endosulfan II	0.2	2.5
Endosulfan Sulfate	0.2	3.0
Ehtion	1.0	
Guthion	5.0	40.
Hexachlorobenzene	0.02	1.0
Heptachlor	0.02	0.5
Heptachlor Epoxide	0.06	1.0
Lindane	0.03	1.0
Malathion	0.4	5.0
Methoxychlor	0.5	10.
Mirex	0.5	5.0
Molinate	10.	
Methyl Parathion	0.25	3.0
Ethyl Parathion	0.25	3.0
PCB (Arochlors)	1.0	20.
Propanil	0.5	5.0
Propazine	5.0	50.
Profluralin	0.06	1.0
Phosalone	1.0	3.0
Pentachlorophenol (PCP)	2.0	5.0
Phorate	0.25	
Pyrethrins	5.0	
Pentachloronitrobenzene	0.02	0.4
Prometon		60.
Ronnel	0.7	
Sevin	50.	
Toxaphene	5.0	50.
Treflan	0.06	1.0
Vapona (Dichloruos)	0.3	
Velpar	50.	
Tebuthiuron (Spike)	20.	60.
Norflurazone	20.	50.
2,4 - D	20.	50.
Silvex	5.0	10.

	Water (PPB)	Sediment (PPB)
2,4,5 - T	5.0	10.
Decachlorobithenyl (DCB)	0.5	4.0
Pichloram	3.0	
Terbufos (counter)	0.4	

* - Detection limit for some pesticides have not been determined in a sediment matrix by our laboratory.

DEPARTMENT
OF AGRICULTURE
P. O. BOX 12847
AUSTIN, TEXAS 78711 - (512) 463-7476
An Equal Opportunity Employer

DECEMBER 21, 1989

Mark Wieland
3116 So. Congress
Austin, Tx 78704

Dear Mark,

Re: Documentation of TDA methodology on The Lower Colorado River Pesticide Study.

In response to your request for documentation of the methods used by the Texas Department of Agriculture Brenham and San Juan laboratories during the two year study, the following references are presented:

1. EPA Draft Method 1: Determination of Nitrogen- and Phosphorus-containing Pesticides in Ground Water by Gas Chromatography with a Nitrogen-Phosphorus detector. (1987)
2. EPA Draft Method 2: Determination of Chlorinated Pesticides in Ground Water by Gas Chromatography with an Electron Capture Detector. (1987)
3. EPA Draft Method 5: The measurement of N-Methylcarbamoyl Oximes and N-Methyl Carbamates in groundwater by direct aqueous injection by HPLC with Post Column Derivatization. (1987)

The methods referenced above have since been accepted in the EPA Drinking Water Methods (1989).

If we can be of any further assistance, please let us know.

Sincerely,

Ismael Nava

Ismael (Smiley) Nava
San Juan Lab Manager
Texas Dept. of Agriculture

APPENDIX E

CURRENT AUSTIN/TRAVIS COUNTY HEALTH DEPARTMENT HEALTH ADVISORY

AUSTIN-TRAVIS COUNTY HEALTH DEPARTMENT
PUBLIC INFORMATION OFFICE
CONTACT PERSON: BRUCE TRUITT 469-2118

TO: NEWS DIRECTORS

RE: **HEALTH ADVISORY--HUMAN CONSUMPTION OF TOWN LAKE FISH**

DATE: JULY 10, 1987

FOR IMMEDIATE RELEASE

Today the Austin-Travis County Health Department reinforced a 1985 Health Advisory urging citizens to cease consumption of certain species of fish found in Austin's Town Lake. Health officials stress that this measure is precautionary and is prompted by the presence of the pesticide chlordane in fish fillets at levels exceeding US Food and Drug Administration guidelines.

The species in which chlordane is present at significant levels are carp, shad and stripped bass as was first recognized in a 1985 Health Department study. Recent studies indicate that chlordane may be a cancer-causing agent in animals. It is this development which prompts the reinforcement of the initial advisory.

The principal source of the chlordane accumulation in Town Lake is believed to be washout from around building foundations treated for termite control.

-----MORE-----

At present, there is no concern over acute toxicity since there are no signs or symptoms associated with eating fish contaminated at the level of 2 parts per million. However, long term accumulation of chlordane in the body's fatty tissues can occur in persons who regularly consume these fish over extended periods of time.

Until chlordane's role as a carcinogen is further clarified and pending analyses of additional fish from Town Lake are complete, the Austin-Travis County Health Department strongly recommends that:

1. Carp, shad and stripped bass from Town Lake should not be consumed.

2. Persons who over a period of years have been regular consumers of fish from Town Lake should stop eating all fish from this source.

3. Persons regularly consuming species other than carp, shad and stripped bass should do so no more frequently than twice per month.

APPENDIX F

PARTICIPANT CONTACT LIST

RELIANCE MAILING LIST PARTICIPANT CONTACT LIST 1/ 4/1990 PAGE 1
User codes: 604 through 624. by Name

DeRoche Lawrence	Austin Health Department 15 Waller Street Austin, Tx 78702	Wk ph: 469-2015
Dvorsky Chuck	LCRA P.O. Box 220 Austin, Tx 78767	Wk ph: 473-3372
Halverson Wes	404 E. East First Street Austin, Tx 78701	Hm ph: 639-9639 Wk ph: 476-6192
Henderson Buck	L.C.R.A. P.O. Box 220 Austin, Tx 78767	Wk ph: 473-3374
Hinson Mel	Michael Brandon & Assoc. 3530 Red Hill Avenue Santa Anna, Ca 92705	Wk ph: 714-250-0555
Kleinsasser Roy	T.P.W.D. Post Office Box 947 San Marcos, Tx 78667	Wk ph: 353-3480
McClintock Nancy	City of Austin - E.C.S.D. P.O. Box 1088 Austin, Tx 78767	Wk ph: 499-2650
McCurdy Robert	Clear Clean Colorado Ranch Road 1, 30X Bastrop, Tx 78602	Wk ph: 321-7766
Mosier Doyle	L.C.R.A. P.O. Box 220 Austin, Tx 78767	Wk ph: 473-3597
Moss Randy	Tx. Parks & Wildlife Dept 4200 Smith School Road Austin, Tx 78744	Wk ph: 389-4726
Nava Smiley	Tx. Dept. of Agriculture Post Office Box 1157 Pharr, Tx 78577	Wk ph: 1-787-6866
Palacnek Randy	T.W.C. Post Office Box 13087 Capital Station Austin, Tx 78711	Wk ph: 463-8420
Palafox Dennis	Texas Parks & Wildlife Dp 4200 Smith School Road Austin, Tx 78744	Wk ph: 389-4726
Pimentel David	Travis Co. Environmental Analyst - P.O. Box 1748 Austin, Tx 78767	Wk ph: 320-7421

RELIANCE MAILING LIST PARTICIPANT CONTACT LIST 1/ 4/1990 PAGE 2
User codes: 604 through 604, by Name

Remaley Tom	L.C.R.A. P.O. Box 220 Austin, Tx 78767	Wk ph: 473-4001
Stecher Stephen	City of Austin - E.C.S.D. P.O. Box 1088 Austin, Tx 78767	Wk ph: 499-8550
Sweet Charles	State Health Lab 1100 West 49th Street Austin, Tx 78756	Wk ph: 458-7318
Wieland Mark	Clear Clean Colorado 3116 S. Congress Austin, Tx 78704	Hm ph: 462-0432 Wk ph: 462-1588

18 NAMES PRINTED