TEXAS DEPARTMENT OF WATER RESOURCES

REPORT 264

PESTICIDE AND PCB CONCENTRATIONS IN TEXAS—WATER, SEDIMENT, AND FISH TISSUE

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INTRODUCTION

The role of pesticides in controlling unwanted insects and weeds has been recognized since the mid-nineteenth century. From that time to the present, their use has increased from the application of a single compound to combat the Colorado potato beetle to the usage of millions of pounds of insecticides and herbicides in the United States annually. The concerns of this report are directed toward those compounds that eventually make their way into lakes, rivers, and estuaries where they are potentially hazardous to the people and wildlife of the State of Texas. In the sections following the introduction, the sources of data, methods of collection and analysis, criteria used for evaluation, and factors affecting ambient concentrations are discussed prior to the evaluation of actual levels in water, sediment, and fish tissue.

As background for the rest of the report, this introduction discusses briefly the history and development of the various compounds, the pathways of pesticides in the environment, their presence in organisms, and the need for monitoring environmental levels.

Development of Pesticides

Through the 1920's, insecticides were derived from a small range of inorganic copper and arsenic compounds, or from naturally occurring substances such as pyrethrum, nicotine, and rotenone. With the exception of pyrethrum and nicotine which acted as neurotoxins, these early insecticides inhibited the production of ATP (adenosine triphosphate) which supplies the energy necessary for muscular and other activity.

The first synthetic insecticide, dithiocyanodiethyl ether, was developed in 1929, but the period of most intense research began in 1939 with the synthesis of the organochlorine DDT in Switzerland. It was a neurotoxin which affected the nerve covering and had residual effects lasting for months. Chemically related compounds such as methoxychlor and DDD acted in the same way.

The potential of other chlorinated hydrocarbons was rapidly uncovered. In 1942 BHC (Benzene hexachloride or hexachlorocyclohexane) was discovered by the French and English. Its most effective isomer, gamma-BHC, was marketed in a pure grade form under the name lindane. Another cyclodiene, chlordane, a mixture of terpenoid compounds, was found to be an effective residual insecticide in 1945. By 1948, chlordane's most active ingredient, heptachlor, and two other derivatives, aldrin and dieldrin, were available. Around the same time toxaphene, obtained by the chlorination of turpentine, was also marketed. This whole group of cyclodienes were neurotoxic like DDT but acted at the nerve ganglion rather than along the nerve axon.

A new group of compounds, the organophosphates, grew out of the German chemical warfare effort. They were modified to be used as insecticides, and, in 1945, parathion appeared, followed by malathion and then diazinon. Today, there are numerous organophosphate compounds, both liquids and solids, which generally fall into the three main categories of phosphorothioates (parathion, methyl parathion, diazinon), phosphorodithioates (malathion), and phosphates (dichlorvos). Like the cyclodiene derivatives, the organophosphates are ganglionic poisons which result in tetanic paralysis. Some of them are also used as systemic herbicides.

Like the insecticides, the first herbicides were generally arsenical compounds which brought about rapid contact injury due to membrane breakdown. Sodium arsenite was used as a soil sterilant as early as 1900, and the next significant development was of the synthetic organic DNOC in 1935. It worked by destroying the roots and conducting vessels of the plant.

Concurrent research in Britain and the United States resulted in the phenoxy herbicides by 1944.

These were divided into two categories: MCPA and 2,4-D for broad-leaved weeds, and 2,4,5-T and silvex for woody perennials. Rather than poisoning the plants, these compounds behave like growth hormones except they cause uncontrolled cell division. Eventually the plant dies from softening of the roots and necrosis in all tissues.

Pesticides in the Environment

Pesticides reach the environment through a variety of pathways, the most common of which are discussed below. In rural agricultural areas pesticides reach water systems in such ways as deliberate application to water bodies for the control of undesirable aquatic plants and insects; aerial application for terrestrial pests; windblown drifts from aerial application, as much of the spray remains for a time in the atmosphere; adherence to soil particles, hence to water systems by rainfall runoff; and accidental spills.

The major route of pesticides to water systems in urban areas is through rainfall runoff. Most homeowners use fertilizers containing herbicides or pesticides in addition to those applied separately to lawns and gardens. Large open spaces such as golf courses, parks, and vegetated ditch banks are also treated on a regular basis. These compounds enter storm sewers from lawn watering or rainfall where they tend to accumulate until a major rainfall event flushes the storm sewer system. The first flush of storm water may therefore contain a high concentration of pesticides. Improper disposal of excess quantities of pesticides into sanitary or storm sewers constitutes another potentially significant source in urban areas. Pesticides may also be carried directly to receiving water by runoff.

Another source of pesticides in State waters is from municipal and industrial dischargers. These entities can receive pesticides from storm sewers, infiltration, illegal disposal, spills, and from industrial waste. Treatment plants that are overloaded or have insufficient solids removal would be expected to discharge more pesticides, because of most pesticides' attraction to particulate matter.

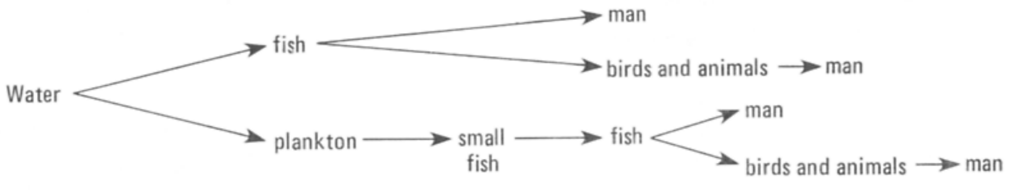
Once in the water, the fate of a given pesticide will be a function of its persistence and solubility. More soluble compounds will readily dissolve in the water, but most of the pesticides, especially the chlorinated hydrocarbons, are relatively insoluble and have an affinity for particulate matter. They become part of the suspended sediment load and will continue to move with the stream until the velocity of flow no longer carries them. Once deposited as silt, the compounds may be detectable in sediment but not in water samples, yet still exert an influence on the water. Physical processes such as high streamflow or man's activities cause mixing of materials from the sediment into the water. Chemical changes resulting from seasonal variations, oxygenation, and respiration also influence the rate of movement and distribution of compounds between water and sediment.

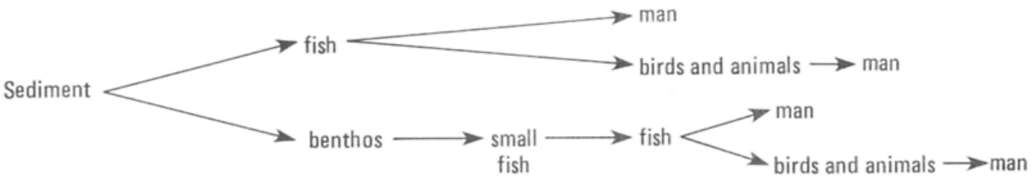
Pesticides in Organisms

If a compound persists for a significant length of time, it will eventually be incorporated in the native biota through one of the following pathways:

The primary mechanisms involved in the transfer and concentration of compounds in and through the various organisms are bioaccumulation and biomagnification.

Bioaccumulation involves uptake from the environment—surrounding water or sediment—into body tissues. Some species of plankton have been shown to concentrate pesticides 265 times the amount found in





surrounding water (Brown, 1978). Benthos and bottom-feeding fish may directly consume contaminated sediments. Fish may also absorb compounds through the skin and gills, and over a period of time in contaminated water, levels in a given organism may be quite high.

Biomagnification is the increased concentration of a contaminant at successively higher trophic levels, so that organisms at the top of the food chain have the highest concentrations. For this reason, fish feeding on plankton and benthic macroinvertebrates have generally higher concentrations than either the plankton or benthos. In a now classic example, DDT was concentrated up the food chain through fish to piscivorous birds where it caused thin eggshells and consequent population decline. In aquatic systems, fish are the highest trophic level and, therefore, tend to have the largest concentrations of contaminants.

Bioaccumulation and biomagnification may be occurring concurrently in the same organism. For instance, large fish preying on bottom- and plankton-feeding fish experience biomagnification while they may also tend to have higher pesticide levels from bioaccumulation due to anatomical differences, such as larger digestive and gill system surface areas and higher lipid content.

Monitoring Pesticides in the Environment

Pesticide levels in the environment are monitored for two basic reasons. First, many pesticides are toxic to humans. Pesticide residues in domestic water supplies, or in organisms used as food, may constitute a threat to human health, depending upon such factors as residual concentration, intensity of utilization of the water or food resource, residual toxicity, and the presence or absence of other agents that tend to either mitigate or intensify the effects of the pesticides. Environmental monitoring data and knowledge of these other factors provide a basis for avoiding potential instances of pesticide poisoning and for correcting the problem by eliminating the source of contamination.

Secondly, the effects of some pesticides on non-target species can reduce or eliminate those species in the affected area. Due to ecological relationships such as food webs, pollination, and cover (habitat) requirements, reductions in some species can lead to reduction in others. From man's standpoint, a commercial or sport fishing resource could be damaged, or the biological community in a recreational area could be made less diverse and enjoyable. A program of collection and evaluation of environmental data can be utilized to protect these resources from pesticide damage.

In light of all this, the Enforcement and Field Operations Division of the Texas Department of Water Resources maintains the Statewide Monitoring Network (SMN) which includes monitoring of common pesticides in water, sediment, and fish tissue at selected locations statewide.

While the presence of a pesticide in water and sediment is more indicative of recent contamination, the persistence and low water solubility of most of the compounds result in their eventually being concentrated in fish tissues. Non-migratory fish concentrate pesticides form their environment throughout their life span and consequently are valuable indicators of past and present pollution and, in general, a monitoring mechanism less ephemeral than water and sediment conditions.

All these data, combined with appropriate data from other monitoring programs, are utilized to identify and correct problems associated with the use or misuse of pesticides.

SOURCES OF DATA

Pesticide data for water and sediments which are used in this report were collected by the Texas Department of Water Resources and supplemented with U.S. Geological Survey data where available at the Department's Statewide Monitoring Network stations. These data may also appear in other publications. From October 1973 to December 1977, the Texas Department of Water Resources and U.S. Geological Survey made approximately 2,000 determinations for pesticides in water and sediment at the sites given in Table 1. Subsequent changes in sites have been made, based on evaluation of data already collected and the need for information in previously uninvestigated areas. The sites were chosen because of their proximity to highly populated urban areas, agricultural areas, or locations in bay systems which receive water and sediment from the major river systems. Based on toxicity, persistence, bioaccumulation, and magnitude of use, the Texas Department of Water Resources has concentrated its monitoring program upon the chlorinated hydrocarbons, organophosphates, and phenoxy herbicides.

In addition, pesticide data collected during intensive monitoring surveys conducted by the agency were also utilized. These data constituted most of the information on pesticides in reservoirs. The time frame covered for this information is from 1972 to 1977. The bodies of water sampled in this program are given in Table 2.

Data on pesticides in tissue were obtained by this Department, by the Texas Parks and Wildlife

Table 1.—Statewide Monitoring Network (SMN) Stations That Have Been or Are Being Routinely Monitored for Pesticides in Water, Sediment, or Tissue. Sites are shown on Figure 1, and are more specifically described in the "Statewide Monitoring Network Station Inventory Report" (Texas Department of Water Resources, 1978).

Station	Location	Number of Samples included in this report		
		Sediment	Water	Tissue
	Inland Waters			
0101.0100	Canadian River	2	22	—
0101.0300	do	1	—	—
0102.0400	Lake Meredith	2	2	—
0102.0500	do	1	1	—
0103.0100	Canadian River	13	18	—
0103.0200	do	9	9	—
0104.0100	Wolf Creek	—	2	—
0105.0100	Rita Blanca Lake	—	1	—
0105.0200	do	—	1	—
0200.0500	Mackenzie Reservoir	9	1	—
0202.0100	Red River	16	17	—
0204.0100	do	2	16	—
0205.0100	do	4	16	—
0207.0100	Prairie Dog Town Fork Red River	—	3	—
0214.0100	Wichita River	3	4	—
0219.0100	Lake Wichita	1	—	—
0220.0100	Pease River	—	2	—
0222.0100	Salt Fork Red River	—	2	—
0223.0400	Greenbelt Lake	3	3	—
0302.0100	Wright Patman Lake	3	—	—
0303.0200	Sulphur River	18	18	—
0400.0300	Little Cypress Creek	15	15	—
0402.0100	Cypress Creek	4	2	—
0403.0100	Lake O' the Pines	2	—	—
0500.0600	Big Cow Creek	1	—	—
0503.0100	Sabine River	1	—	—
0503.0200	do	—	2	—
0503.0300	do	9	9	—
0504.0200	Toledo Bend Reservoir	3	—	—
0505.0200	Sabine River	20	19	—
0506.0100	do	3	3	—
0507.0100	Lake Tawakoni	3	—	—
0600.0100	Bayou La Nana	1	—	—
0602.0100	Neches River	16	19	—
0604.0200	do	3	—	—

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Station	Location	Number of samples included in this report		
		Sediment	Water	Tissue
	Inland Waters			
0604.0400	Neches River	—	1	—
0610.0200	Sam Rayburn Reservoir	1	—	—
0611.0100	Angelina River	—	3	—
0802.0100	Trinity River	3	—	—
0802.0200	do	—	1	—
0803.0025	Lake Livingston	1	—	—
0803.0200	do	3	16	—
0804.0300	Trinity River	9	—	—
0804.0400	do	2	—	—
0805.0100	do	16	19	—
0805.0300	do	10	12	—
0806.0200	West Fork Trinity River	1	—	—
0812.0100	do	3	3	—
0824.0100	Elm Fork Trinity River	3	4	—
0831.0100	Clear Fork Trinity River	2	2	—
0834.0100	Lake Amon G. Carter	1	—	—
1000.0600	Halls Bayou	8	17	—
1000.0800	Hunting Bayou	—	1	—
1000.0900	do	11	15	—
1000.2700	Buffalo Bayou	8	16	—
1000.2900	do	8	11	—
1003.0100	East Fork San Jacinto River	2	2	—
1004.0100	West Fork San Jacinto River	2	2	—
1012.0100	Lake Conroe	1	—	—
1012.0200	do	1	—	—
1102.0100	Clear Creek	2	—	—
1102.0200	do	1	—	—
1106.0150	Bastrop Bayou	—	1	—
1200.0500	Buffalo Springs Lake	1	3	1
1200.1600	Allens Creek	3	—	—
1200.1800	Bessies Creek	2	—	—
1200.2300	Little Brazos River	1	1	—
1202.0100	Brazos River	18	17	—
1202.0133	do	2	—	—
1202.0166	do	2	—	—
1202.0300	do	—	2	—
1202.0600	do	—	7	—

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		Number of samples included in this report		
Station	Location	Sediment	Water	Tissue
	Inland Waters			
1203.0300	Whitney Lake	2	—	—
1204.0100	Brazos River	1	2	—
1206.0300	do	3	3	—
1208.0300	do	4	2	—
1209.0300	Navasota River	—	1	—
1212.0100	Somerville Lake	—	2	—
1212.0200	do	1	2	—
1213.0100	Little River	—	2	—
1216.0200	Stillhouse Hollow Lake	2	—	—
1220.0300	Belton Lake	2	—	—
1225.0200	Waco Lake	2	—	—
1225.0300	do	1	—	—
1226.0100	Bosque River	—	2	—
1232.0150	Clear Fork Brazos River	8	8	—
1232.0200	do	2	—	—
1232.0400	do	—	2	—
1241.0100	Double Mountain Fork Brazos River	1	2	—
1302.0100	San Bernard River	—	2	—
1400.0100	Beals Creek	—	1	—
1400.0200	do	1	—	—
1402.0100	Colorado River	14	21	—
1402.0200	do	2	1	—
1402.0700	do	—	1	—
1409.0100	do	2	2	—
1409.0150	do	—	1	—
1410.0100	do	—	8	—
1412.0200	do	—	2	—
1414.0100	Pedernales River	2	3	—
1414.0200	do	—	2	—
1417.0100	Pecan Bayou	1	—	—
1421.0100	Concho River	13	16	—
1421.0150	do	—	1	—
1421.0300	do	—	3	—
1422.0100	Lake Nasworthy	1	—	—
1423.0100	Twin Buttes Reservoir	1	—	—
1602.0100	Lavaca River	13	15	—
1602.0200	do	3	—	—
1603.0100	Navidad River	14	14	—

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Station	Location	Number of samples included in this report		
		Sediment	Water	Tissue
	Inland Waters			
1603.0200	Navidad River	3	–	–
1802.0100	Guadalupe River	16	18	–
1803.0200	do	2	1	–
1805.0400	Canyon Lake	3	–	–
1806.0200	Guadalupe River	1	–	–
1806.0300	do	–	1	–
1808.0100	San Marcos River	1	1	–
1900.0100	Salado Creek	–	12	–
1901.0100	San Antonio River	8	20	–
1901.0300	do	17	14	–
1901.0650	do	–	12	–
1902.0100	Cibolo Creek	3	1	–
1903.0100	Medina River	15	14	–
1903.0200	do	4	–	–
1905.0100	do	–	11	–
1906.0100	Leon Creek	1	–	–
2000.0500	Poesta Creek	1	1	–
2002.0100	Mission River	16	17	–
2004.0100	Aransas River	1	1	–
2100.0100	Hondo Creek	–	11	–
2100.0200	Seco Creek	–	10	–
2103.0130	Lake Corpus Christi	2	2	–
2103.0200	do	3	–	–
2104.0100	Nueces River	14	23	–
2106.0050	Frio River	10	12	–
2107.0200	Atascosa River	1	–	–
2111.0100	Sabinal River	–	11	–
2112.0300	Nueces River	3	12	–
2302.0200	Rio Grande	2	1	–
2302.0300	do	–	1	–
2303.0100	Falcon Reservoir	2	–	–
2304.0200	Rio Grande	2	–	–
2306.0100	do	–	1	–
2306.0300	do	3	8	8
2307.0100	do	1	–	–
2308.0100	do	2	1	–
2310.0100	Pecos River	1	–	–
2311.0100	do	–	4	–

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Station	Location	Number of samples included in this report		
		Sediment	Water	Tissue
	Bays and Estuaries, Including Tidal Portions of Rivers			
0501.0100	Sabine River Tidal	3	—	—
0508.0100	Adams Bayou Tidal	—	3	—
0601.0100	Neches River Tidal	2	—	1
0601.0500	do	2	—	—
0700.0100	Taylor Bayou	2	—	—
0703.0200	Sabine Neches Canal	2	—	—
0801.0100	Trinity River Tidal	3	—	—
0901.0100	Cedar Bayou Tidal	—	3	—
1000.0200	Greens Bayou	—	1	—
1001.0100	San Jacinto River Tidal	1	1	—
1001.0200	do	1	—	—
1005.0100	Houston Ship Channel	3	2	—
1006.0100	do	3	2	—
1006.0200	do	2	2	—
1006.0300	do	3	2	—
1007.0100	do	3	2	—
1101.0100	Clear Creek Tidal	1	3	—
1103.0200	Dickinson Bayou Tidal	3	—	—
1105.0200	Bastrop Bayou Tidal	—	2	—
1107.0100	Chocolate Bayou Tidal	—	3	—
1301.0100	San Bernard River Tidal	1	—	—
1304.0100	Caney Creek Tidal	3	1	—
1401.0100	Colorado River Tidal	2	—	—
1501.0100	Tres Palacios Creek Tidal	1	—	—
1700.0100	Chocolate Bayou	2	—	—
1700.0300	Lynns Bayou Basin	1	—	—
1701.0200	Victoria Barge Canal	2	—	—
2001.0100	Mission River Tidal	1	—	—
2003.0100	Aransas River Tidal	3	1	—
2101.0100	Nueces River Tidal	—	1	—
2200.0100	Cayo Del Oso	1	—	—
2201.0100	Arroyo Colorado Tidal	2	2	1
2201.0200	do	3	2	—
2301.0100	Rio Grande Tidal	2	2	—
2411.0100	Sabine Pass	1	—	—

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Station	Location	Number of samples included in this report		
		Sediment	Water	Tissue
	Bays and Estuaries, Including Tidal Portions of Rivers			
2412.0200	Sabine Lake	3	–	–
2421.0400	Galveston Bay	3	2	–
2423.0100	East Bay	4	2	–
2424.0100	West Bay	3	2	–
2431.0100	Moses Lake	1	–	–
2434.0100	Christmas Bay	3	3	–
2441.0100	East Matagorda Bay	2	–	–
2451.0100	Matagorda Bay	2	–	–
2451.0200	do	2	–	–
2452.0100	Tres Palacios Bay	2	–	–
2453.0100	Lavaca Bay	1	–	–
2453.0200	do	2	–	–
2453.0300	do	2	–	–
2454.0100	Cox Bay	2	–	–
2455.0100	Keller Bay	2	–	–
2456.0100	Carancahua Bay	2	–	–
2461.0100	Espiritu Santo Bay	2	–	–
2462.0100	San Antonio Bay	2	–	–
2462.0300	do	1	–	–
2463.0100	Mesquite Bay	1	–	–
2471.0100	Aransas Bay	2	–	–
2472.0100	Copano Bay	3	–	–
2481.0100	Corpus Christi Bay	2	–	–
2481.0400	do	1	–	–
2481.0500	do	2	–	–
2482.0100	Nueces Bay	1	1	–
2482.0200	do	1	1	–
2482.0300	do	3	1	–
2482.0400	do	1	1	–
2483.0100	Redfish Bay	2	–	–
2484.0100	Corpus Christi Inner Harbor	3	–	–
2484.0200	do	5	3	2
2484.0300	do	3	–	–
2491.0200	Laguna Madre	3	–	–
2492.0200	Baffin Bay	2	–	–
2494.0100	Brownsville Ship Channel	1	2	–
2501.0400	Gulf of Mexico	1	–	–

Table 2.—Intensive Monitoring Surveys Conducted by Texas Department of Water Resources. These surveys included collection of sediment samples for pesticide analysis. General Locations of the Surveys are Indicated on Figure 2.

Intensive Monitoring Survey	Location	Segment
1	Pedernales River	1414
2	Concho River	1421
3	Lake Tawakoni	0507
4	Bardwell Lake	0815
5	Lake Lewisville	0823
6	Lake Lavon	0821
7	Pecan Bayou	1417
8	Lake Ray Hubbard	0820
9	Lake Livingston	0803
10	Toledo Bend Reservoir	0504
11	Falcon Reservoir	2303
12	Sam Rayburn Reservoir	0610
13	Clear Fork Brazos River	1232
14	Adams Bayou	0508
15	Hubbard Creek Reservoir	1233
16	Taylor Bayou	0701
17	Wright Patman Lake	0302
18	Sulphur River	0303
19	Lake Arlington	0828
20	Somerville Lake	1212
21	Amistad Reservoir	2305
22	Cedar Creek Reservoir	0818
23	Grapevine Lake	0826
24	Lake Meredith	0102
25	O. C. Fisher Lake	1425
26	Lake Travis	1404
27	Lake Nasworthy	1422
28	Twin Buttes Reservoir	1423
29	Lake Corpus Christi	2103
30	San Antonio River	1901
31	Sabine River	0505
32	Possum Kingdom Lake	1207
33	Whitney Lake	1203
34	Lakes Dunlap and McQueeny	1804
35	Lake Texoma	0203
36	Caney Creek Above Tidal	1305
37	Lake Granbury	1205
38	Cibolo Creek	1902
39	Lake O' the Pines	0403
40	Chiltipin Creek	—

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Intensive Monitoring Survey	Location	Segment
41	Lake Houston	1002
42	Lake Austin	1403
43	Lake Wichita	0219
44	Lake Buchanan	1408
45	Leon Creek	1906
46	Medina River	1903
47	Rita Blanca Lake	0105
48	Black Bayou	0406
49	James Bayou	0407
50	Caddo Lake	0401
51	Big Cypress Creek	0404
52	Lake Amon G. Carter	0834
53	Nueces River Tidal	2101
54	Bastrop Bayou Above Tidal	1106
55	Neches River Tidal	0601
56	McKinney Bayou	0225
57	Trinity River	0804 0805 0806 0819 0822
58	Red Bluff Reservoir	2312
59	Lake Brownwood	1418
60	Chocolate Bayou Above Tidal	1108
61	Little Wichita River	0211
62	Clear Creek, Tidal and Above	1101 1102
63	Colorado River	1412
64	Oyster Creek Above Tidal	1110
65	Cypress Creek	1009
66	Nueces Bay	2482
67	Red River	0204
68	Noland River	1227
69	Pease River	0220
70	Lavaca Bay	2453
71	Dickinson Bayou, Tidal and Above	1103 1104

Table 3.—Urban Runoff Measurement Stations in the Statewide Monitoring Network (SMN) Where Pesticide Residues in Fish Tissue are Monitored on an Annual Basis. Monitoring was Initiated Spetember 1, 1977.

Station	Location
0601.0100	Neches River Tidal at State Highway 87 bridge north of Port Arthur.
0805.0100	Trinity River at State Highway 34 southwest of Rosser.
1006.0100	Houston Ship Channel at San Jacinto Monument.
1200.0500	Buffalo Springs Lake at dam.
1901.0300	San Antonio River at Farm Road 1518 west of Elmendorf
2201.0200	Arroyo Colorado Tidal at low water bridge at Port Harlingen.
2484.0200	Corpus Christi Inner Harbor near Navigation Bridge.

Department, and by the U.S. Fish and Wildlife Service. In September 1977, the Department of Water Resources initiated monitoring of pesticides in fish tissue at seven established urban runoff measurement stations (Table 3). These and special survey or complaint data, which comprised the basis for this topic of the report, are presently too few to be considered representative of mean concentrations of pesticide residues in fish tissue throughout the State.

METHODS OF DATA COLLECTION AND ANALYSIS

Collection Methods

Water samples obtained by the Texas Department of Water Resources were collected at depths of approximately 1 foot below the surface, except those collected in the Houston Ship Channel which were composited from the bottom to the surface. The samples were stored in glass jars with teflon liners and kept on ice until shipment to one of three contracted laboratories for analysis by gas chromatography techniques.

Sediment samples were collected with either an Ekman or Peterson dredge, composited, mixed, and stored in glass jars with teflon liners. Iced samples were then sent to one of the three contracted laboratories for analysis by gas chromatography techniques.

Fish tissue samples were obtained with standard fish collection equipment, that is, seines, gill nets, trawls, and electroshock. Prepared samples were wrapped in aluminum foil, placed in plastic bags, and frozen or kept on ice until they could be hand delivered to the appropriate laboratory. In some cases larger fish were dissected to allow for analysis of edible tissue or individual organs. Minnows and other small fish were analyzed as whole fish.

All pesticide analyses were conducted by the following contracted laboratories: Texas Department of Health Laboratory, Austin; Texas Department of Water Resources—U.S. Environmental Protection Agency Laboratory, Houston; and the Sabine River Authority of Texas Laboratory in Orange.

Concentrations of pesticides in water are expressed as micrograms per liter (μg/l), with 1 μg/l being equivalent to one part pesticide per billion parts water. Pesticide concentrations in sediment and fish samples are expressed as micrograms per kilogram (μg/kg), or one part pesticide per billion parts sediment (dry weight) or tissue (wet weight).

Analytical Methods

Because of the numerous interferences involved in pesticide analysis, environmental samples of water, tissue, and sediment must go through separation and cleanup procedures before being analyzed by gas chromatography techniques.

Separation Procedure.—If the sample is sufficiently free of interfering materials, the pesticides can be extracted with an organic solvent, concentrated by evaporation of all of the solvent but a few milliliters, and analyzed by gas chromatography. This situation seldom exists except in samples such as treated potable water; therefore, the sample after the initial extraction must be purified. One widely used technique is to evaporate the extracting solvent, dissolve the residue in petroleum ether, and extract with acetonitrile. The acetonitrile is diluted with distilled water and extracted with petroleum ether. These exchanges leave behind many interfering materials such as fats. If sufficient interfering materials have been eliminated, the concentrated solvent can then be analyzed by gas chromatography. However, most samples will require treatment with florisil. The concentrated sample is transferred to the surface of a prepared florisil column and eluted with 200 ml of 6 percent ethyl ether in hexane. These separate fractions, after concentration by evaporation to a small volume, usually 2 to 5 milliliters, are analyzed by gas chromatography. Each fraction will contain a different group of pesticides if present. Some samples may require additional specialized techniques for purification.

Gas Chromatograph.—A gas chromatograph apparatus is made up of several basic elements including the injection unit, column, oven, carrier gas, detector, and recording device. The response is dependent on such factors as the volume of unknown compound injected, the length of the column and the mobile and support phase in the column, the type of detector, the use of different carrier gases and different flow rates, and the temperature of the oven. By manipulating these variables, the analyst can achieve better separation of compounds which might otherwise reach the detector at the same time, making identification and measurement impossible.

The analysis consists of injecting a small volume of the purified sample extract into the gas chromatograph, measuring the time of elution and the magnitude of the peak recorded as the pesticide reaches the detector, and comparing these measurements with one obtained with like equipment from known compounds.

Confirmation.—Following an initial analysis, it is essential that the analysis be confirmed to exclude other compounds that might behave similarly in the particular column used. This is done by changing columns; a general rule is that confirmation required detection and measurement on at least two dissimilar columns. Confirmation can also be assisted by use of different detectors:

a. An electron capture detector is the most sensitive and is used for halogen compounds and some others.
b. A flame ionization detector is used for hydrocarbons.
c. A flame photometric detector is specific for organophosphates and sulfur compounds.
d. Microcoulometric filtration is specific for halogens but lacks the sensitivity for most pesticide levels found in environmental residues.

CRITERIA FOR EVALUATING PESTICIDE CONCENTRATIONS

In this report, sample results for pesticides in water are compared to criteria established by the U.S. Environmental Protection Agency in 1976 and published in "Quality Criteria for Water" (Table 4). In addition, the recommended pesticide limits for protection of marine habitats published by the Environmental Protection Agency in 1976 in "The Ecological Impact of Synthetic Organic Compounds on Estaurine Ecosystems" (Table 5) are used for comparative purposes. Also available for use in evaluating Texas data are the tolerances established by the U.S. Food and Drug Administration for pesticide levels in edible fish and shellfish (Table 6). At the time this report was prepared these were the sources of the most current criteria available for evaluating environmental data on pesticide levels in water and tissue. There are no comparable criteria for evaluating levels in sediment.

The Environmental Protection Agency 1980 water quality criteria for fresh water and marine life have superceded, for 9 pesticides, the 1976 criteria used in preparation of this report. These 1980 criteria are shown in Appendix I.

Water quality criteria are not water quality standards. Water quality standards are established for selected constituents in Texas surface waters in the "Texas Water Quality Standards", upon approval by the Texas Department of Water Resources and the U.S. Environmental Protection Agency. These standards take into account the uses desired for a given body of water, and the natural or background level of water quality. There are no water quality standards for pesticides in Texas waters. Data from the Texas Department of Water Resources monitoring program and other sources are presently being evaluated to determine whether such standards are necessary.

Water quality criteria, on the other hand, provide a basis for establishing standards. As derived in the "Quality Criteria for Water" (Table 4), criteria take into account information on such factors as acute toxicity (Table 7), chronic toxicity, bioaccumulation, magnification by food chains, and antagonistic or synergistic interactions with other constituents that might be present. They do not depend on considerations of economic or technological feasibility. Also, they do not allow for regional differences in background levels or tolerances of the aquatic organisms present. As a result, criteria tend to be at least as restrictive, if not more so, than the standards derived from them. Also, because

Table 4.—Criteria for Pesticides in Water, Derived From "Quality Criteria for Water" 1976, U.S. Environmental Protection Agency. (All Values are Expressed as $\mu g/l$—parts per billion.)

Pesticide	Raw water supplies	Fresh water	Marine
2,4-D	100	—	—
2,4,5-T	—	—	—
Silvex	10	—	—
Heptachlor*	10	0.001	0.001
Heptachlor epoxide	—	—	—
Lindane*	4.0	.01	.004
Methoxychlor	100	.03	.03
Aldrin* and dieldrin*	—	.003	.003
Endrin*	.02	.004	.004
Chlordane*	—	.01	.004
Toxaphene*	5.0	.005	.005
Total DDT* (DDT + DDD + DDE)	—	.001	.001
Malathion	—	.1	.1
Parathion	—	.04	.04
Methyl parathion	—	—	—
Diazinon	1.0	.009	.009
PCBs*	—	.001	.001

*See Appendix I for 1980 criteria revisions. The 1980 criteria were published by the U.S. Environmental Protection Agency subsequent to completion of this report.

they are not constrained by considerations of technological feasibility, pesticide criteria in some cases fall well below the limits of detection employed by laboratories in analyzing samples for their presence.

Through application of the criteria, areas are identified where water quality problems may exist. These areas are in turn subjected to more intensive study. Such a study is designed to determine whether a water quality problem does in fact exist, that is, whether the pesticide levels present are making the water unsuitable for a desired use such as human domestic use or propagation of fish and wildlife. When necessary, pollution abatement programs are implemented to improve and maintain water quality at a level suitable for the desired use.

Table 5.—Recommended Criteria for Pesticides in Estuarine Water, Derived From "The Ecological Impact of Synthetic Organic Compounds on Estuarine Ecosystems," 1976, U.S. Environmental Protection Agency. (All values are expressed as μg/l—parts per billion).

Pesticides	Estuarine water
2,4-D	10,000
2,4,5-T	10,000
Silvex	10,000
Heptachlor*	0
Lindane*	0
Methoxychlor	0
Aldrin*	0
Dieldrin*	0
Endrin*	0
Chlordane*	0
Toxaphene*	0
Total DDT* (DDT + DDD + DDE)	0
Parathion	5,000

The value 0 is understood to mean that these pesticides should not be applied at all near areas where they may reach marine habitats.

*See Appendix I for 1980 criteria revisions.

FACTORS AFFECTING AMBIENT CONCENTRATIONS

In the following sections, pesticide data for locations around the State are summarized in several ways. The categories are (1) frequency of detection of the compounds in fresh and estuarine water and sediment, (2) a description and summary of the individual compounds, and (3) geographical distribution of the contaminants. In general, the results of this data evaluation reflect the degree of application and extent of use of pesticides in Texas. However, there are other factors which play a role in the level of pesticide residues in water, sediment, and tissue. Some of the more important—land use, soil characteristics, suspended solids concentration, solubility of the compound, and timing of sample collection—are discussed briefly below.

While the pesticide application rate in rural agricultural areas may be greater than in populated regions, land use practices generally result in more contaminants reaching the waterways in urban areas. Agricultural practices such as land terracing and contour plowing discourage heavy runoff, while large tracts of pavement in urban areas promote it.

The type of soil also has an effect on the attenuation of pesticides through two processes, the amount of runoff water absorbed into the ground and the amount of pesticide adsorbed to the sediment particles. Light-textured soil such as sand and sandy loam provides relative ease of infiltration for water but tends not to attract the pesticide molecules. Heavier textured, more dense, clay soils inhibit water absorption but do attract the more insoluble pesticides.

Interaction between the solubility of the pesticides and the concentration of suspended solids will also determine the amount of contaminant detected in the water. Generally, pesticides, including most of the chlorinated hydrocarbons and the industrial chemical group PCB, are relatively insoluble in water and tend to

Table 6.—U.S. Food and Drug Administration 1978 criteria for pesticides in Edible Fish and Shellfish (All values are expressed as μg/kg—parts per billion).

Pesticide	Fish	Shellfish
Heptachlor + heptachlor epoxide	300	300
Aldrin + dieldrin	300	300
Endrin	300	300
Toxaphene	5,000	5,000
Total DDT (DDT + DDD + DDE)	5,000	–
PCBs	5,000	5,000

Table 7.—Toxicity Values for Various Pesticides and Herbicides to a Sensitive Species (Bluegill Sunfish) in 24-hour and 96-hour Standard Toxicity Tests. These are Concentrations Which are Lethal to 50 percent of the Organisms in the Indicated Time Period (Brown, 1978; Edwards, 1973; Bowen, 1966; McKee and Wolf, 1963).

Pesticide	TLm value (μg/l)	Time period (hours)
Endrin	0.6	96
Aldrin	1.3– 5.2	96
Chlordane	2.2– 40	96
Toxaphene	2.6– 3.5	96
Dieldrin	7.9– 14	96
PCBs	7.0– 15	96
DDT	4.5– 16	96
Heptachlor	13 – 19	96
Diazinon	22 – 59	96
Methoxychlor	53 – 62	96
Lindane	51 – 77	96
Malathion	55 –110	96
Parathion	500	96
Methyl parathion	5,720	96
Silvex	9,600	96
2,4,5-T	55,000	24
2,4-D	350,000	24

Fish in standing water are unable to escape from an insecticide once it has been added to the water. Therefore, they are submitted to its physiological effects until it is removed by adsorption and sedimentation or other mechanisms. Thus the toxic effects increase, and the median lethal concentration (Tlm or LC_{50}) decreases, with the duration of exposure. In assessing the toxicities of insecticides, the 96-hour exposure period is preferred to one of 48 or 24 hours.

move in a particulate rather than a dissolved form. However, certain of the synthetic organics such as the chlorinated hydrocarbon toxaphene and the industrial phenols are more water soluble. For example, Bowman and others (1960) reported water to be saturated with DDT at 1.2 μg/l, Edwards (1973) reported the solubility of dieldrin to be approximately 100 times greater than DDT, and Grzenda and others (1964) reported the solubility of toxaphene to be 400 μg/l. When the soluble pesticides are spilled in water, most of the pesticide will remain in the water and only small amounts will be found in the sediment. Less soluble compounds would be detected in water only if there were few suspended particles and a large concentration of the pesticide. As most Texas waters are fairly turbid, this seldom occurs.

The timing of the sample plays a crucial role in both the location and detection of compounds, especially the less persistent ones. Collection during or immediately after a spill or runoff event will show concentrations in water of both persistent and non-persistent compounds. Water samples taken several days later do not reveal the less persistent organophosphates and carbamates which have already degraded or the more persistent but less soluble organochlorines which have settled in the sediment.

The nature of the various synthetic organics influences their behavior not only in the water and sediment but also in tissue. Most of the chlorinated hydrocarbons have an affinity for fat in which they are relatively soluble. Thus, residues in fish tissue differ from organ to organ, and higher levels tend to be found in organs such as the liver and ovaries which have a greater lipid content.

The effects of these factors on concentrations statewide will be evident in the data summaries that follow.

FREQUENCY OF DETECTION OF SELECTED PESTICIDES

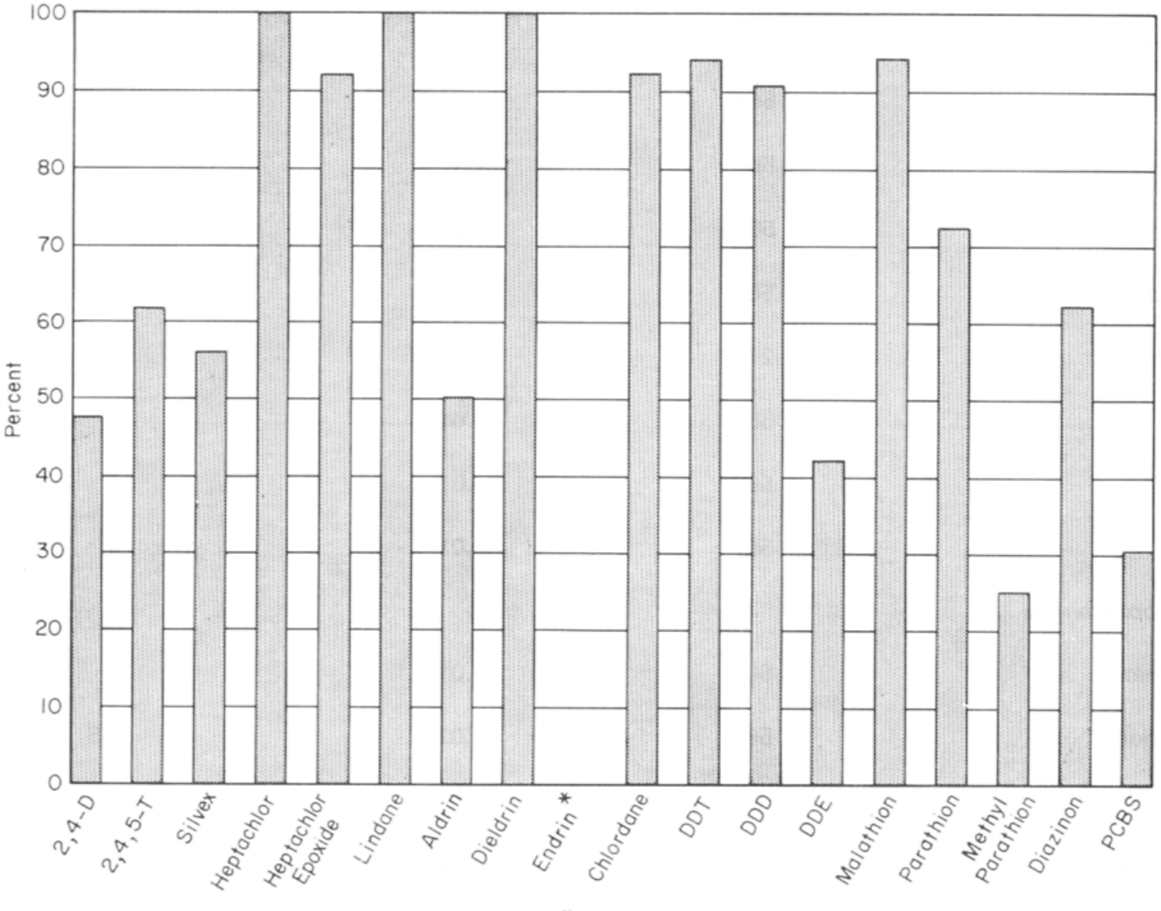
Fresh Water

Prior to 1976, the Department of Water Resources had a fairly extensive pesticides-in-water sampling program. Because concentrations were nearly always below agency analytical detection limits, coverage was reduced substantially at that time. For that reason, the majority of pesticide in fresh water data are from the U.S. Geological Survey whose analytical detection limits were much lower. The latter program is employed to determine the concentration and distribution of pesticides in streams where potential contamination could result from past and present application of commonly used pesticides. The only pesticide in fresh water data from the U.S. Geological Survey used in this report were those in common with Statewide Monitoring Network stations maintained by the Texas Department of Water Resources. Of these 47 sites, 37 percent were located in or influenced by urban areas while the remaining 63 percent were in rural areas scattered throughout the major river basins of the State.

A summary of the U.S. Geological Survey data is shown in Table 8, indicating the percent of determinations above the detection limits for each of the compounds. The compound most frequently detected was diazinon at 35 percent. It was followed by:

2,4-D	27%
2,4,5-T	26%
Dieldrin	16%
Chlordane	9%
Lindane	9%
Silvex	9%
Malathion	7%
DDT	6%
DDE	5%
DDD	4%
PCBs	2%
Heptachlor epoxide	2%
Heptachlor	<1%
Endrin	<1%
Parathion	<1%
Methyl parathion	<1%
Toxaphene	Not detected
Methoxychlor	Not detected

Of the positive pesticide determinations in fresh water samples collected by the U.S. Geological Survey, at Statewide Monitoring Network stations, most were from the streams and bayous draining Houston, Dallas, and San Antonio, as shown in Figure 2. For 12 of the 18 compounds, more than 50 percent of the positive determinations represented sites in these heavily populated areas.



*Endrin has not been detected in samples by the U.S. Geological Survey at these stations

Figure 2.—Percentage of Positive Pesticide Determinations in Fresh Water Samples Collected by the U.S. Geological Survey, at Statewide Monitoring Network Stations, That Were From the Houston, Dallas, or San Antonio Areas

Table 8.—Summary of Pesticide Data for Fresh Water—Samples collected by the U.S. Geological Survey at Statewide Monitoring Network Stations. Period covered is from October 1973 to December 1977.

Pesticide	Number of determinations	Limit of detection (μg/l)	Percentage of determinations above or equal to detection limit
Chlorophenoxy Herbicides			
2,4-D	555	0.01	27
2,4,5-T	551	.01	26
Silvex	555	.01	9
Chlorinated Hydrocarbons			
Heptachlor	567	.01	.5
Heptachlor epoxide	568	.01	2
Lindane	566	.01	9
Methoxychlor	53	.01	0
Aldrin	563	.01	2
Dieldrin	567	.01	16
Endrin	566	.01	.2
Chlordane	563	.1	9
Toxaphene	271	.01	0
DDT	567	.01	6
DDD	567	.01	4
DDE	567	.01	5
Organophosphates			
Malathion	561	.01	7
Parathion	565	.01	.5
Methyl parathion	567	.01	.7
Diazinon	567	.01	35
Industrial Chemicals			
PCBs	512	1	2

Estuarine Water

The data summarized here were all collected by the Department of Water Resources. Because there were considerably fewer estuarine than fresh water sampling sites and no U.S. Geological Survey data were available, the number of determinations is substantially lower than that utilized for fresh water sampling stations. The detection limits are also less sensitive, due to the availability of data from only this agency. This should be taken into account when reviewing the summary in Table 9. Lindane was most frequently detected, in 17 percent of the samples analyzed. The only other pesticides found at levels above detectable limits were aldrin (3 percent) and dieldrin (2 percent).

Fresh Water Sediment

As in the case of the fresh water, most of the fresh water sediment data considered in this section are from the U.S. Geological Survey. The Department of Water Resources maintains a program primarily in areas where concentrations have been detected in the past. As with the fresh water data, considerable amounts of the historical fresh water sediment data are below detection limits and provide little basis for evaluation. For these reasons, the data summarized in this section are those collected by the U.S. Geological Survey at sites in common with the Statewide Monitoring Network. Although there were fewer sediment than water samples analyzed, the percentages of positive determinations for rural versus urban sites were similar. During the period from October 1973 to December 1977, few organophosphates in sediments were analyzed due to their non-persistent characteristics. Also, the chloraphenoxy herbicides were not analyzed in sediment because of their extreme water solubility.

The frequency of occurrence of the remaining compounds is shown in Table 10. DDE, the final breakdown product of DDT, was detected at or above its detection limit in 53 percent of the fresh water sediment samples. It was followed by:

DDD	45%
Dieldrin	39%
Chlordane	38%
DDT	33%
PCBs	28%
Heptachlor epoxide	6%
Heptachlor	2%
Lindane	2%
Aldrin	2%
Toxaphene	2%

These results are in keeping with the nature of the chlorinated hydrocarbons as insoluble and non-biodegradable in water and their tendency to adhere to particles in the water that eventually settle in the sediment. As with the fresh water determinations, many of the positive determinations of fresh water sediment were found in streams draining the heavily populated, industrialized areas such as the Trinity River below Dallas, San Antonio River, and Houston Ship Channel including its tributaries; however, agricultural areas such as the Arroyo Colorado drainageway were also found to be affected.

Estuarine Sediment

As with estuarine water, data for estuarine sediment were available only from the Department of Water Resources. The data summarized in Table 11 show, with one exception, the general absence of significant levels of pesticides in estuarine sediments. Only PCBs occurred frequently, being detected in 49 percent of the samples, due to their ubiquitous nature and to the role of estuaries as the settling basins for contaminants brought in from fresh water systems. The detection frequency of pesticides in estuarine sediment is as follows:

DDE	12%
Dieldrin	8%
DDD	6%
Chlordane	3%
DDT	2%
Lindane	1%
Aldrin	1%
Methyl parathion	< 1%

CHARACTERISTICS AND OCCURRENCE OF SELECTED PESTICIDES IN WATER, SEDIMENT, AND TISSUE

The following section describes basic characteristics, toxicities, and criteria for water for some selected pesticides. Found here is also a discussion of concentrations above detectable limits in fresh and estuarine water, fresh and estuarine sediment, and fish tissue data where available. These brief discussions elaborate on the information given in Tables 8, 9, 10, and 11. The highest

Table 9.—Summary of Pesticide Data for Estuarine Water—Samples Collected by the Texas Department of Water Resources at Statewide Monitoring Network Stations in Bays, Estuaries, and Tidal Portions of Streams. Period covered is from October 1973 to December 1977.

Pesticide	Number of determinations	Limit of detection (μg/l)	Percentage of determinations above or equal to detection limit
Chlorophenoxy Herbicides			
2,4-D	64	50	0
2,4,5-T	64	10	0
Silvex	64	10	0
Chlorinated Hydrocarbons			
Heptachlor	64	.04	0
Heptachlor epoxide	64	.06	0
Lindane	64	.03	17
Methoxychlor	64	1.1	0
Aldrin	64	.04	2
Dieldrin	64	.02	2
Endrin	64	.02	0
Chlordane	64	5.0	0
Toxaphene	64	5.0	0
DDT	64	.24	0
DDD	64	.30	0
DDE	64	.09	0
Organophosphates			
Malathion	64	1.4	0
Parathion	64	.5	0
Methyl parathion	64	.5	0
Diazinon	64	.02	0
Industrial Chemicals			
PCBs	64	2.0	0

Table 10.—Summary of Pesticide Data for Fresh Water Sediment—Samples collected by the U.S. Geological Survey Where Available at Statewide Monitoring Network Stations. Period Covered is from October 1973 to December 1977.

Pesticide	Number of determinations	Limit of detection (μg/kg)	Percentage of determinations above or equal to detection limit
Chlorinated Hydrocarbons			
Heptachlor	351	0.1	2
Heptachlor epoxide	351	.1	6
Lindane	351	.1	2
Methoxychlor	17	.1	0
Aldrin	346	.1	2
Dieldrin	350	.1	39
Endrin	351	.1	0
Chlordane	344	10	38
Toxaphene	159	.1	2
DDT	350	.1	33
DDD	351	.1	45
DDE	351	.1	53
Organophosphates			
Malathion	14	.1	0
Parathion	13	.1	0
Methyl parathion	13	.1	0
Diazinon	16	.1	0
Industrial Chemicals			
PCBs	330	10	28

Table 11.—Summary of Pesticide Data for Estuarine Sediment—Samples collected by the Texas Department of Water Resources at Statewide Monitoring Network Stations in Bays, Estuaries, and Tidal Portions of Streams. Period covered is from October 1973 to December 1977.

Pesticide	Number of determinations	Limit of detection (μg/kg)	Percentage of determinations above or equal to detection limit
Chlorophenoxy Herbicides			
2,4-D	196	100	0
2,4,5-T	196	20	0
Silvex	196	20	0
Chlorinated Hydrocarbons			
Heptachlor	196	1.0	0
Heptachlor epoxide	196	1.0	0
Lindane	196	1.0	1
Methoxychlor	196	20	0
Aldrin	196	1.0	1
Dieldrin	196	3.0	8
Endrin	196	3.0	0
Chlordane	196	20	3
Toxaphene	196	50	0
DDT	196	5.0	2
DDD	196	3.0	6
DDE	196	2.0	12
Organophosphates			
Malathion	196	5.0	0
Parathion	196	5.0	0
Methyl parathion	196	5.0	.5
Diazinon	196	5.0	0
Industrial Chemicals			
PCBs	196	20	49

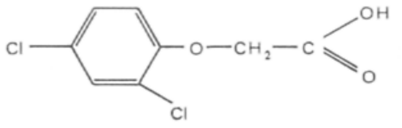
concentrations found in the time period covered by this report are also given along with their locations.

Chlorophenoxy Herbicides

The chlorophenoxy herbicides were first discovered by British and United States scientists in the early 1940's. The discovery resulted in the formulation of 2,4-D for selective control of broad-leaved weeds, followed by 2,4,5-T and silvex for control of woody perennials. They act in the same way as natural growth hormones, except they enter all cells and cause grossly abnormal, uncontrolled plant growth culminating in plant death (Brown, 1978).

Chlorophenoxy compounds are broken down by sunlight (photo decomposition) and soil microorganisms. Depending on soil types, they disappear from a few weeks to several months after application. Therefore, residues do not build up from one year to the next. These compounds are manufactured in a variety of forms including esters, salts, and various oil solutions. They are packaged as liquids, powders, or granules. The salt formations are the most water soluble and are readily absorbed by plant roots. Ester formulations are not directly water soluble but are sold as emulsifiable concentrates which, when mixed with water, break down into extremely fine particles. The particles tend to stick to the plant and are absorbed through stem and leaves. Because they are common ingredients in most home, lawn, and garden products, these herbicides have been detected more frequently in streams draining developed residential and urban areas (U.S. Environmental Protection Agency, 1976a; Thomson, 1977).

2,4-D



(2,4-Dichlorophenoxyacetic acid)

2,4-D was first manufactured in 1942 by the Amchem Products Company. It is selective for herbaceous plants and is often mixed with other herbicides and fertilizers. Most home-use weed killers sold for lawns and gardens contain 2,4-D. 2,4-D is the most widely used herbicide for control of nuisance aquatic plants. The following are 24-hour TLm values (standard toxicity tests where 50 percent of the organisms tested are killed in the 24-hour exposure period) for two aquatic organisms (McKee and Wolf, 1963):

Toxicity

24-hour TLm value (μg/l)	Organism
350,000	bluegill sunfish *(Lepomis macrochirus)*
350,000	bass *(Micropterus salmoides)*

Criteria

100 μg/l in water to protect domestic water supplies (U.S. Environmental Protection Agency, 1976a).

10,000 μg/l is recommended in estuarine waters for the protection of marine life (U.S. Environmental Protection Agency, 1976b).

Fresh Water Determinations

Of the 148 pesticide in fresh water samples collected by the Department of Water Resources, all 2,4-D determinations have been below the 50 μg/l detection limit. However, utilizing lower detection limits as shown in Table 8, 2,4-D has been found frequently in streams draining highly populated urban areas. The highest values recorded have been 4.2 μg/l at station 0805.0300 on the Trinity River below Dallas and 7.8 μg/l at station 1000.2700 on Buffalo Bayou in Houston. Subsequent samples showed lower concentrations at both sites.

Estuarine Water Determinations

Of the 64 pesticide in estuarine water samples collected by the Department, all 2,4-D determinations have been below the 50 μg/l detection limit as shown in Table 9.

Fresh Water Sediment Determinations

For several years, this agency included analyses of the chlorophenoxy herbicides in fresh water sediment samples. However, during routine sampling and intensive monitoring surveys, 2,4-D was never found to be above the 100 μg/kg detection limit. Consequently, it has been deleted from sediment analyses.

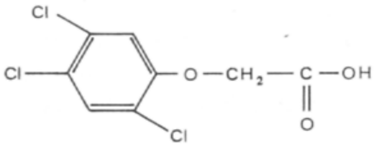
Estuarine Sediment Determinations

All 2,4-D determinations in estarine sediment have been below the 100 μg/kg detection limit during routine sampling and intensive monitoring surveys as shown in Table 11.

Residues in Fish Tissue

The chlorophenoxy herbicides are not included in fish tissue analyses because of their rapid degradation and elimination in fish and shellfish.

2,4,5-T



(2,4,5-Trichlorophenoxyacetic acid)

2,4,5-T was first manufactured in 1945 by the Amchem Products Company. It is selective for woody plants. In April 1970, because of the toxic effects to fish, 2,4,5-T was banned for use in aquatic systems by the U.S. Environmental Protection Agency. It has been reported to be the most toxic to fish of all the chlorophenoxy herbicides. Given below is the only toxicity value found in the references used for this report (McKee and Wolf, 1963):

Toxicity

55,000 μg/l has been found to be the threshold value for fish.

Criterion

> 10,000 μg/l is recommended in estuarine water for the protection of marine life (U.S. Environmental Protection Agency, 1976b).

Fresh Water Determinations

Of the 148 pesticide in fresh water samples collected by the Department, all 2,4,5-T determinations have been below the 10 μg/l detection limit. However, utilizing lower detection limits as shown in Table 8, 2,4,5-T is found frequently in streams draining highly populated urban areas. The highest value recorded has been 0.46 μg/l at stations 1000.2700 on Buffalo Bayou in Houston and 1802.0100 on the Guadalupe River north of San Antonio Bay. Subsequent sampling showed lower concentrations at both sites.

Estuarine Water Determinations

Of the 64 pesticide in estuarine water samples collected by the agency, all 2,4,5-T determinations have been below the 10 μg/l detection limit as shown in Table 9.

Fresh Water Sediment Determinations

For several years, the agency included analyses of the chlorophenoxy herbicides in fresh water sediment samples. However, during the routine sampling and intensive monitoring surveys, 2,4,5-T was never found to be above the 20 μg/kg detection limit. Consequently, it has been deleted from pesticide in sediment analyses.

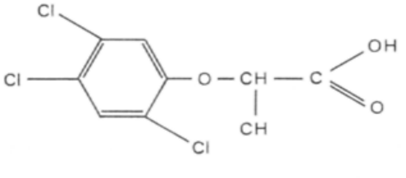
Estuarine Sediment Determinations

All 2,4,5-T determinations in estuarine sediment have been below the 20 μg/kg detection limit during routine sampling and intensive monitoring surveys, as shown in Table 11.

Residues in Fish Tissue

The chlorophenoxy herbicides are not included in fish tissue analyses because of their rapid degradation in aquatic organisms.

Silvex (2,4,5-TP)



(2-(2,4,5-Trichlorophenoxy) propionic acid)

Silvex was first manufactured in 1954 by the Dow Chemical Company. It is used for the eradication of plants which are resistant to both 2,4-D and 2,4,5-T. When used for the eradication of nuisance aquatic plants it is often mixed with 2,4-D. The following is a 96-hour TLm value for one species of fresh water fish (Edwards, 1973):

Toxicity

96-Hour TLm value (μg/l)	Organism
9,600	bluegill sunfish *(Lepomis macrochirus)*

Criteria

10 μg/l in water to protect domestic water supplies (U.S. Environmental Protection Agency, 1976a).
10,000 μg/l is recommended in estuarine waters for the protection of marine life (U.S. Environmental Protection Agency, 1976b).

Fresh Water Determinations

In the 148 pesticide in fresh water samples collected by the Department, all silvex determinations have been below the 10 μg/l detection limit. However, utilizing lower detection limits as shown in Table 8, silvex is occasionally found in streams draining highly populated urban areas. The highest value recorded has been 0.70 μg/l at station 1900.0100 on Salado Creek in San Antonio. Subsequent sampling showed reduced concentrations.

Estuarine Water Determinations

In the 64 pesticide in estuarine water samples collected by the agency, all silvex determinations have been below the 10 μg/l detection limit as shown in Table 9.

Fresh Water Sediment Determinations

For several years, the agency included analyses of the chlorophenoxy herbicides in fresh water sediment samples. However, during routine sampling and intensive monitoring surveys, silvex was never found to be above the 20 μg/kg detection limit. In one intensive monitoring survey conducted on segments 0805 and 0806 (Trinity River in the Dallas-Fort Worth area) where lower detection limits were utilized, silvex was detected four times in concentrations ranging from 0.4 to 0.7 μg/kg. As with other chlorophenoxy herbicides, because of its rapid degradation in sediment, it has been deleted from pesticide determinations in sediment samples.

Estuarine Sediment Determinations

All silvex determinations in estuarine sediment have been below the 20 μg/kg detection limit during routine sampling and intensive monitoring surveys as shown in Table 11.

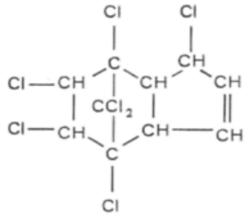
Residues in Fish Tissue

The chlorophenoxy herbicides are not included in fish tissue analyses because of their rapid degradation in aquatic organisms.

Chlorinated Hydrocarbon Pesticides

The chlorinated hydrocarbon pesticides, also known as organochlorine compounds, were first introduced in the early 1940's. The compounds which contain chlorine, carbon, and hydrogen, are environmentally the most important group of synthetic organic pesticides because of their widespread use, great stability, and toxicity. The chlorinated hydrocarbons are considered to be neurotoxic to both aquatic and terrestrial organisms. Organisms exposed to these pesticides exhibit uncoordinated movements, sluggishness alternating with hyperactivity, and difficulty in respiration. The most hazardous aspect of these compounds is their tendency to accumulate in the fatty tissue of animals, including man. The chlorinated hydrocarbons discussed in this report are: heptachlor, heptachlor epoxide, lindane (gamma BHC), methoxychlor, aldrin and dieldrin, endrin, chlordane, toxaphene, DDT, DDD, and DDE.

Heptachlor



Characterization

Heptachlor is a chlorinated hydrocarbon pesticide derived from a refined ingredient of chlordane. This compound is practically insoluble in water and exhibits a mild camphoraceous odor. Raw heptachlor is a white solid or crystalline material manufactured into dusts, wettable powders, emulsifiable concentrates and granules.

In the environment, heptachlor is rapidly degraded, primarily by soil microorganisms, to heptachlor epoxide. Also, heptachlor epoxide arises from the degradation of the heptachlor component of chlordane. Consequently, unless there has been a recent introduction, heptachlor epoxide is detected more often than its parent compound.

Sources and Uses

Heptachlor was first manufactured in 1948 by the Velsicol Chemical Company. It is used in the control of cotton insects, soil insects, grasshoppers, onion thrips, and alfalfa weevils. In the 1950's before the introduction of mirex, heptachlor was used throughout the southeastern United States for the control of the imported fire ant. This program caused direct mortality to a variety of birds in the vicinity of the application (Edwards, 1973; Thomson, 1976).

The U.S. Environmental Protection Agency has stated that by July 1, 1983, most products containing heptachlor will be cancelled or their application for registration denied.

Metabolism and Toxicity

Heptachlor is degraded to its epoxide by volatilization and microbial epoxidation. Once in the epoxide state, it is very resistant to further oxidation and hydrolysis. Therefore, it remains relatively stable in the environment. The average time for 95 percent of a correctly applied dosage of heptachlor to disappear in soil is estimated to be 3.5 years. However, measurable amounts of epoxide have been detected 9 years after application in silty loam. Volatilization has been found to be the major factor in the loss of heptachlor from soil. Heptachlor has also been found to bioaccumulate in the food chain and is suspected to be carcinogenic. The following are concentration factors for various fresh water and marine organisms, based on wet weight (Edwards, 1973; McKee and Wolf, 1963; U.S. Environmental Protection Agency, 1976a):

oysters	18,000X
marine fish	2,800–2,130X
bluegill	1,840X

Heptachlor has a relatively low toxicity to mammals but is highly toxic to aquatic organisms in amounts less than 1 µg/l. Fish kills have resulted from the application of 0.25 pound per acre when applied near reservoirs. This compound has been found to be much less toxic to fish when applied as a dust as opposed to a wettable powder or emulsifiable concentrate. The following are 96-hour TLm values (standard toxicity tests where 50 percent of the organisms tested are killed in the 96-hour exposure period) for some aquatic and marine organisms (McKee and Wolf, 1963; U.S. Environmental Protection Agency, 1976a):

Concentration (µg/l)	Organism
7.9 - 19.0	bluegill sunfish *(Lepomis macrochirus)*
34.0	black bullhead *(Ictalurus melas)*
56.0 - 94.0	fathead minnow *(Pimephales promelas)*
0.9 - 1.10	stonefly *(Pteronarcy* sp.)
3.77	pinfish *(Lagodon rhomboides)*
3.0	juvenile striped bass *(Morone saxatilis)*
0.85	spot *(Leiostomus xanthurus)*
0.11	pink shrimp *(Penaeus duorarum)*

Criteria

0.001 µg/l in water to protect fresh water and marine life (U.S. Environmental Protection Agency, 1976a).

300.0 µg/kg in edible fish or shellfish tissue to protect consumers (U.S. Food and Drug Administration, 1978).

The water quality criteria for heptachlor used in preparation of this report (above) have been superceded by the Environmental Protection Agency 1980 water quality criteria for fresh water and marine life. The new criteria are shown in Appendix I.

Fresh Water Determinations

Of the 148 pesticide in fresh water samples collected by the Department of Water Resources, all heptachlor determinations have been below the 0.04 µg/l detection limit. Concentrations below 0.04 µg/l were found by the U.S. Geological Survey to occur infrequently in streams and bayous draining the Dallas and Houston areas (Table 8).

Estuarine Water Determinations

Of the 64 pesticide in estuarine water samples collected by the Department all heptachlor determinations have been below the 0.04 μg/l detection limit as shown in Table 9. Utilization of lower detection limits, however, has revealed heptachlor at low concentrations at stations 2424.0100 in West Bay (0.005 μg/l) and 2431.0100 in Moses Lake (0.001 μg/l).

Fresh Water Sediment Determinations

Of the 749 pesticide in fresh water sediment samples collected by this agency during routine sampling and intensive monitoring surveys, heptachlor has been detected only once above the 1.0 μg/kg detection limit. That value was 16.6 μg/kg found at station 1200.1800 on Bessies Creek southeast of Ellis in the Brazos River basin. Subsequent sampling at this site showed concentrations below detectable limits. Utilizing lower detection limits, the U.S. Geological Survey found heptachlor only infrequently in the State (Table 10).

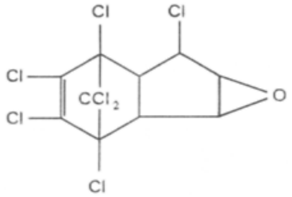
Estuarine Sediment Determinations

Of the 196 pesticide in estuarine sediment samples collected by the Department during routine sampling and intensive moniroring surveys, all heptachlor determinations have been below the 1.0 μg/kg detection limit as shown in Table 11.

Residues in Fish Tissue

Residues of heptachlor have not been detected in fish samples collected by the agency during routine monitoring and special surveys.

Heptachlor Epoxide



Heptachlor epoxide is a degradation product of heptachlor and chlordane. Once heptachlor is introduced into the environment, it is oxidized to heptachlor epoxide. Therefore, any heptachlor that has not been recently introduced to the environment will be detected as heptachlor epoxide (see previous discussion of heptachlor).

Toxicity

Heptachlor epoxide is considered to be more toxic than its parent compound, heptachlor (Edwards, 1973).

Fresh Water Determinations

Of the 148 pesticide in fresh water samples collected by the Department of Water Resources, all heptachlor epoxide determinations have been below the 0.06 μg/l detection limit. Concentrations below 0.06 μg/l were found by the U.S. Geological Survey to occur infrequently in streams and bayous draining the Dallas and Houston areas (Table 8).

Estuarine Water Determinations

Of the 64 pesticide in estuarine water samples collected by the agency, all heptachlor epoxide determinations have been below the 0.06 μg/l detection limit as shown in Table 9.

Fresh Water Sediment Determinations

Of the 749 pesticide in fresh water sediment samples collected by the Department during routine sampling and intensive monitoring surveys, all heptachlor epoxide determinations have been below the 1.0 μg/kg detection limit. Concentrations below 1.0 μg/kg were found occasionally by the U.S. Geological Survey in streams and bayous draining the Dallas and Houston areas (Table 10).

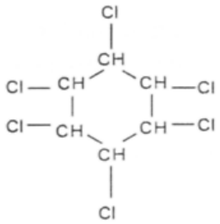
Estuarine Sediment Determinations

Of the 196 pesticide in estuarine sediment samples collected by the agency during routine sampling and intensive monitoring surveys, all heptachlor epoxide determinations have been below the 1.0 μg/kg detection limit (Table 11). Concentrations below 1.0 μg/kg were found occasionally by the U.S. Geological Survey in streams and bayous draining the Dallas and Houston areas.

Residues in Fish Tissue

Residues of heptachlor epoxide have not been detected in fish samples collected by the Department during routine monitoring and special surveys.

Lindane (Gamma BHC)



Characterization

Lindane is a chlorinated hydrocarbon (organochlorine) compound used as an insecticide. Lindane is the gamma isomer of nine possible stereoisomers of a parent compound called benzene hexachloride (BHC). All the insecticidal properties of BHC are derived from its gamma isomer. The name lindane is used when commercial preparations of BHC contain 99 percent or more of the gamma isomer. The compound is manufactured in a variety of forms, including wettable powders, emulsifiable concentrates, crystals, dusts, smears (for screwworms), and aerosols, and it is also mixed with other pesticides. Lindane has been known to produce a musty flavor and odor to some crops and also to give water the same unpleasant properties (Thomson, 1976).

Sources and Uses

Lindane was developed by the Chevron Chemical Company and ICI of England in 1945. It is now produced by Woolfolk Chemical Company, Hooker Chemical Company, and Celamerck. The compound is applied uniformly on foliage and soil, used as a seed treatment, as a household insecticide, and applied to older animals as a smear for screwworms. The application rate is usually 1/8 to 1 pound per 100 gallons of water or 1/4 to 4 pounds per acre (Thomson, 1976).

Because of lindane's extreme toxicity, the National Technical Advisory Committee to the Secretary of the Interior has recommended that it should not be applied near marine habitats (U.S. Environmental Protection Agency, 1976b).

Metabolism and Toxicity

Lindane can enter an organism through direct consumption, inhalation, or by skin absorption. In lethal doses it works as a stomach poison. A lethal dose to a man weighing 70 kg is approximately 15 grams. Its residual life in soil has been found to be the same as DDT. Lindane has been found to persist in water for a period of 10 to 12 years. Standard toxicity tests yielded the following LC$_{50}$ (concentration that killed 50 percent of the organisms in a standard toxicity experiment) results (Edwards, 1973; McKee and Wolf, 1963; U.S. Environmental Protection Agency, 1976a):

Time (hours)	Concentration (µg/l)	Organism
96	30	bluegill fingerlings *(Lepomis macrochirus)*
96	77	bluegill sunfish *(Lepomis macrochirus)*
96	56	fathead minnow *(Pimephales promelas)*
8	6	midge larvae *(Chironomus* sp.)
8	100	snails *(Lymnaeid* sp.)
48	.04	brown shrimp *(Penaeus aztecus)*

Criteria

4.0 µg/l in water to protect domestic water supplies (U.S. Environmental Protection Agency, 1976a).

0.01 µg/l in water to protect fresh water aquatic life (U.S. Environmental Protection Agency, 1976a).

0.004 µg/l in water to protect marine life (U.S. Environmental Protection Agency, 1976a).

The water quality criteria for lindane used in preparation of this report (above) have been superceded by the Environmental Protection Agency 1980 water quality criteria for fresh water and marine life. The new criteria are shown in Appendix I.

Fresh Water Determinations

Of the 148 pesticide in fresh water samples collected by the Department only one sample was found to have a concentration of lindane above the 0.03 µg/l detection limit. A concentration of 0.087 was found at station 1000.0200 on Greens Bayou in Houston. Utilizing lower detection limits, the U.S. Geological Survey has occasionally detected lindane in streams and bayous draining the Dallas, Houston, and San Antonio areas (Table 8). The highest values recorded by the Survey have been

0.09 μg/l at station 0805.0300 on the Trinity River below Dallas and 0.27 μg/l at station 1000.2700 on Buffalo Bayou in Houston. Subsequent sampling showed concentrations below detectable limits.

Estuarine Water Determinations

Of the 64 pesticide in estuarine water samples collected by the Department, 17 percent had concentrations greater than the 0.03 μg/l detection limit as shown in Table 9. The majority of these concentrations were found in the Houston Ship Channel, as was the highest value of 0.093 μg/l at station 1007.0100. Subsequent sampling showed concentrations below detectable limits at all sites on the channel.

Fresh Water Sediment Determinations

Of the 749 pesticide in fresh water sediment samples collected during routine sampling and intensive monitoring surveys, lindane has only been detected twice above the 1.0 μg/kg detection limit. In 1974, concentrations of 3.0 μg/kg and 5.0 μg/kg were found at stations 1012.0100 and 1012.0200, both on Lake Conroe. There were no subsequent samples taken during the time period covered in this report. The U.S. Geological Survey has only detected lindane at concentrations less than 1.0 μg/kg infrequently (Table 10).

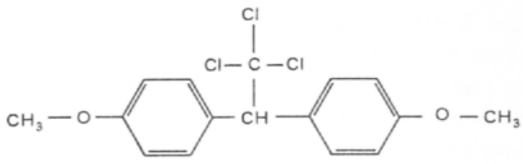
Estuarine Sediment Determinations

Of the 196 pesticide in estuarine sediment samples collected by the Department during routine sampling and intensive monitoring surveys, lindane has been detected three times above the 1.0 μg/kg detection limit (Table 11). These values were 9.0 μg/kg and 11.0 μg/kg at stations 1005.0100 and 1007.0100, both on the Houston Ship Channel, and 2.0 μg/kg at station 0801.0100 in the tidal portion of the Trinity River. Sebsequent samples showed concentrations below detectable limits at all sites.

Residues in Fish Tissue

Residues of lindane have not been detected in the fish samples collected by the agency during routine monitoring and special surveys.

Methoxychlor



Characterization

Methoxychlor is a chlorinated hydrocarbon compound used as a pesticide. It is slightly soluble in water and very soluble in alcohol. The compound is formulated in a variety of ways including dusts, wettable powders, and emulsifiable concentrates. Methoxychlor is also manufactured under the following names: DMDT, Marlate, Methoxychide, Methoxo, and Moxie (McKee and Wolf, 1963; Thomson, 1976).

Sources and Uses

Methoxychlor was first manufactured in 1944 by the Geigy Chemical Company and C. I. Dupont de Nemours Company. Today Dupont is its principal producer. Methoxychlor is used as a pesticide for numerous fruit and vegetable crops. It is also used in grain bins, outdoor fogging, and beef and dairy cattle protection. Its application rate is usually from 1/4 to 1/2 pound per acre. Application starts at the first signs of infestation and is repeated at one to two week intervals as needed (Thomson, 1976).

The National Technical Advisory Committee to the Secretary of the Interior has recommended that methoxychlor should not be applied near marine habitats due to its extreme toxicity (U.S. Environmental Protection Agency, 1976b).

Metabolism and Toxicity

Methoxychlor has been found to degrade in water after a few weeks or less. In contrast, research has shown that it has a long residual effect in sediment.

Methoxychlor, like other chlorinated hydrocarbons, enters aquatic organisms through direct absorption and uptake through orifices. Susceptibility to uptake has been shown to decrease with increasing temperatures.

Although methoxychlor is similar in structure to DDT, it is only 1/25 to 1/50 as toxic to warm-blooded animals. A lethal dose to a man weighing 154 pounds is estimated to be approximately 350 grams. Research also shows that this compound is less bioaccumulative in aquatic organisms than other chlorinated hydrocarbons. Methoxychlor is converted to water soluble compounds and then eliminated from tissues (Edwards, 1973; U.S. Environmental Protection Agency, 1976a; McKee and Wolf, 1963).

Standard toxicity tests utilizing 96-hour TLm values (standard toxicity tests where a concentration of a substance kills 50 percent of the organisms tested) for methoxychlor show the following results (Edwards, 1973; McKee and Wolf, 1963; U.S. Environmental Protection Agency, 1976a):

TLm (µg/l)	**Organism**
62.0	bluegill sunfish *(Lepomis macrochirus)*
64.0	fathead minnow *(Pimephales promelas)*
3.3	juvenile striped bass *(Morone saxatilis)*
0.5	crayfish *(Orconectes nails)*

Methoxychlor has been found to be non-phytotoxic (nontoxic to plants).

Criteria

100.0 µg/l in water to protect domestic water supplies (U.S. Environmental Protection Agency, 1976a).

0.03 µg/l in water to protect fresh water and marine life (U.S. Environmental Protection Agency, 1976a).

Fresh Water Determinations

Of the 148 pesticide in fresh water samples collected by the Department of Water Resources, all methoxychlor determinations have been below the 1.1 µg/l detection limit.

Estuarine Water Determinations

Of the 64 pesticide in estuarine water samples collected by this agency, all methoxychlor determinations have been below the 1.1 µg/l detection limit as shown in Table 9.

Fresh Water Sediment Determinations

Of the 749 pesticide in fresh water sediment samples collected by the agency during routine sampling and intensive monitoring surveys, all methoxychlor determinations have been below the 20 µg/kg detection limit.

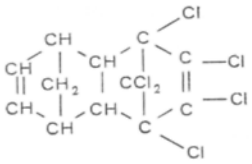
Estuarine Sediment Determinations

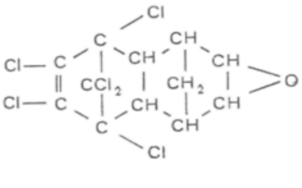
Of the 196 pesticide in estuarine sediment samples collected by the agency during routine sampling and intensive monitoring surveys, all methoxychlor determinations have been below the 20 µg/kg detection limit as shown in Table 11.

Residues in Fish Tissue

Residues of methoxychlor have not been detected in fish samples collected by the agency during routine and special surveys.

Aldrin and Dieldrin





Characterization

Aldrin and dieldrin are synthetic organic pesticides (chlorinated hydrocarbons) which are insoluble in water, slightly soluble in oils, and moderately soluble in most organic solvents with the exception of some petroleum solvents and methanol. These compounds are stable in organic and inorganic acids and alkalies used in agriculture (McKee and Wolf, 1963).

Dieldrin has the same chemical formulation as aldrin with the exception of an additional oxygen atom.

Aldrin and dieldrin are manufactured in a variety of forms including wettable and dry powders, xylene solutions, dusts, and emulsifiable concentrates.

These synthetic organic pesticides have high insecticidal activities and are resistant to degradation to nontoxic end products. They have been found to persist for months and sometimes years following application. Aldrin and dieldrin are assayed for water quality purposes in regard to their extreme persistence and toxicity to fresh and marine water life (McKee and Wolf, 1963; Thomson, 1976).

Sources and Uses

Aldrin and dieldrin were first manufactured by J. Hyman and Company, although Shell Chemical Company had been licensed to develop the compounds since 1948. These compounds have been heavily restricted for agricultural purposes by the U.S. Environmental Protection Agency. However, in a survey of 15 coastal states, dieldrin was the second most common synthetic organic pesticide found in sediment. Because of the heavy restrictions in the United States, environmental concentrations of these insecticides are expected to decline (U.S. Environmental Protection Agency, 1976b; Thomson, 1976).

Aldrin and dieldrin were used to control a wide variety of agricultural pests and also occasionally used as a mosquito larvicide. These compounds were applied as soil insecticides, seed treatments, and more often sprayed directly on plant foliage. The application rates ranged from 1/2 to 5 pounds per acre (Thomson, 1976).

Metabolism and Toxicity

Aldrin and dieldrin, like other chlorinated hydrocarbons, do not readily degrade to nontoxic end products. Therefore, their toxic properties continue to persist in the environment. Aldrin is metabolically transformed to dieldrin in aquatic organisms and by physicochemical and microbial processes on surface soil (Edwards, 1973; McKee and Wolf, 1963).

A compound known as photodieldrin can be formed from dieldrin by photochemical microbial processes. Photodieldrin has been found to be 1.3 to 12.2 times more toxic to fresh water organisms than its parent compound.

These compounds can enter an organism either by direct consumption or skin absorption. They have acute and chronic effects by all routes of administration and kill organisms by acting as a stomach poison. Dieldrin has been found to be similar to aldrin in toxicity to aquatic organisms; therefore, acceptable water concentrations are based on the sum of both. In aquatic organisms they bioaccumulate so that they may be passed to humans. These substances are considered carcinogenic, and direct human exposure should be kept at a minimum. Human illness has occurred in workers associated with their manufacture. An acutely lethal dose to a man weighing 70 kilograms is 5 grams (McKee and Wolf, 1963; Thomson, 1976). Dieldrin toxicity is prescribed by the grade of dieldrin used and the nature of the solvent by which it is formulated. Two milligrams per liter has been shown to kill fish, whereas 0.07 to 2 pounds per acre in a closed pond has produced a 50 percent mortality after 96 hours. Standard toxicity tests utilizing LC_{50} values (standard toxicity tests where a concentration of a substance kills 50 percent of the organisms tested) for aldrin and dieldrin show the following results (U.S. Environmental Protection Agency, 1976a):

Pumpkinseed sunfish *(Lepomis gibbosus)*

LC_{50} (dieldrin µg/l)	Time (hours)
1.55	24
1.20	48
.75	72
.67	96

After prolonged exposure of 12 weeks at 0.00168 µg/l, *Lepomis gibbosus* survived but swimming ability and oxygen consumption were adversely affected.

Ninety-six hour LC_{50} values for dieldrin for some other fish native to Texas are:

LC_{50} (µg/l)	Fish
1.6	fathead minnow *(Pimephales promelas)*
7.9	bluegill sunfish *(Lepomis macrochirus)*
8.5	green sunfish *(Lepomis cyanellus)*

Ninety-six hour LC_{50} values for aldrin are as follows:

LC_{50} (µg/l)	Fish
1.3	bluegill sunfish *(Lepomis macrochirus)*
2.8	fathead minnow *(Pimephales promelas)*
2.8	goldfish *(Carassium auratus)*

In estuaries, the relative toxicity of 12 insecticides to seven species of fish was tested. The decreasing order of toxicity to the fish tested was endrin, DDT, dieldrin, aldrin, followed by the organophosphates.

Dieldrin has been suspected as a cause in the reproductive failure of the brown pelican *(Pelicanus occidentalis)*. The brown pelican is on the list of endangered species established by the Texas Parks and Wildlife Department.

Criteria (Summation of dieldrin and aldrin)

0.003 µg/l in water to protect fresh water and marine life (U.S. Environmental Protection Agency, 1976a).

300.0 µg/kg in edible fish and shellfish tissue to protect consumers (U.S. Food and Drug Administration, 1978).

The water quality criteria for aldrin and dieldrin used in preparation of this report (above have been superceded by the Environmental Protection Agency 1980 water quality criteria. The new criteria are shown in Appendix I.

Aldrin

Fresh Water Determinations

Of the 148 pesticide in fresh water samples collected by the Department of Water Resources, one sample was found to have a concentration of aldrin above the 0.04 µg/l detection limit. That concentration of 0.101 µg/l was found at station 1000.0800 on Hunting Bayou in Houston. Subsequent samples showed concentrations below detectable limits. Utilizing lower detection limits, the U.S. Geological Survey has occasionally found detectable concentrations of aldrin in streams and bayous draining the Dallas and Houston areas (Table 8).

Estuarine Water Determinations

Of the 64 pesticide in estuarine water samples collected by the Department, one sample was found to have a concentration of aldrin above the 0.04 µg/l detection limit (Table 9). That concentration of 8.3 µg/l was found at station 2424.0100 in West Bay, a secondary bay to Galveston Bay. Subsequent samples showed concentrations below detectable limits. Utilizing lower detection limits, aldrin was detected once at a concentration of 0.018 µg/l at station 1007.0100 on the Houston Ship Channel.

Fresh Water Sediment Determinations

Of the 749 pesticide in fresh water sediment samples collected by the Department during routine sampling and intensive monitoring surveys, only one sample was found to have a concentration of aldrin above the 1.0 µg/kg detection limit. That concentration of 33.0 µg/kg was found on Hillebrandt Bayou in the Sabine River basin. The U.S. Geological Survey, utilizing lower detection limits, has detected aldrin at concentrations less than 1.0 µg/kg infrequently (Table 10).

Estuarine Sediment Determinations

Of the 196 pesticide in estuarine sediment samples collected by the Department during routine sampling and intensive monitoring surveys, aldrin has been detected three times above the 1.0 µg/kg detection limit. These concentrations were 158 µg/kg, 3,100 µg/kg, and 7,290 µg/kg found at stations 1006.0100, 1006.0300, and 1005.0100, all on the Houston Ship Channel. Subsequent sampling showed concentrations below detectable limits at all sites.

Residues in Fish Tissue

Residues of aldrin have not been detected in fish samples collected by the agency during routine monitoring and special surveys.

Dieldrin

Fresh Water Determinations

Of the 148 pesticide in fresh water samples collected by the Department of Water Resources, all dieldrin determinations have been below the 0.02 µg/l detection limit. However, utilizing lower detection limits, the U.S. Geological Survey has found dieldrin frequently in streams and bayous draining the Dallas, Houston, and San Antonio areas (Table 8). The highest values recorded have been 8.2 µg/l at station 0805.0100 and several determinations of 0.04 µg/l at station 0805.0300, both on the Trinity River below Dallas. Subsequent samples at both sites showed concentrations below detectable levels.

Estuarine Water Determinations

Of the 64 pesticide in estuarine water samples collected by the Department, one sample was found to have a concentration of dieldrin above the 0.02 μg/l detection limit (Table 9). That value was 0.041 μg/l found at station 1107.0100 in the tidal portion of Chocolate Bayou south of Houston. Subsequent samples showed concentrations below detectable limits.

Fresh Water Sediment Determinations

Of the 749 pesticide in fresh water sediment samples collected by the agency during routine sampling and intensive monitoring surveys, 94 samples were found to have concentrations of dieldrin above the 3.0 μg/kg detection limit. The highest values found were 44 μg/kg at station 0805.0100 and 54 μg/kg at station 0805.0300, both on the Trinity River below Dallas. Subsequent samples at both sites showed fluctuating concentrations with most levels being above detectable limits. The U.S. Geological Survey, utilizing lower detection limits, found dieldrin frequently throughout most of the major river basins in Texas (Table 10).

Estuarine Sediment Determinations

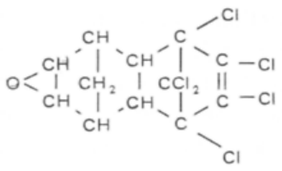
Of the 196 pesticide in estuarine sediment samples collected during routine sampling and intensive monitoring surveys, 15 samples were shown to have concentrations of dieldrin above the 3.0 μg/kg detection limit as shown in Table 11. The highest values recorded have been 19 μg/kg and 51 μg/kg at station 1007.0100 on the Houston Ship Channel. Subsequent sampling showed concentrations below detectable limits.

Residues in Fish and Shellfish Tissue

In 1969 residues of dieldrin were found in 60 percent of the fish samples collected by the Texas Parks and Wildlife Department. This 1969 sampling program included all the major bays of Texas. Residues of dieldrin in whole fish tissue ranged from undetectable levels in some samples from all sites to 280 μg/kg in one sample from the lower Laguna Madre. In a similar study conducted on oysters, the Parks and Wildlife Department data showed a dramatic increase in positive dieldrin determinations, from 13 percent of samples in 1965 to 35 percent in 1968 (Childress, 1970).

Residues of dieldrin have been detected only twice in fish tissue samples collected by the Department of Water Resources during routine sampling and intensive surveys. A concentration of 12 μg/kg was found in a composite sample of blue suckers (whole fish), and 72 μg/kg in a composite sample of channel and blue catfish (edible tissue), both from the Rio Grande below the Rio Conchos (Mexico) confluence near Presidio in 1979. The most probable reason for the decline of dieldrin in tissue is the cancellation imposed by the U.S. Environmental Protection Agency in 1974 for the majority of its uses.

Endrin



Characterization

Endrin is a synthetic organic (chlorinated hydrocarbon) compound used as a pesticide and in a few instances as a rodenticide. Endrin is manufactured in a variety of forms including granules, emulsifiable concentrates, and baits. The compound is insoluble in water, acetone, and benzene, and slightly soluble in alcohol.

Sources and Uses

Endrin was originally manufactured by J. Hyman and Company, although Shell and Velsicol Chemical Companies are now licensed for its manufacture. Endrin is used to control insects (including boring forms) in production of cotton, sugarcane, barley, oats, rye, wheat, and ornamentals. In some instances endrin is used in the control of mice in orchards. This compound can be used by spraying directly on plants when insects first appear (spring and summer), as a soil insecticide, and as a seed treatment (Thomson, 1976).

The National Technical Advisory Committee to the Secretary of the Interior has recommended that endrin should not be applied near marine habitats due to its extreme toxicity (U.S. Environmental Protection Agency, 1976b).

Metabolism and Toxicity

Endrin is reported to break down rapidly in water, sediment, and plant and animal tissue after initial exposure. Fish are able to excrete endrin almost totally in a relatively short time. Although endrin's chemical constituents break down quickly in relation to other chlorinated hydrocarbons, it is assayed for water quality purposes in regard to accidental spills and irresponsible discharges.

Endrin can enter an organism by a number of different pathways, including absorption through skin and direct uptake through an organism's orifices. It kills the organism by acting as a stomach poison. As stated earlier, when fish are subjected to chronic but not lethal doses, they are able to excrete most of their endrin uptake. However, behavioral and physiological effects have been documented: hypersensitivity, blocked hormone production, inhibited liver functions, and many other physiological disorders. Temperature has a direct proportional relationship with endrin's effect on fish. The higher the temperature, the higher their metabolic rate and the greater their endrin uptake. Temperature also effects the chemical breakdown and physical properties of endrin. The higher the temperature, the more readily the chemical is broken down (Edwards, 1973; McKee and Wolf, 1963; Thomson, 1978).

Endrin is one of the most toxic to fresh water fish of all the economic poisons. There have been several cases where populations of a few species have developed resistance, but this resistance was found only where endrin was used extensively. Endrin has also been demonstrated to be very toxic to fresh water insects and micro- and macrocrustacea.

Standard toxicity tests yield LC_{50} values (lethal concentrations that kill 50 percent of the organisms in a toxicity experiment) of 1 µg/l or less for fresh water fish. Of all the materials tested affecting endrin toxicity, activated carbon was the only factor which reduced toxicity. Activated carbon absorbed approximately 95 percent of an endrin-spiked sample (Edwards, 1973; McKee and Wolf, 1963; U.S. Environmental Protection Agency, 1976a).

96-hour LC_{50} value (µg/l)	Organism
0.6	bluegill sunfish *(Lepomis macrochirus)*
1.0	fathead minnow *(Pimephales promelas)*
0.094	juvenile striped bass *(Morone saxatilis)*
0.1	striped killifish *(Fundulus majalis)*
0.037	pink shrimp *(Penaeus duorarum)*

Criteria

0.2 µg/l in water to protect domestic water supplies (U.S. Environmental Protection Agency, 1976a).

0.004 µg/l in water to protect fresh water and marine life (U.S. Environmental Protection Agency, 1976a).

300.0 µg/kg in edible fish or shellfish tissue to protect consumers (U.S. Food and Drug Administration, 1978).

The water quality criteria for endrin used in preparation of this report (above) have been superceded by the Environmental Protection Agency 1980 water quality criteria for fresh water and marine life. The new criteria are shown in Appendix I.

Fresh Water Determinations

Of the 148 pesticide in fresh water samples collected by the Department, all endrin determinations have been below the 0.02 µg/l detection limit.

Estuarine Water Determinations

Of the 64 pesticide in estuarine water samples collected by the agency, all endrin determinations have been below the 0.02 µg/l detection limit (Table 9).

Fresh Water Sediment Determinations

Of the 749 pesticide in fresh water sediment samples collected by the agency during routine sampling and intensive monitoring surveys, all endrin determinations have been below the 3.0 µg/kg detection limit.

Estuarine Sediment Determinations

Of the 196 pesticide in estuarine sediment samples collected by the agency during routine sampling and intensive monitoring surveys, all endrin determinations have been below the 3.0 µg/kg detection limit as shown in Table 11.

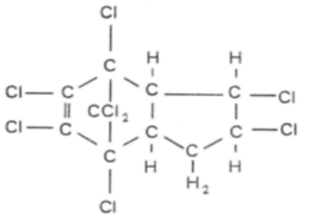
Residues in Fish and Shellfish Tissue

In 1969, residues of endrin were found in 13 percent of the fish samples collected by the Texas Parks and Wildlife Department. This program included samples from the Matagorda Bay area, San Antonio Bay area, Corpus Christi Bay area, and the lower Laguna Madre. Residues of endrin were detected only in the lower Laguna Madre where concentrations ranged from undetectable levels to 730 μg/kg. In a similar study conducted on oysters from these same areas, endrin was found only once, at a concentration of 10 μg/kg in the San Antonio Bay area (Childress, 1970).

In August 1978, the U.S. Fish and Wildlife Service conducted a pesticide in fish tissue study on the Arroyo Colorado. Data from this survey showed that endrin residues were present in whole fish samples from the Arroyo at locations extending from McAllen to the Port of Harlingen. Concentrations ranged from 80 μg/kg near San Juan to 570 μg/kg in the Llano Grande. In a similar study conducted by that agency in 1976 and 1977, endrin residues were detected sporadically throughout the Rio Grande and the Arroyo Colorado in low concentrations (U.S. Fish and Wildlife Service, 1976-77 and 1978).

Residues of endrin have been detected only once in fish samples collected by the Texas Department of Water Resources, during a special survey on the Rio Grande below the Rio Conchos (Mexico) confluence near Presidio in 1979. A concentration of 6.8 μg/kg was found in a composite sample of 2 blue suckers (whole fish).

Chlordane



Characterization

Chlordane is a synthetic organic (chlorinated hydrocarbon) compound used as a pesticide and in some instances as a fungicide. The compound is manufactured under several trade names such as: Velsicol 106S, CD-68, Toxichlor, Octaklor, Synklor, and Kypchlor. Chlordane is an amber-colored viscous liquid, insoluble in water but mixable with hydrocarbon solvents. Technical grade chlordane is a mixture of toxic compounds that are not separated in manufacturing. The compound is manufactured in a variety of forms including wettable powders, emulsifiable concentrates, dusts, and in solutions (Thomson, 1976).

Sources and Uses

Chlordane was developed by the Velsicol Chemical Company in 1945. Its high chronic toxicity prevented the use of chlordane on edible crops. On December 24, 1975 the U.S. Environmental Protection Agency suspended the production and use of chlordane for agricultural purposes. The suspension was the result of positive results found in carcinogenicity tests. This action should result in a gradual decrease in concentrations now present in the environment. However, the compound is still used for termite and roach control, and it has widespread agricultural use outside the United States (U.S. Environmental Protection Agency, 1976b; Thomson, 1976).

Chlordane was applied as a soil insecticide and seed treatment, and sprayed directly on plant foliage. Application rates ranged from 1 to 10 pounds per acre.

Before the U.S. Environmental Protection Agency suspension of this compound, the National Technical Advisory Committee to the Secretary of the Interior had recommended that chlordane should not be applied near marine habitats.

Metabolism and Toxicity

Chlordane can enter an organism through direct consumption or by skin absorption. It kills organisms by acting as a stomach poison. Its fumigant action has long residual effects. Fish can concentrate chlordane directly from water by a factor of 1,000 to 3,000 times the ambient water concentrations. Concentrations of 10 to 100 μg/kg are common in fish tissue throughout the United States (Edwards, 1973; McKee and Wolf, 1963; U.S. Environmental Protection Agency, 1976b; Thomson, 1976).

Due to chlordane's persistence, bioaccumulation potential, and carcinogenicity, human exposure should be kept to a minimum. A fatal dose to a man weighing 70 kg has been reported to be between 6 to 60 grams (U.S. Environmental Protection Agency, 1976a).

Chlordane dust has been found to be toxic to fingerling bass and bluegill sunfish at food concentrations of 100,000 μg/kg. In a toxicity test conducted in a closed pond, 5 pounds per acre killed 87 percent of the bluegills. All fish survived at an application rate of 0.5 pound per acre. Standard toxicity tests yield the following LC_{50} (Concentrations that kill 50 percent of the organisms in a toxicity experiment) results for a 96-hour exposure period (Edwards, 1973; McKee and Wolf, 1963; U.S. Environmental Protection Agency, 1976a):

Concentration (µg/l)	Fish
2.2	bluegill sunfish *(Lepomis macrochirus)*
5.2	fathead minnows *(Pimephales promelas)*
50.0	catfish *(Ictalurus* sp.)

Acute toxicity values found for fresh water invertebrates are similar to those found in fish for a 96-hour exposure period:

Concentration (µg/l)	Invertebrate
2.8	*Daphnia magna* (water flea)
9.7	*Hyallella azteca* (scud)
1.0	*Chironomus larva* (fly larvae)

Alkalinity, pH, and hardness of water have been found to have little effect on the toxicity of chlordane in an aquatic environment.

Criteria

0.01 µg/l in water to protect fresh water aquatic life (U.S. Environmental Protection Agency, 1976a).

0.004 µg/l in water to protect marine life (U.S. Environmental Protection Agency, 1976a).

The water quality criteria for chlordane used in preparation of this report (above) have been superceded by the Environmental Protection Agency 1980 water quality criteria for fresh water and marine life. The new criteria are shown in Appendix I.

Fresh Water Determinations

Of the 148 pesticide in fresh water samples collected by the Department of Water Resources, all chlordane determinations have been below the 5.0 µg/l detection limit. However, utilizing lower detection limits, the U.S. Geological Survey has detected chlordane sporadically at concentrations less than 5.0 µg/l in streams and bayous draining the Dallas, Houston, and San Antonio areas (Table 8).

Estuarine Water Determinations

Of the 64 pesticide in estuarine water samples collected by the Department, all chlordane determinations have been below the 5.0 µg/l detection limit as shown in Table 9.

Fresh Water Sediment Determinations

Of the 749 pesticide in fresh water sediment samples collected by the agency during routine sampling and intensive monitoring surveys, chlordane, has been detected 32 times above the 20 µg/kg detection limit. The highest values recorded have been 236 µg/kg and 610 µg/kg, both at station 0805.0300 on the Trinity River. Subsequent samples showed reduced but still significant concentrations (50 to 63 µg/kg). Concentrations lower than 20 µg/kg have been found in most of the major river basins, and subsequent sampling showed these concentrations to recur only in rivers draining highly populated urban areas (Table 10).

Estuarine Sediment Determinations

Of the 196 pesticide in estuarine sediment samples collected by the agency during routine sampling and intensive monitoring surveys, chlordane has been detected six times above the 20 µg/kg detection limit (Table 11). The highest values found have been 106 µg/kg in the tidal portion of Dickinson Bayou, Galveston County, and 130 µg/kg at station 2201.0200 in the tidal portion of the Arroyo Colorado drainageway. Subsequent samples from the Arroyo showed reduced but still significant concentrations (45 to 59 µg/kg). Chlordane in the Arroyo was attributable to the large volume of irrigation return flow and agricultural runoff.

Residues in Fish and Shellfish Tissue

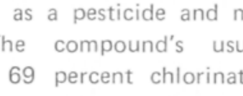
Analytical procedures for chlordane were not perfected by the Texas Parks and Wildlife Department until 1969, consequently few chlordane data are available for the tissue samples collected from 1965 to 1969. This program included oyster and fish samples from the Galveston, Matagorda, San Antonio, Aransas, and Corpus Christi Bay areas, and the lower Laguna Madre. The only residues of chlordane in fish tissue were found in San Antonio Bay. Residues ranged from below detectable limits to 122 µg/kg. Oyster samples collected in 1969 showed that chlordane residues were prevalent only in San Antonio and Aransas bays. These residues ranged from below detectable limits in both bays to 340 µg/kg in Aransas Bay (Childress, 1970).

In the 1976 and 1977 U.S. Fish and Wildlife Service pesticide in tissue study on the Rio Grande and Arroyo Colorado, residues of chlordane in the Rio Grande were detected sporadically and concentrations ranged from 240 µg/kg near McNary to 47 µg/kg near Mission. The highest concentration (613 µg/kg) was found in the Llano Grande Lake on the Arroyo Colorado.

The Texas Department of Water Resources has several times detected chlordane residues in fish tissue samples. The following is a list of locations and concentrations found:

Calaveras Lake	7.8	µg/kg	channel catfish *(Ictalurus punctatus)*
Victor Braunig Lake (East Lake)	33.1	µg/kg	channel catfish *(Ictalurus punctatus)*
San Antonio River, station 1901.0300	152.0	µg/kg	spotted gar *(Lepisosteus oculatus)*
North Fork Double Mountain Fork Brazos River in Lubbock	650.0	µg/kg	bullhead catfish *(Ictalurus melas)*
Corpus Christi	220	µg/kg	sea catfish *(Arius felis)*
Inner Harbor, station 2484.0200	750	µg/kg	Spanish mackerel *(Scomberomorus maculatus)*

Toxaphene



Characterization

Toxaphene is a chlorinated camphene (Chlorinated hydrocarbon) derived from southern pine. It is used as a pesticide and more recently as a piscicide. The compound's usual formulation contains 67 to 69 percent chlorination. Toxaphene is manufactured in a variety of forms including dusts, emulsifiable concentrates, and wettable powders. The compound is insoluble in water but highly soluble in organic solvents and oils.

Sources and Uses

Toxaphene was first manufactured by Hercules Incorporated in 1946. It soon became one of the most widely used pesticides. In more recent years, toxaphene has replaced rotenone as the more favored piscicide in the United States, due to its toxicity, low cost, and ease of application. As a pesticide the compound is either sprayed directly on foliage or mixed with water and applied to the soil. When the latter method is used, the soil is cultivated immediately to insure minimum runoff. Toxaphene, when used as a pesticide is applied 1 to 3 pounds per acre. As a piscicide, application ranges from 20 to 100 µg/l or in as low a dose as possible to achieve desired results (Thomson, 1976; McKee and Wolf, 1963).

Metabolism and Toxicity

When the pesticide is absorbed by organisms from the environment, it accumulates in fatty tissues. However, it has been shown to dissipate rather quickly. In lethal doses, the compound kills by acting as a stomach poison. Although in some cases toxaphene persists in the environment years after application, it is eventually broken down by soil microorganisms. In water, the breakdown occurs more rapidly in turbid hard water than in clear soft water (Thomson, 1976; McKee and Wolf, 1963).

The acutely lethal dose of toxaphene to a man weighing 70 kilograms is estimated to be 5 grams. It is unlikely that man or animal would consume such a toxic concentration due to the chemical's extreme terpene odor. Toxaphene has been implicated in the reproductive failure of ducks and other waterfowl. Significant losses in waterfowl populations have occured from a single spraying of 1.5 pounds per acre (McKee and Wolf, 1963; U.S. Environmental Protection Agency, 1976a; Thomson, 1976).

Toxaphene has been found to be three times as toxic to fish as rotenone. With the exception of endrin, it is also more toxic to fish than any of the other chlorinated hydrocarbons. Because of the facts mentioned above, the compound has been recently used as a piscicide. The other advantages of using the compound (low cost and ease of application) usually outweigh the one major disadvantage, its stability with long periods of toxicity. A number of lake sediments have remained toxic to aquatic fauna from 3 to 4 years after application. Normally lakes treated with the piscicide require from 2 to 12 months before detoxification reduces concentrations to a level suitable for restocking. The long persistence of toxaphene has been shown in some cases to be due to unnecessarily high application rates for a given area of water. Standard toxicity tests yield the following LC_{50} (concentration that kills 50 percent of the organisms in a toxicity experiment) results for a 96-hour exposure period (U.S. Environmental Protection Agency, 1976a; McKee and Wolf, 1963):

Concentration (μg/l)	Fish
2.0	largemouth bass *(micropterus salmoides)*
18.0	bluegill sunfish *(Lepomis macrochirus)*

Microcrustacea in general appear to be less affected by toxpahene than aquatic insect larvae. Laboratory tests have shown that *Daphnia* sp. have a 75 times greater tolerance limit than fish. However severe the effect of toxaphene on non-target fauna, repopulation usually occurs within a year (U.S. Environmental Protection Agency, 1976a; McKee and Wolf, 1963).

Criteria

5.0 μg/kg in water to protect domestic water supplies (U.S. Environmental Protection Agency, 1976a).

0.005 μg/l in water to protect fresh water and marine life (U.S. Environmental Protection Agency, 1976a).

5,000.0 μg/kg in edible fish tissue to protect consumers (U.S. Food and Drug Administration, 1978).

The water quality criteria for toxaphene used in preparation of this report (above) have been superceded by the Environmental Protection Agency 1980 water quality criteria for fresh water and marine life. The new criteria are shown in Appendix I.

Fresh Water Determinations

Of the 148 pesticide in fresh water samples collected by the Department of Water Resources, all toxaphene determinations have been below the 5.0 μg/l detection limit.

Estuarine Water Determinations

Of the 64 pesticide in estuarine water samples collected by the agency, all toxaphene determinations have been below the 5.0 μg/kg detection limit as shown in Table 9.

Fresh Water Sediment Determinations

Of the 749 pesticide in fresh water sediment samples collected by the Department during routine sampling and intensive monitoring surveys, all determinations for toxaphene have been below the 50 μg/kg detection limit. Utilizing lower detection limits, the U.S. Geological Survey has detected concentrations ranging from 20 to 48 μg/kg in three samples from the Trinity River below Dallas. The highest value recorded by the Survey has been 62 μg/kg at station 0303.0200 on the Sulphur River northwest of Talco. Subsequent samples showed concentrations below detectable limits.

Estuarine Sediment Determinations

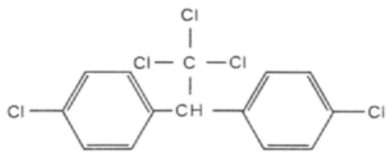
Of the 196 pesticide in estuarine sediment samples collected during routine sampling and intensive monitoring surveys by the Department of Water Resources, all determinations for toxaphene have been below the 50 μg/kg detection limit as shown in Table 11.

Residues in Fish Tissue

In the fall and winter of 1976-77 and again in the summer of 1978, the U.S. Fish and Wildlife Service conducted pesticide in tissue studies on the Rio Grande and the Arroyo Colorado. Residues of toxaphene were detected sporadically in the Rio Grande with concentrations ranging from below detectable limits at the majority of sites sampled to 980 μg/kg in a whole sample of a blue catfish in the Rio Grande at Anzalduas Dam in 1978. Residues of toxaphene were found frequently in the Arroyo Colorado in 1978 with concentrations ranging from 9,680 μg/kg in a whole sample of a blue catfish at Harlingen to 31,500 μg/kg in a whole sample of the same species at the Port of Harlingen (U.S. Fish and Wildlife Service, 1978).

Residues of toxaphene have not been detected in fish samples collected by this Department during routine monitoring and special studies. However, at the time of this report areas where high concentrations of toxaphene were found by the U.S. Fish and Wildlife Service are being resampled.

DDT, DDD, and DDE



Characterization

DDT is a chlorinated hydrocarbon compound formerly used as a pesticide. It was one of the first and the most widely used chlorinated hydrocarbon pesticides in the world. In fact, its use was so widespread that today almost everyone stores a trace amount of DDT in their body fat.

DDT is a white crystalline compound that was manufactured as emulsifiable concentrates, dusts, and wettable powders. Application rates ranged from 1 to 2 pounds per acre. The compound is almost insoluble in water and has a half-life of 12 to 17 years.

DDD, sometimes known as Rhothane or TDE, is a metabolite of DDT but was also manufactured as a pesticide. It exhibits chemical properties similar to DDT and was used in the same ways although applied at higher rates. Chemically it has one less chlorine atom (Thomson, 1976).

DDE is the major and final breakdown product of DDT. This compound was not manufactured as a pesticide. DDE with a half-life in excess of 10 years is one of the most, if not the most, widely distributed pesticide residues in our environment.

Sources and Uses

DDT was first manufactured by the Geigy Chemical Company in 1940 and by 1944 it was in worldwide use. Today it is only produced by the Montrose Chemical Company. In January of 1971 the Environmental Protection Agency cancelled all products and uses of DDT except the following (U.S. Environmental Protection Agency, 1978):

1. By the U.S. Public Health Service and other Health Service Officials for control of vector diseases.
2. By the U.S. Department of Agriculture or military for health quarantine.
3. In drugs, for controlling body lice. (To be dispensed only by a physician).
4. In the formulation of prescription drugs for controlling body lice.

DDD was manufactured by the Rohm and Haas Chemical Company. In March 1971, the Environmental Protection Agency cancelled all products containing DDD (U.S. Environmental Protection Agency, 1978).

DDT and DDD were used to combat almost all insects, with such exceptions as crickets, grasshoppers, boll weevils, and most aphids. However, many insects became resistant from the prolonged use of these compounds.

Metabolism and Toxicity

These compounds are almost insoluble in water and are not decomposed by sunlight. They are extremely stable in sediment, adhering to sediment particles and decomposing at a rate of 5 percent per year. DDT and its metabolites are lipophilic in nature (accumulate in body fat) and are bioaccumulated upward through the food chain with little being lost due to excretion. Some animals at the top of the food chain have been found to have inordinately high amounts of these compounds. For example, 1,100,000 μg/kg of DDE has been detected in brown pelican eggs. The upward passage of these compounds through the food chain is of major significance since they are considered to be carcinogenic (Edwards, 1973; McKee and Wolf, 1963; U.S. Environmental Protection Agency, 1976b; Childress, 1970).

Many aquatic and terrestrial micro- and macroorganisms are able to metabolize DDT to DDD and DDE. Aquatic organisms have been found to be more susceptible to their toxic effects than terrestrial organisms, and aquatic insects and invertebrates have been shown to be more susceptible than fish. The compounds are less toxic in aquatic systems where there is an abundance of aquatic plants. Aquatic plants, especially the green alga *Cladophora* sp., accumulate these pesticides faster and in greater concentrations than aquatic animals (Edwards, 1973; McKee and Wolf, 1963; U.S. Environmental Protection Agency, 1976a). DDT and its metabolities kill by action on the central nervous system of insects (Thomson, 1976).

Standard toxicity tests utilizing 96-hour TLm values (standard toxicity tests where a concentration of a substance kills 50 percent of the organisms tested) for DDT show the following results (Edwards, 1973; McKee and Wolf, 1963; U.S. Environmental Protection Agency, 1976a):

TLm (μg/l)	Organism
2.0	fingerling bass *(Micropterus salmoides)*
27.0	goldfish *(Carassius auratus)*
16.0	bluegill sunfish *(Lepomis macrochirus)*
32.0	fathead minnow *(Pimephales promelas)*
0.24	crayfish *(Orconectes nais)*

In a toxicity test utilizing 7 species of estuarine fish and 12 pesticides, only endrin was found to be more toxic than DDT (U.S. Environmental Protection Agency, 1976b).

Investigations in Texas have shown the sublethal effects of DDT and its metabolites on the juvenile sea trout, *Cynoscion nebulosus*, in the lower Laguna Madre. The decline of this species was attributed to their inability to withstand natural stress and to immobility of recently hatched fish, both of which lead to increased predation. Also, the decline of the brown pelican, *Pelecanus occudentalis*, along the entire Texas coast was probably attributable to pesticide residues. However, since the ban of DDT, both species have recovered significantly (Childress, 1970).

Criteria

Criteria are based on total DDT which is the summation of DDT, DDD, and DDE:

0.001 μg/l in water to protect fresh water and marine life (U.S. Environmental Protection Agency, 1976a).

5,000.0 μg/kg in edible fish tissue to protect consumers (U.S. Food and Drug Administration, 1978).

The water quality criteria for DDT, DDD, and DDE used in preparation of this report (above) have been superceded by the Environmental Protection Agency 1980 water quality criteria for fresh water and marine life. The new criteria are shown in Appendix I.

Fresh Water Determinations

Of the 148 pesticide in fresh water samples collected by the Department of Water Resources, all DDT determinations have been below the 0.24 μg/l detection limit. Utilizing lower detection limits, the U.S. Geological Survey has found DDT infrequently at concentrations less than 0.24 μg/l in streams and bayous draining the Houston and San Antonio areas (Table 8).

Estuarine Water Determinations

Of the 64 pesticide in estuarine water samples collected by the Department, all DDT determinations have been below the 0.24 μg/l detection limit as shown in Table 9.

Fresh Water Sediment Determinations

Of the 749 pesticide in fresh water sediment samples collected by the agency during routine sampling and intensive monitoring surveys, DDT has been detected 60 times in amounts greater than the 5.0 μg/kg detection limit. The highest value recorded has been 725 μg/kg on Leon Creek in San Antonio. Subsequent sampling showed high but decreasing concentrations. The source of these compounds was unknown at the time of this report and samples were still being collected. Utilizing lower detection limits, the U.S. Geological Survey has found DDT frequently at low concentrations throughout the major river basins of Texas (Table 10). Intensive monitoring surveys have shown Lake Murvaul (9.6 μg/kg), Lake Austin (5.3 μg/kg), Twin Buttes Reservoir (4.1 μg/kg), and Lake Livingston (3.5 μg/kg) to have the highest average concentration of total DDT in reservoirs sampled for sediment.

Estuarine Sediment Determinations

Of the 196 estuarine sediment samples collected by the Department of Water Resources during routine sampling and intensive monitoring surveys, DDT has been detected 5 times above the 5.0 μg/kg detection limit as shown in Table 11. The highest values recorded have been 28 μg/kg at station 2482.0300 in Nueces Bay, and 4,920 μg/kg at station 1005.0100 and 6,070 μg/kg at station 1006.0100 both on the Houston Ship Channel. Subsequent sampling showed concentrations below detectable limits at all sites.

Residues in Fish and Shellfish Tissue

The Texas Parks and Wildlife Department collected oyster and fish samples monthly for pesticide analyses from 1965 to 1979. This program included samples from the Galveston, Matagorda, San Antonio, Aransas, and Corpus Christi Bay areas, and the lower Laguna Madre, including the Arroyo Colorado natural drainageway. Tissue samples showed that residues of DDT and its metabolites were present in all Texas bay areas. Incidences of occurrence was found to decrease slightly in oysters (from 89 to 70 percent) and remain essentially the same in fish (100 to 99 percent) in this time period. Concentrations were found to increase southward in Texas bays. Appendix E shows the highest concentrations found in this study.

The U.S. Fish and Wildlife Service collected fish from the Rio Grande and Arroyo Colorado for pesticide analyses in the fall and winter of 1976 through 1977 and again in the summer of 1978. Concentrations of DDT and its metabolites found are given in Appendix F.

Residues of DDT, DDD, and DDE detected in fish samples collected by the Texas Department of Water Resources are given in Appendix G.

DDD

Toxicity

Similar to that of DDT.

Criteria

See previous discussion of DDT.

Fresh Water Determinations

Of the 148 pesticide in fresh water samples collected by the Department of Water Resources all DDD determinations have been below the 0.30 μg/l detection limit. Utilizing a lower detection limit the U.S. Geological Survey has detected DDD at concentrations less than 0.30 μg/l infrequently in streams and bayous draining the Houston and San Antonio areas (Table 8).

Estuarine Water Determinations

Of the 64 pesticide in estuarine water samples collected by the agency, all DDD determinations have been below the 0.30 μg/l detection limit as shown in Table 9.

Fresh Water Sediment Determinations

Of the 749 pesticide in fresh water sediment samples collected by the Department during routine sampling and intensive monitoring surveys, DDD has been detected 109 times above the 3.0 μg/kg detection limit. The highest values recorded have been 180 μg/kg at station 1417.0100 on Pecan Bayou southeast of Brownwood and 210 μg/kg on Leon Creek in San Antonio. Subsequent sampling showed reduced concentrations at both sites. Utilizing lower detection limits, the U.S. Geological Survey has found DDD frequently throughout most of the major river basins of Texas (Table 10).

Estuarine Sediment Determinations

Of the 196 pesticide in estuarine sediment samples collected by the Department during routine sampling and intensive monitoring surveys, DDD has been detected 12 times above the 3.0 μg/kg detection limit as shown in Table 11. The highest values recorded have been 10.0 μg/kg at station 2201.0200 on the tidal portion of the Arroyo Colorado and 226 μg/kg at station 1006.0200 on the Houston Ship Channel. Subsequent sampling showed concentrations below detectable limits at both sites.

Residues in Fish and Shellfish Tissue

See previous discussion of DDT, and Appendices E, F, and G.

DDE

Toxicity

Similar to that of DDT.

Criteria

See previous discussion under DDT.

Fresh Water Determinations

Of the 148 pesticide in fresh water samples collected by the Department of Water Resources, all determinations for DDE have been below the 0.09 μg/l detection limit. Utilizing lower detection limits, the U.S. Geological Survey has detected DDE infrequently at concentrations below 0.09 μg/l in the Red, Brazos, and San Antonio River basins (Table 8).

Estuarine Water Determinations

Of the 64 pesticide in estuarine water samples collected by the Department, all determinations for DDE have been below the 0.09 μg/l detection limit as shown in Table 9.

Fresh Water Sediment Determinations

Of the 749 pesticide in fresh water sediment samples collected by this agency during routine sampling and intensive monitoring surveys, DDE has been detected 208 times above the 2.0 μg/kg detection limit. Utilizing lower detection limits, the U.S. Geological Survey has found DDE frequently throughout most of the major river basins in Texas (Table 10). The highest values recorded have been 100 μg/kg at station 1423.0100 on Twin Buttes Reservoir and 190 μg/kg at station 1417.0100 on Pecan Bayou southeast of Brownwood. At the time of this report, subsequent samples showed reduced concentrations in Pecan Bayou; however, elevated concentrations were found in Twin Buttes Reservoir (180 μg/kg).

Estuarine Sediment Determinations

Of the 196 pesticide in estuarine sediment samples collected by the Department during routine sampling and intensive monitoring surveys, DDE has been detected 24 times above the 2.0 μg/kg detection limit as shown in Table 11. The highest values recorded have been 90 μg/kg at station 2201.0200 in the tidal portion of the Arroyo Colorado, and 2,170 μg/kg at station 1005.0100 and 2,340 μg/kg at station 1006.0100, both on the Houston Ship Channel. Previous and subsequent samples showed similar concentrations in the Arroyo, which were attributable to the large volume of irrigation return flow and agricultural runoff that enters the Arroyo. Subsequent sampling on the Ship Channel showed concentrations below detectable limits.

Residues in Fish and Shellfish Tissue

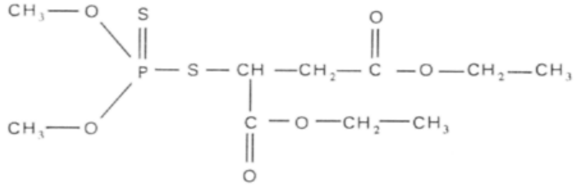
See previous discussion of DDT, and Appendices E, F, and G.

Organophosphate Pesticides

The organophosphate pesticides were first manufactured in 1945. Most of these compounds are relatively unstable in the environment and have been shown to disappear only a few days or weeks after application. Therefore, there are usually several applications during a crop-growing period. The organophosphates show extreme variability with regard to toxicity in aquatic organisms. They have been found to be more toxic than chlorinated hydrocarbons to marine invertebrates. Toxicity and bioaccumulation in oysters have been found to be approximately two orders of magnitude higher for organophosphates than for chlorinated hydrocarbons.

Use of the organophosphates became more extensive when research showed that the chlorinated hydrocarbons were highly persistent, bioaccumulative, and toxic to nontarget organisms. Also, many insects were becoming resistant to the chlorinated hydrocarbons such as DDT. The organophosphates discussed are malathion, parathion, methyl parathion, and diazinon.

Malathion



Characterization

Malathion is an organophosphate compound with insecticidal and acaricidal (miticidal) properties. This compound is a deep brown-yellow liquid that is soluble in water. It is manufactured as wettable powders, emulsifiable concentrates, dusts, aerosols, granules, and baits (McKee and Wolf, 1963; Thomson, 1976).

Sources and Uses

Malathion was developed by the American Cyanamid Company in 1950. The usual application rate is 1/2 to 2 pounds per 100 gallons of water or 1/2 to 3 pounds per acre. Malathion is applied to the soil as a preplant insecticide or can be used as a seed treatment. It is also used as a livestock dip or spray and is frequently used in the eradication of ant mounds (Thomson, 1976).

Metabolism and Toxicity

Malathion can be ingested or absorbed through the skin. The stability of the compound is dependent on the chemical and biological conditions of the water. The half-life of malathion has shown to be reduced from about 5 months at pH 6 to 1 to 2 weeks at pH 8. Standard toxicity tests yield the following values for a 96-hour exposure period (Edwards, 1973; McKee and Wolf, 1963; U.S. Environmental Protection Agency, 1976a; Thomson, 1976):

96-hour TLm value (μg/l)	Organism
110.0	bluegill sunfish *(Lepomis macrochirus)*
50.0	bass *(Micropterus salmoides)*
550.0	mullet *(Mugil cephalus)*
1.0	amphipod *(Gammarus lacustris)*

Criterion

0.1 μg/l of water to protect fresh water and marine life (U.S. Environmental Protection Agency, 1976a).

Fresh Water Determinations

Of the 148 pesticide in fresh water samples collected by the Department of Water Resources, all determinations for malathion have been below the 1.4 μg/l detection limit. Utilizing lower detection limits, the U.S. Geological Survey has detected malathion infrequently in streams and bayous draining the Dallas, Houston, and San Antonio areas (Table 8). The highest value recorded by the Survey has been 14 μg/l at station 1000.2700 on Buffalo Bayou in Houston. Subsequent samples showed reduced concentrations (0.06 μg/l).

Estuarine Water Determinations

Of the 64 pesticide in estuarine water samples collected by the Department, all determinations for malathion have been below the 1.4 μg/l detection limit as shown in Table 9.

Fresh Water Sediment Determinations

Of the 749 pesticide in fresh water sediment samples collected by this agency during routine sampling and intensive monitoring surveys, all malathion determinations have been below the 5.0 μg/kg detection limit.

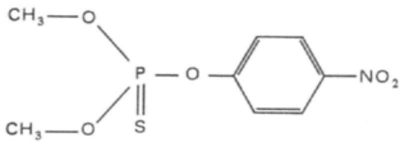
Estuarine Sediment Determinations

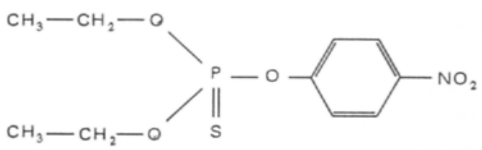
Of the 196 pesticide in estuarine sediment samples collected during routine sampling and intensive monitoring surveys, all malathion determinations have been below the 5.0 μg/kg detection limit as shown in Table 11.

Residues in Fish Tissue

Because of their rapid degradation in aquatic organisms, the organophosphates are not analysed in tissue samples.

Parathion and Methyl Parathion





Characterization

Parathion and methyl parathion are organophosphate compounds used as insecticides and acaricides. Parathion is a yellow liquid which exhibits a garlic-like odor. The compound is insoluble in water but freely soluble with alcohol and some hydrocarbons. Methyl parathion is similar in its solubility. These organophosphate insecticides, which exhibit some fumigant action, are manufactured in a variety of forms including wettable powders, emulsifiable concentrates, dusts, granules, and aerosols, and are often mixed with other pesticides. They, like some other organophosphate insecticides, are unstable in water and have shown no tendency to accumulate in nontarget components of the treated biota (McKee and Wolf, 1963; U.S. Environmental Protection Agency, 1976a; Thomson, 1976).

Sources and Uses

Parathion and methyl parathion were developed in 1947 and 1949, respectively, by the Bayer Company in Germany. Monsanto and Kerr McGee companies are the principle producers today in the United States. Both compounds are used extensively by public health authorities for mosquito abatement and control. As a mosquito larvicide they are usually applied at 0.1 to 3 pounds per acre on irrigated pastures. Also when used as mosquito larvicides, nontarget organisms are unaffected or their numbers are only temporarily reduced. However, some mosquito populations have become resistant to both compounds. Methyl parathion has been used successfully since 1962 on the aquatic gnat, *Charobus ascitopus*. When used in terrestrial environments, the compounds are usually applied to row or orchard crops. Immediately after application, they should be disced into the soil and the treated area should be quarantined for 48 hours. Likewise, the compounds should not be allowed to drift in areas where animals or humans are located. It is recommended that they not be applied in areas where shrimp and crabs are important resources. As with other organophosphate insecticides, which are usually not persistent in nature, areas must be treated several times for full effectiveness (Edwards, 1973; McKee and Wolf, 1963; U.S. Environmental Protection Agency, 1976a; Thomson, 1976).

Metabolism and Toxicity

Parathion and methyl parathion can be ingested or absorbed through the skin. In lethal doses, the compounds act as stomach poisons. A lethal dose for a man weighing 70 kg is 1.5 grams. These compounds do not accumulate in tissue but have been found in concentrations 50 times higher in blood samples from aquatic organisms than in the surrounding water. They are fast acting and do not accumulate in soil, and no harmful effects have been noted on soil microorganisms (Thomson, 1976).

In areas where these compounds are used for mosquito control, concentrations ranging from 0.3 to 70 μg/l were found to last from 3 to 4 days. (The lethal concentration for mosquitoes is approximately 3 μg/l). Similar results were found in surrounding soil, plants, and fauna.

Parathion

Toxicity

Standard toxicity tests yield the following LC_{50} (concentration that kills 50 percent of the organisms in toxicity experiment) range: 500 μg/l for sensitive species of fresh water fish such as the bluegill sunfish (*Lepomis macrochirus)* to 2,500 μg/l for resistant species such as minnows. Some LC_{50} values for marine organisms are 0.2 μg/l for pink shrimp *(Penaeus duorarum)*, and 125 μg/l for mullet *(Mugil cephalus)*. Parathion has been found to be acutely toxic to aquatic invertebrates at 1 μg/l. Standard toxicity tests show the following parathion values for a 96-hour exposure period (Edwards, 1973; McKee and Wolf, 1963; U.S. Environmental Protection Agency, 1976a):

96-hour LC_{50} value (μg/l) for parathion	Organism
500	bluegill sunfish *(Lepomis macrochirus)*
1,600	fathead minnow *(Pimephales promelas)*
18.0	juvenile striped bass *(Morone saxatilis)*
0.43	caddis fly larvae *(Hydropsyche californica)*

Criterion

0.04 μg/l in water to protect fresh water and marine life (U.S. Environmental Protection Agency, 1976a).

Fresh Water Determinations

Of the 148 pesticide in fresh water samples collected by the Department of Water Resources, all determinations for parathion have been below the 0.5 μg/l detection limit. Utilizing lower detection limits, the U.S. Geological Survey has detected parathion in Texas waters only three times, at levels between 0.01 and 0.50 μg/l (Table 8). The highest value recorded has been 0.50 μg/l at station 1901.0100 on the San Antonio River southeast of Goliad. Subsequent samples showed concentrations below detectable limits.

Estuarine Water Determinations

Of the 64 pesticide in estuarine water samples collected by the Department, all determinations for parathion have been below the 0.5 μg/l detection limit as shown in Table 9.

Fresh Water Sediment Determinations

Of the 749 pesticide in fresh water sediment samples collected by the agency during routine sampling and intensive monitoring surveys, all determinations for parathion have been below the 5.0 μg/kg detection limit.

Estuarine Sediment Determinations

Of the 196 pesticide in estuarine sediment samples collected during routine sampling and intensive monitoring surveys, all determinations for parathion have been below the 5.0 μg/kg detection limit as shown in Table 11.

Residues in Fish Tissue

Because of their rapid degradation in aquatic organisms, the organophosphates are not analysed in tissue samples.

Methyl Parathion

Toxicity

96-hour TLm value (μg/l) for methyl parathion (McKee and Wolf, 1963)	Organism
5,720	bluegill sunfish *(Lepomis macrochirus)*

Criteria

None available.

Fresh Water Determinations

Of the 148 pesticide in fresh water samples collected by the Department, all determinations for methyl parathion have been below the 0.5 μg/l detection limit.

Estuarine Water Determinations

Of the 64 pesticide in estuarine water samples collected by the agency, all determinations for methyl parathion have been below the 0.5 μg/l detection limit as shown in Table 9.

Fresh Water Sediment Determinations

Of the 749 pesticide in fresh water sediment samples collected by the agency during routine and intensive monitoring surveys, all determinations for methyl parathion have been below the 5.0 μg/kg detection limit.

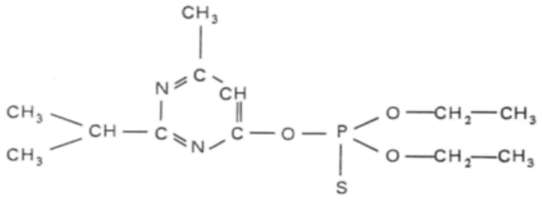
Estuarine Sediment Determinations

Of the 196 pesticide in estuarine sediment samples collected during routine sampling and intensive monitoring surveys, methyl parathion has been detected only once over the 5.0 μg/kg detection limit as shown in Table 11. That value was 13 μg/kg at station 2484.0200 in the Corpus Christi Inner Harbor. Subsequent samples showed concentrations below detectable limits.

Residues in Fish Tissue

Because of their rapid degradation in aquatic organisms, the organophosphates are not analysed in fish tissue.

Diazinon



Characterization

Diazinon is a organophosphate compound with high insecticidal and acaricidal properties. Diazinon exhibits a faint ester-like odor and is miscible with a number of hydrocarbon solvents. The compound is manufactured as wettable powders, emulsifiable concentrates, granules, aerosols, a 4 to 6 pounds per gallon oil solution, dusts, and as a fertilizer mix.

Sources and Uses

Diazinon was developed in 1956 by the Ciba-Geigy Corporation. After investigative research showed that organochlorine pesticides were highly persistent and toxic to nontarget organisms, organophosphates such as diazinon became popular. The usual application of diazinon is 1/4 to 1 pound per 100 gallons of water or 1/4 to 2 pounds per acre. Diazinon is applied to the soil as a preplant insecticide or can be used as a seed treatment. It is also used as a sheep dip (in dilution) and sprayed for the control of horseflies in barns and stables (Thomson, 1976).

Metabolism and Toxicity

Diazinon can be ingested or absorbed through the skin. In lethal dose it acts as a stomach poison. A lethal dose to a man weighing 70 kg is approximately 25 grams. In nonlethal doses it causes the abnormal function of an enzyme essential to the liver. Little information is available on the persistence of organophosphates. Although these compounds are advertised as being short-lived, some may not be because of the lack and inconsistency of information dealing with their persistence (Edwards, 1973; McKee and Wolf, 1963; U.S. Environmental Protection Agency, 1976b; Thomson, 1976).

The following results were found in a research study where diazinon was applied to 0.255 kg/ha in an estuarine system (U.S. Environmental Protection Agency, 1976b):

Persistence (days)	Substrate
4	intertidal sand
6	salt marsh sod
10	salt marsh mud

Standard toxicity tests found that 500 µg/l of diazinon killed 50 percent of the largemouth bass *(Micropterus salmoides)* in a 96-hour exposure period. Organophosphates have been found to be much more toxic than organochlorines to marine invertebrates. Also, bioaccumulation in oysters for a 24-hour period was found to be two orders of magnitude higher for the organophosphates than the organochlorines (U.S. Environmental Protection Agency, 1976b). Standard toxicity tests yield the following values for 96- and 48-hour exposure periods (Edwards, 1973; McKee and Wolf, 1963; U.S. Environmental Protection Agency, 1976a):

TLm value (µg/l)	Organism
59.0 (96-hour)	bluegill sunfish *(Lepomis macrochirus)*
500.0 (96-hour)	bass *(Micropterus salmoides)*
250.0 (48-hour)	juvenile white mullet *(Mugil curema)*

Criteria

1.0 µg/l in water to protect domestic water supplies (U.S. Environmental Protection Agency, 1976a).

0.009 µg/l in water to protect fresh water and marine life (U.S. Environmental Protection Agency, 1976a).

Fresh Water Determinations

Of the 148 pesticide in fresh water samples collected by the Department of Water Resources, all determinations for diazinon have been below the 0.02 µg/l detection limit. Utilizing lower detection limits, the U.S. Geological Survey has found diazinon to be the most frequently detected pesticide in Texas waters (Table 8). Concentrations of diazinon have been found throughout most of the major river basins in Texas. The highest values recorded have been 0.77 µg/l at station 1000.2700 on Buffalo Bayou in Houston and 0.75 µg/l at station 0805.0300 on the Trinity River below Dallas. Prior and subsequent samples showed similar concentrations at both sites.

Estuarine Water Determinations

Of the 64 pesticide in estuarine water samples collected by the Department, all determinations for diazinon have been below the 0.02 µg/l detection limit as shown in Table 9.

Fresh Water Sediment Determinations

Of the 749 pesticide in fresh water sediment samples collected during routine sampling and intensive monitoring surveys, all determinations for diazinon have been below the 5.0 µg/kg detection limit. However, utilizing a lower detection limit, diazinon was detected at a concentration of 0.3 µg/kg during an intensive monitoring survey of McKinney Bayou north of Texarkana.

Estuarine Sediment Determinations

Of the 196 pesticide in estuarine sediment samples collected during routine sampling and intensive monitoring surveys, all determinations for diazinon have been below the 5.0 µg/kg detection limit as shown in Table 11.

Residues in Fish Tissue

Because of their rapid degradation in aquatic organisms, the organophosphates are not analyzed in fish tissue.

Industrial Chemicals—PCBs (Polychlorinated Biphenyls)

Characterization

PCBs or polychlorinated biphenyls are a mixture of synthetic organic compounds containing varying amounts of chlorine. Their physical state varies from colorless, oily liquids to yellow or black resins, depending on the degree of chlorination. They are only slightly soluble in water but are soluble in oils and fats. They have a very low flammability, are poor conductors (good dielectrics), and are resistant to degradation by heat, acids, alkalies, and biological organisms. Although chemical and physical properties vary somewhat among the compounds, they are usually assayed and considered as a group for water quality monitoring purposes (U.S. Environmental Protection Agency, 1976a).

Sources and Uses

The only domestic manufacturer of PCBs is Monsanto, which markets them as Aroclors, such as Aroclor 1242, with the numbers designating the molecular type and degree of chlorination. There are also some foreign producers who export to the United States. Due to their low flammability, heat stability, and dielectric properties, they formerly had a wide range of industrial applications including insulation of transformers, capacitors, hydraulic fluids, inks, and carbonless carbon paper (U.S. Environmental Protection Agency, 1976a). In response to growing evidence of PCB resistance to environmental degradation and of their toxicity, Monsanto began in 1971 to restrict production and limit distribution mainly to certain electrical applications in which there is no suitable replacement for PCBs.

Metabolism and Toxicity

PCBs, like DDT and related organochlorine compounds, are relatively non-biodegradable and are fat-soluble. Thus, like DDT, they tend to accumulate in the fatty tissues of organisms; a number of aquatic organisms have been observed to accumulate PCBs in their tissues to concentrations reaching 3,000 to 200,000 times the environmental levels. The PCBs are lethally toxic to fish and aquatic invertebrates at environmental concentrations of several parts per billion. Also like DDT, PCBs tend to be most concentrated in higher organisms (mammals and birds) at the top of food chains; acute toxicity for higher animals, however, is somewhat lower than for fish and invertebrates.

Accidental exposure of humans to an acutely toxic amount of PCBs, as low as 0.5 gram per month taken orally, has resulted in skin lesions and liver disorders. In 1971 the average uptake for a teen-age male was 15 micrograms per day; subsequent years showed a steady decline to 1975 (Jelinek and Corneliussen, 1976).

Standard toxicity tests yield the following range of values in a 96-hour exposure period (U.S. Environmental Protection Agency, 1976a):

96-hour TLm value (µg/l)	**Organism**
7.7 - 15.0	fathead minnow *(Pimephales promelas)*

Criteria

0.001 µg/l in water to protect fresh water and marine life (U.S. Environmental Protection Agency, 1976a).

5,000.0 µg/kg in edible fish tissue to protect consumers (U.S. Food and Drug Administration, 1978).

The water quality criteria for PCBs used in this report (above) have been superceded by the Environmental Protection Agency 1980 water quality criteria for fresh water and marine life. The new criteria are shown in Appendix I.

Fresh Water Determinations

Of the 148 pesticide in fresh water samples collected by the Department of Water Resources, only one determination for PCBs was above the 2.0 µg/l detection limit. That value was 2.2 µg/l found at station 1212.0200 on Somerville Lake in March 1976 (Appendix A). At the time of this report, there have been no subsequent samples taken; however, an intensive monitoring survey conducted in June 1975 revealed PCBs in sediment throughout the reservoir in low concentrations. Utilizing lower detection limits, the U.S. Geological Survey found PCBs infrequently in Buffalo Bayou and the Brazos and Colorado Rivers (Table 8). Subsequent samples at these sites showed concentrations below detectable limits.

Estuarine Water Determinations

Of the 64 pesticide in estuarine water samples collected by this Department, all determinations for PCBs have been below the 2.0 µg/l detection limit as shown in Table 9.

Fresh Water Sediment Determinations

Of the 749 pesticide in fresh water sediment samples collected by the agency during routine and intensive monitoring surveys, PCBs were detected 378 times above the 20 µg/kg detection limit. The highest value recorded was 8,900 µg/kg on the North Fork Double Mountain Fork Brazos River in Lubbock. Subsequent samples showed reduced but still significant concentrations (6,500 µg/kg). The source of these compounds was unknown at the time of this report. Utilizing lower detection limits, the U.S. Geological Survey has found PCBs to be ubiquitous in most of the major river basins in Texas.

Intensive monitoring surveys have shown Lake Nasworthy (94 µg/kg), Lake Brownwood (57 µg/kg), and Caddo Lake (48 µg/kg) to have the highest average concentrations of PCBs in the reservoir sediments sampled.

Estuarine Sediment Determinations

Of the 196 pesticide in estuarine sediment samples collected during routine and intensive monitoring surveys, PCBs were detected 96 times above the 20 µg/kg detection limit as shown in Table 11. The highest values recorded have been 390 µg/kg at station 2484.0100 in the Corpus Christi Inner Harbor and 371 µg/kg at station 1006.0300 in the Houston Ship Channel. Subsequent samples showed reduced concentrations in the Inner Harbor (46 µg/kg). At this time, no additional data are available from the Houston Ship Channel.

Residues in Fish and Shellfish Tissue

The Texas Parks and Wildlife Department collected oyster and fish samples monthly for PCB analyses in 1969. This program included samples from Galveston, Matagorda, San Antonio, Aransas, and Corpus Christi Bay areas, and the lower Laguna Madre, including the Arroyo Colorado. Peak concentrations ranged from below detectable limits in oysters to 1,200 µg/kg in a whole body sample of a mullet from Corpus Christi Bay. Of special note in regard to the biomagnification phenomenon, the tissue of a white pelican from Corpus Christi Bay was found to contain 115,000 µg/kg of PCBs (Childress, 1970).

DISTRIBUTION BY RIVER BASIN

The various river basins in Texas provide an accessible and logical means of looking at the geographical distribution of pesticide concentrations statewide. Not only are there unique qualities such as soil types, population density, and agricultural endeavors associated with each basin, but contaminants introduced in an area will remain there until they decompose or are carried to the sea.

In Table 12, positive pesticide determinations in fresh water are listed by river basin. By far the largest percentage of positive determinations are in the Trinity, San Jacinto, and San Antonio River basins which drain Texas principal urban areas.

Positive determinations in fresh water sediment are shown in Table 13 and reflect a somewhat different distribution than those in water. While the Trinity, San Jacinto, and San Antonio basins show significant sediment contamination by several pesticide compounds and several of the other basins, the Sulphur, Cypress Creek, Sabine, Brazos, Colorado, and Guadalupe, have a large number of positive determinations for one or two compounds. The most frequently detected were PCBs and the DDT breakdown products, DDD and DDE. Chlordane and dieldrin were found frequently in the three most urbanized basins.

Specific river and estuarine segments where significant pesticide concentrations have been found are discussed below. These areas generally follow the pattern of more frequent occurrences in populated rather than agricultural regions.

Trinity River

Significant pesticide concentrations have been found in the mainstream Trinity from Lake Livingston headwaters to Fort Worth. This stretch of the river is divided into two segments which are described below.

Segment 0804 extends 195 miles from State Highway 21 near Midway in Madison County to State Highway 34 near Rosser in Kaufman County. The drainage area within this segment is characterized by farmland and forested areas. Soil types vary from the prairie type soil of the Blackland Prairie region to the sand and clay soils which characterize the East Texas pine and hardwood forests. At the time of this report there were 37 permitted facilities which discharged municipal wastewater to the segment (Texas Water Quality Board, 1977).

Segment 0805 is approximately 95 miles long, extending from a point on the Trinity River at State Highway 34 near Rosser in Kaufman County to a point on the West Fork Trinity River at Beach Street in Fort Worth in Tarrant County. Most of the segment is within

Table 12.--Summary of Positive Pesticide Determinations in Fresh Water for Each Major River Basin. Data Derived from Sampling by the Texas Department of Water Resources and U.S. Geological Survey, 1973-77.

River Basin	Number of Samples	2,4-D	2,4,5-T	Silvex	Hepta-chlor	Hepta-chlor epoxide	Lindane	Methoxy-chlor	Aldrin	Dieldrin	Endrin	Chlordane	Toxaphene	DDT	DDD	DDE	Malathion
Canadian	56	18	9	10	--	--	7	--	--	1	--	1	--	--	--	1	--
Red	64	8	5	--	--	1	2	--	1	2	1	--	--	1	2	8	--
Sulphur	18	5	4	--	--	--	--	--	--	1	--	--	--	--	--	1	--
Cypress Creek	17	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--
Sabine	33	3	6	2	--	--	1	--	--	--	--	--	--	--	--	--	--
Neches	23	5	3	4	--	--	--	--	--	--	--	--	--	--	--	--	--
Trinity	68	29	27	3	2	3	13	19	2	30	--	12	--	4	--	--	--
San Jacinto	52	25	21	9	1	3	24	--	2	32	--	15	--	11	8	1	12
Brazos	61	10	6	1	--	--	1	--	2	1	--	--	--	--	5	--	--
Colorado	65	10	6	--	--	--	--	--	4	--	--	--	--	--	--	--	--
Lavaca	28	9	3	2	--	--	--	--	--	2	--	--	--	--	--	--	--
Guadalupe	20	7	6	--	--	--	--	--	--	--	--	3	--	--	--	--	--
San Antonio	91	22	38	16	--	4	14	--	1	29	--	21	2	16	10	10	6
Nueces	86	--	4	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Rio Grande	20	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--

Table 13.--Summary of Positive Pesticide Determinations in Fresh Water Sediment for Each Major River Basin. Data Derived from Sampling by the Texas Department of Water Resources and U.S. Geological Survey, 1973-77.

River Basin	Number of Samples	PCBs	DDT	DDD	DDE	Dieldrin	Chlordane	Hepta-chlor	Hepta-chlor epoxide	Lindane	Aldrin	Silvex	Toxaphene	Diazinon
Canadian	41	15	--	--	--	--	1	--	--	--	--	--	--	--
Red	61	12	2	6	17	--	--	--	--	--	--	--	--	1
Sulphur	37	17	16	20	21	12	--	--	--	1	1	--	--	--
Cypress Creek	55	35	6	11	3	8	9	1	1	--	--	--	--	--
Sabine	83	29	9	16	13	11	15	--	--	--	--	--	--	--
Neches	49	6	--	1	1	1	3	--	--	--	--	--	--	--
Trinity	130	50	11	78	70	53	44	--	4	--	--	4	2	--
San Jacinto	53	34	25	27	27	31	30	2	10	4	6	--	--	--
Brazos	112	50	10	11	33	16	5	3	--	--	--	--	--	--
Colorado	104	57	7	17	23	20	1	--	--	1	--	--	--	--
Lavaca	33	5	3	2	9	7	3	--	--	--	--	--	--	--
Guadalupe	38	17	14	16	17	11	--	--	1	--	--	--	--	--
San Antonio	94	58	36	44	57	40	36	1	6	2	--	--	--	--
Nueces	44	6	2	4	18	5	6	--	--	--	--	--	--	--
Rio Grande	47	12	8	9	33	2	--	--	--	--	--	--	--	--

the Dallas-Fort Worth metropolitan area, and at the time of this report there were 84 permitted municipal and industrial dischargers to the segment as well as urban runoff from the area (Texas Water Quality Board, 1977). During dry periods the flow in this segment is dominated by treated effluent from discharges to the segment. Over the years large amounts of sludge have accumulated on the stream bottom, and because of their affinity for particulate organic matter, appreciable amounts of pesticides are consequently found. The four major municipal dischargers have made substantial wastewater treatment improvements recently, but untreated drainage from storm sewers is at least as significant a factor in the resulting pesticide concentrations.

Pesticide concentrations in the downstream segment 0804 are also attributable to the discharges, both non-point (widely distributed) and point sources, in the Dallas-Fort Worth area.

Sediment samples from both these segments have shown significant concentrations of chlordane, toxaphene, and PCBs. In addition, appreciable amounts of heptachlor epoxide, DDT, DDD, and DDE are found frequently.

Water samples have shown elevated concentrations of 2,4-D, lindane, dieldrin, and diazinon. On a sporadic basis heptachlor, heptachlor epoxide, aldrin, chlordane, DDT, DDD, DDE, and malathion are found in lesser but still appreciable amounts.

Houston Ship Channel

Elevated pesticide levels in the San Jacinto River basin are restricted to the Houston Ship Channel (segments 1005 and 1006) and its tributaries, Buffalo, Hunting, Greens, and Halls Bayous.

Segment 1005 extends approximately 7 miles from Morgans Point at the Houston Ship Channel junction with Galveston Bay to the San Jacinto River confluence. There are approximately 17 principal industrial dischargers in this segment. Segment 1006 extends approximately 14 miles from the San Jacinto River confluence to the Houston Ship Channel turning basin, including the tidal portions of all tributaries. There are approximately 60 principal industrial dischargers in this segment.

The Houston Ship Channel serves one of the largest ports in the world and is lined with the heaviest concentration of petrochemical plants in the country. It receives a wide variety of treated industrial and municipal wastes, as well as the City of Houston's storm water runoff, by tributaries and directly to the channel. Approximately nine of the industries manufacture pesticides or use them in their manufacturing processes. Eleven other, similar industries located near the channel do not discharge but have the potential to affect the channel during catastrophic conditions, such as hurricanes, major floods, and accidental spills.

Sediment samples from this estuarine area have shown significant concentrations of aldrin, total DDT, and PCBs. In addition, heptachlor epoxide and chlordane are frequently found in lesser but still appreciable amounts.

In water, appreciable concentrations of 2,4-D, 2,4,5-T, lindane, malathion, and diazinon have been found. Almost all the other compounds analyzed are detected sporadically, including heptachlor, heptachlor epoxide, aldrin, dieldrin, chlordane, total DDT, and PCBs.

Recent improvements to the waste treatment plants have dramatically decreased the amount of suspended and dissolved material being discharged with the wastewaters to these stream segments. However, due to the rapid growth and continued industrialization of the Houston area, runoff will still contribute a heavy pesticide load to these segments.

North Fork Double Mountain Fork Brazos River

The North Fork Double Mountain Fork (segment 1200), in the upper part of the Brazos River basin, originates in the City of Lubbock and flows southeast to its confluence with the Double Mountain Fork in Kent County.

Extremely high concentrations of PCBs have been found in the stream sediment in the City of Lubbock. Several surveys have not revealed a source, but subsequent samples show concentrations to be declining.

Pecan Bayou

Pecan Bayou (segment 1417) is a tributary to the Colorado River flowing some 57 miles from Lake Brownwood to near Goldthwaite in Mills County. High concentrations of total DDT and PCBs found in sediment and fish samples have been attributed to the city of Brownwood's sewage treatment plant which discharges upstream.

San Antonio River

The San Antonio River is designated segment 1901 and extends 238 miles from the headwater springs in the City of San Antonio to its confluence with the Guadalupe River in Victoria County.

The City of San Antonio's three major sewage treatment plants are the primary sources (98 percent) of wastewater discharges to the upper portion of this river basin. However, urban runoff in the upper portion and agricultural runoff in the lower portion are probably the main sources of pesticides in this basin.

Sediment samples have shown significant concentrations of total DDT and PCBs. In addition, appreciable amounts of heptachlor, dieldrin, and chlordane are found frequently.

Water samples have shown appreciable concentrations of 2,4,5-T, silvex, and parathion. In addition, appreciable amounts of heptachlor, lindane, dieldrin, chlordane, total DDT, malathion, and diazinon are found less frequently.

Leon Creek

Leon Creek is a tributary to the Median River in the San Antonio River basin west of San Antonio. Segment 1906 of Leon Creek extends approximately 26 miles from the Medina River confluence to State Highway 16 northwest of Leon Valley. The creek traverses housing subdivisions, a county park, Kelly Air Force Base, and farm and ranch land.

Sediment samples have shown extremely high concentrations of total DDT and PCBs. Whole fish samples have also shown high concentrations of total DDT. Areas where these high values were found were isolated in the Kelly Air Force Base region of this segment.

Arroyo Colorado

The Arroyo Colorado (segment 2201) is a natural drainageway that originates southwest of the City of Mission and flows easterly past the City of Harlingen, then northeast to the Laguna Madre. The lower, 25-mile reach below Harlingen is considered tidal.

Within Starr, Hidalgo, Cameron, and Willacy Counties, through which the Arroyo flows, total pesticide usage is approximately 32.5 percent of the total amount used throughout the rest of the State, 16,823,000 pounds in 1979 (personal communication, Charles Webster of Texas Tech University Pesticide Laboratory in San Benito). In addition, flow in the Arroyo is sustained from irrigation return flows, urban runoff, and treated municipal sewage discharges. Consequently, sources for pesticides in the segment are numerous and for the most part widely distributed (non-point). Sediment samples have shown significant concentrations of chlordane and total DDT on a regular basis.

Rio Grande

Although the Rio Grande forms the entire southern border of the State, only one segment has shown a significant degree of pesticide contamination. Segment 2306 extends downstream from the Rio Conchos (Mexico) confluence near Presidio to the upper end of Amistad Reservoir.

Below the City of Presidio, the Rio Grande is influenced not only by the quality of the Rio Conchos inflow but also by irrigation return flows from Mexico that enter the Rio Grande upstream of the Rio Conchos confluence. Sediment, whole minnow, and fish samples have shown significant concentrations of total DDT.

PARTIAL LIST OF SUSPENDED AND CANCELLED PESTICIDES

The following list considers only those compounds that have been discussed in the preceding text. Numerous additional pesticides have been suspended or cancelled for various uses. For a more complete listing, or for additional detail, refer to the publication of the U.S. Environmental Protection Agency (1978) titled "Suspended and Cancelled Pesticides".

2,4-D: Products for use on certain small grains must bear label cautioning against grazing fields within 2 weeks after treatment (October 1967).

2,4,5-T: Chlorodioxin contaminants are not allowed (September 1970).

Suspended are (April 1970):

1. all uses in lakes, ponds, or on ditch banks.
2. liquid formulation for use around the home, recreation areas, and similar sites.

Cancelled are (May 1970):

1. all granular formulations for use around the home, recreation areas, and similar sites.
2. all uses on food crops intended for human consumption (an exception on rice).

Silvex: Chlorodioxin contaminants are not allowed (September 1970).

Heptachlor: Most registered products containing heptachlor will be effectively cancelled, or their application for registration denied, by July 1, 1983. Uses not affected are the same as for chlordane.

Lindane: Cancelled for use in vaporizers (December 1974).

Aldrin and Dieldrin: Cancelled for all uses (October 1974) except as follows:

1. subsurface ground injection for termite control.
2. dipping of non-food roots and tops.
3. moth-proofing by manufacturing processess in a closed system.

Endrin: Cancelled (May 1964) for use on tobacco.

Chlordane: Most registered products containing chlordane were effectively cancelled, or their application for registration denied by December 31, 1980. Uses not affected:

1. subsurface ground injection for termite control.
2. dipping of non-food roots and tops.

Toxaphene: Cancelled for certain uses on cabbage and lettuce (February 1969).

DDT: Cancelled for all products (January 1971) except for use:

1. by the U.S. Public Health Service and other Health Service Officials for control of vector diseases.
2. by the U.S. Department of Agriculture or military for health quarantine.
3. in drugs, for controlling body lice. (To be dispensed only by a physician.)
4. in the formulation of prescription drugs for controlling body lice.

DDD (TDE): Cancelled for all products containing DDD (March 1971).

PCBs: Eliminated are all uses of active or inactive ingredients as pesticides (October 1970).

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APPENDIX A

Pesticide Concentrations in Fresh Water Samples Collected by the Texas Department of Water Resources at Statewide Monitoring Network Stations (μg/l)

(For locations of sampling stations see Figure 1 and Table 1.)

Station	Date	PCBs	Diazinon	DDT	DDD	DDE	Aldrin	Chlordane	Dieldrin	Endrin	2,4-D	2,4,5-T	Silvex	Heptachlor	Heptachlor epoxide	Lindane	Methoxychlor	Parathion
0102.0400	June 16, 1975	< 2.0	< 0.02	< 0.24	< 0.30	< 0.09	< 0.04	< 5.0	< 0.14	< 0.2	< 50	< 10	< 10	< 0.04	< 0.06	< 0.03	< 1.1	< 0.5
	June 2, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .2	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
0102.0500	June 18, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .2	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
0103.0100	June 11, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .2	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Aug. 26, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .2	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	July 20, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .2	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
0104.0100	July 7, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .2	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Sept. 10, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .2	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
0105.0100	June 21, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .2	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
0105.0200	June 21, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .2	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
0200.0500	June 17, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .2	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
0202.0100	July 25, 1974	1.3	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .2	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	July 16, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .2	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
0204.0100	July 12, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .2	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Aug. 4, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .2	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
0207.0100	Aug. 20, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .2	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	June 3, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .2	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Aug. 3, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .2	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
0214.0100	July 12, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .2	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Aug. 4, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .2	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Apr. 15, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .2	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	July 8, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .2	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
0220.0100	Oct. 9, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .2	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Aug. 2, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .2	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
0222.0100	July 16, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Aug. 13, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
0223.0400	June 20, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	June 18, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	June 3, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
0303.0200	Sept. 26, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	July 2, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
0402.0100	Aug. 13, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Aug. 10, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
0503.0200	Aug. 15, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Aug. 24, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
0505.0200	Aug. 22, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	July 10, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Aug. 3, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
0506.0100	Sept. 3, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	July 10, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Aug. 9, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
0602.0100	June 20, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Sept. 24, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
0604.0400	Aug. 5, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
0611.0100	June 18, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Sept. 16, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	June 29, 1976	< 1.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 10	< 10	< 10	< .06	< .06	< .06	< 1.0	< 1.5

* In addition to the compounds tabulated, fewer determinations have been made for toxaphene, malathion, and methyl parathion; however, all have been below their detection limits of 5.0, 1.4, and 0.5 μg/l, respectively.

APPENDIX A
Pesticide Concentrations in Fresh Water Samples Collected by the Texas Department of Water Resources at Statewide Monitoring Network Stations (μg/l)--Continued

Station	Date	PCBs	Diazinon	DDT	DDD	DDE	Aldrin	Chlordane	Dieldrin	Endrin	2,4-D	2,4,5-T	Silvex	Heptachlor	Heptachlor epoxide	Lindane	Methoxychlor	Parathion
0802.0100	July 26, 1976	< 2.0	< 0.02	< 0.24	< 0.30	< 0.09	< 0.04	< 5.0	< 0.14	< 0.02	--	--	--	--	--	--	--	--
0802.0200	Apr. 25, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	--	--	--	--	--	--	--	--
	July 29, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	--	--	--	--	--	--	--	--
	July 27, 1976	< 1.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	--	--	--	--	--	--	--	--
0804.0300	Apr. 16, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< 0.04	< 0.06	< 0.03	< 1.1	< 0.5
	July 30, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	July 28, 1976	< 1.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 10	< 10	< 10	< .06	< .06	< .06	< 1.5	< 1.5
0805.0100	Aug. 6, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	June 26, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Oct. 2, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
0812.0100	Oct. 3, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Nov. 5, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Oct. 22, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
0824.0100	Aug. 14, 1974	< 1.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	July 8, 1975	< 1.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Apr. 15, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	July 9, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
0831.0100	Nov. 5, 1974	< 1.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Oct. 22, 1975	< 1.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
1000.0800	Oct. 23, 1975	< 2.0	< .02	< .24	< .30	< .09	--	< 5.0	< .14	< .02	--	--	--	< .04	< .06	< .01	--	--
1003.0100	Sept. 26, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Sept. 13, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
1004.0100	Sept. 26, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Sept. 13, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
1106.0150	Aug. 3, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
1200.0500	May 26, 1977	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Aug. 18, 1977	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Oct. 25, 1977	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
1200.2300	June 16, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
1202.0100	Aug. 14, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
1202.0300	June 18, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	June 17, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
1204.0100	July 2, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Aug. 26, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
1206.0300	July 10, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Aug. 5, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	June 22, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
1208.0300	Oct. 16, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Oct. 14, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
1209.0300	June 21, 1974	1.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
1212.0100	Dec. 2, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	--	--	--	--	--	--	--	--
	Mar. 23, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	--	--	--	--	--	--	--	--
1212.0200	Mar. 23, 1976	2.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1213.0100	June 16, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
1226.0100	Aug. 7, 1974	1.8	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	--	--	--	< .04	< .06	< .03	< 1.1	< .5
	Aug. 25, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5

APPENDIX A

Pesticide Concentrations in Fresh Water Samples Collected by the Texas Department of Water Resources at Statewide Monitoring Network Stations (μg/l)—Continued

Station	Date	PCBs	Diazinon	DDT	DDD	DDE	Aldrin	Chlordane	Dieldrin	Endrin	2,4-D	2,4,5-T	Silvex	Heptachlor	Heptachlor epoxide	Lindane	Methoxychlor	Parathion
1232.0400	Dec. 16, 1975	< 2.0	< 0.02	< 0.24	< 0.30	< 0.09	< 0.04	< 5.0	< 0.14	< 0.02	< 50	< 10	< 10	< 0.04	< 0.06	< 0.03	< 1.1	< 0.5
	Feb. 3, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
1241.0100	Dec. 20, 1974	< 2.0	< 0.02	< 0.24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Dec. 17, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
1302.0100	June 23, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Sept. 20, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
1400.0100	Nov. 21, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
1402.0100	June 22, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	May 14, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
1402.0200	July 18, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
1402.0700	June 27, 1974	10	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
1409.0100	Dec. 12, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Sept. 9, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
1409.0150	Dec. 10, 1973	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
1412.0200	Nov. 21, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Jan. 6, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
1414.0100	Sept. 25, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Dec. 11, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Sept. 10, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
1414.0200	Sept. 25, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Dec. 11, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
1421.0100	Aug. 20, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Aug. 6, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Aug. 18, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
1421.0150	Aug. 20, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
1421.0300	Aug. 20, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Aug. 6, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Aug. 19, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
1602.0100	May 14, 1974	3.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	--	--	--	< .04	< .06	< .03	< 1.1	< .5
	Aug. 28, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
1802.0100	June 23, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Sept. 22, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
1803.0200	July 18, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
1806.0300	July 11, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
1808.0100	Sept. 24, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
1901.0100	Aug. 2, 1973	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	.14	< .04	< .06	< .03	< 1.1	< .5
1902.0100	July 18, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
1903.0200	July 12, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
2000.0500	Dec. 18, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
2002.0100	May 5, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	June 23, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Sept. 22, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
2004.0100	Dec. 20, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5

APPENDIX A
Pesticide Concentrations in Fresh Water Samples Collected by the Texas Department of Water Resources at Statewide Monitoring Network Stations (µg/l)—Continued

Station	Date	PCBs	Diazinon	DDT	DDD	DDE	Aldrin	Chlordane	Dieldrin	Endrin	2,4-D	2,4,5-T	Silvex	Heptachlor	Heptachlor epoxide	Lindane	Methoxychlor	Parathion
2103.0130	Mar. 17, 1975	< 2.0	< 0.02	< 0.24	< 0.30	< 0.09	< 0.04	< 5.0	< 0.14	< 0.02	< 50	< 10	< 10	< 0.04	< 0.06	< 0.03	< 1.1	< 0.5
	June 10, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
2104.0100	Mar. 21, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	June 11, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Sept. 7, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
2302.0200	Sept. 30, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
2302.0300	July 28, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
2304.0200	Sept. 15, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
2306.0100	Dec. 10, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
2306.0300	Apr. 15, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
2308.0100	May 20, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
2311.0100	Apr. 8, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5

APPENDIX B

Pesticide Concentrations in Estuarine Water Samples Collected by the Texas Department of Water Resources at Statewide Monitoring Network Stations (μg/l)

(For locations of sampling stations see Figure 1 and Table 1.)

Station	Date	PCBs	Diazinon	DDT	DDD	DDE	Aldrin	Chlordane	Dieldrin	Endrin	2.4-D	2.4.5-T	Silvex	Heptachlor	Heptachlor epoxide	Lindane	Methoxychlor	Parathion
0508.0100	May 14 1975	< 2.0	< 0.02	< 0.24	< 0.30	< 0.09	< 0.04	< 5.0	< 0.14	< 0.02	< 50	< 10	< 10	< 0.04	< 0.06	< 0.03	< 1.1	< 0.5
	Aug. 7 1975	< 2.0	< 0.02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Aug. 4 1976	< 1.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 10	< 10	< 10	< .06	< .06	< .06	< 1.0	< .5
0601.0100	June 2 1977	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 10	< 10	< 10	< .06	< .06	.06	< .1	< .5
	Sept 14 1977	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 10	< 10	< 10	< .06	< .06	.06	< 1.0	< .5
	Dec. 5. 1977	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .03	< .06	< 1.1	< .5
0801.0100	Jan. 13. 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	July 12, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Oct. 18, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
1000.0200	Oct. 23, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
0901.0100	Oct. 10, 1973	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Aug. 14, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	July 12, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Oct. 18, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
1001.0100	May 18, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	.019	< 1.1	< .5
1005.0100	July 15, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Oct. 23, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
1006.0100	July 15, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	.063	< 1.1	< .5
	Oct. 23, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	.0086	< 1.1	< .5
1006.0200	July 15, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	.07	< 1.1	< .5
	Oct. 23, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	.009	< 1.1	< .5
1006.0300	July 15, 1975	< 1.0	< .02	< .24	< .30	< .09	< .02	< 5.0	< .02	< .02	< 50	< 10	< 10	< .02	< .02	.068	< .2	< .5
	Oct. 23, 1975	< 1.0	< .02	< .24	< .30	< .09	< .02	< 5.0	< .02	< .02	< 50	< 10	< 10	< .02	< .02	.024	< .2	< .5
1007.0100	July 15, 1975	< 1.0	< .02	< .24	< .30	< .09	< .018	< 5.0	< .02	< .02	< 50	< 10	< 10	< .02	< .02	.093	< .2	< .5
	Oct. 23, 1975	< 2.0	< .02	< .24	< .30	< .09	< .02	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	.013	< 1.1	< .5
1101.0100	Oct. 11, 1973	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Aug. 14, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	July 14, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
1105.0200	June 23, 1975	< 2.0	< .02	< .24	< .02	< .02	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Aug. 3, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
1107.0100	May 29, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	.017	< 1.1	< .5
	May 22, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .007	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	June 23, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
1304.0100	June 23, 1975	< 1.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .002	< .06	< .03	< 1.1	< .5
2003.0100	Dec. 20, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
2101.0100	Apr. 12, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
2201.0100	Sept. 10. 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	June 22. 1977	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
2201.0200	Mar. 18. 1977	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	June 22, 1977	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
2301.0100	Sept. 30, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	June 30, 1977	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
2421.0400	May 7. 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	May 29, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
2423.0100	May 7, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	May 29, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5

* In addition to the compounds tabulated, fewer have been made for toxaphene, malathion, and methyl parathion; however, all have been below their detection limits of 5.0, 1.4, and 0.5 μg/l, respectively.

APPENDIX B

Pesticide Concentrations in Estuarine Water Samples Collected by the Texas Department of Water Resources at Statewide Monitoring Network Stations (µg/l)–Continued

Station	Date	PCBs	Diazinon	DDT	DDD	DDE	Aldrin	Chlordane	Dieldrin	Endrin	2,4-D	2,4,5-T	Silvex	Heptachlor	Heptachlor epoxide	Lindane	Methoxychlor	Parathion
2424.0100	May 21, 1974	< 2.0	< 0.02	< 0.24	< 0.30	< 0.09	< 8.3	< 5.0	< 0.14	< 0.02	< 50	< 10	< 10	< 0.04	< 0.06	< 0.002	< 1.1	< 0.5
	May 20, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	.005	< .06	< .03	< 1.1	< .5
	May 14, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
2434.0100	May 29, 1974	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	May 22, 1975	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .001	< .06	< .03	< 1.1	< .5
	June 4, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
2482.0100	Apr. 12, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
2482.0200	Apr. 12, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
2482.0300	Apr. 12, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
2482.0400	Apr. 12. 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
2484.0200	Apr. 5, 1977	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	July 5, 1977	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	Dec. 28, 1977	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
2494.0100	Sept. 29, 1976	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5
	June 21, 1977	< 2.0	< .02	< .24	< .30	< .09	< .04	< 5.0	< .14	< .02	< 50	< 10	< 10	< .04	< .06	< .03	< 1.1	< .5

APPENDIX C

Pesticide Concentrations in Fresh Water Sediment Samples Collected by the Texas Department of Water Resources at Statewide Monitoring Network Stations (µg/kg)

(For Locations of sampling stations see Figure 1 and Table 1.)

Station	Date	Heptachlor	Heptachlor epoxide	Lindane	Methoxychlor	Parathion	Methyl Parathion	Toxaphene	PCBs	Aldrin	Chlordane	DDD	DDE	DDT	Diazinon	Dieldrin	Endrin	Malathion
0101.0300	July 18, 1974	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	11	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
0102.0400	June 16, 1975	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	June 2, 1976	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	23	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
0102.0500	Aug. 6, 1974	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	21	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
0103.0100	June 11, 1974	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	15	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
0200.0500	June 17, 1975	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
0202.0100	July 16, 1975	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	6.2	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
0204.0100	July 12, 1974	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	9.0	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	Aug. 4, 1975	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	.5	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
0214.0100	July 12, 1974	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	32	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	Aug. 4, 1975	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	July 8, 1976	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
0219.0100	Feb. 24, 1976	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
0223.0400	June 20, 1974	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	10	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	June 18, 1975	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	June 3, 1976	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	84	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
0302.0100	Aug. 13, 1974	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	120	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	July 15, 1975	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	16	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	Aug. 30, 1977	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	22	< 1.0	< 20	< 3.0	6.1	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
0303.0200	July 2, 1975	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	9.2	< 1.0	< 20	0.6	0.9	0.2	< 5.0	0.3	< 3.0	< 5.0
	Sept. 21, 1976	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	6.2	18.6	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	Sept. 20, 1977	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	4.1	11.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
0402.0100	Sept. 16, 1974	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	15	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	July 15, 1975	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	21	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	Aug. 10, 1976	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	22	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	Sept. 7, 1977	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	30	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
0403.0100	Sept. 18, 1974	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	18	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	Sept. 17, 1975	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
0500.0600	Aug. 16, 1976	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
0503.0100	Aug. 25, 1976	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
0504.0200	May 22, 1974	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	Aug. 5, 1975	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	Aug. 23, 1976	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	22	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
0505.0200	July 10, 1975	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	4.0	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	Aug. 3, 1976	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	32	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	Sept. 8, 1977	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
0506.0100	July 10, 1975	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	18	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	Aug. 9, 1976	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	24	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	Sept. 8, 1977	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	21	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
0507.0100	July 30, 1974	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	103	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	Sept. 29, 1975	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	31	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	Sept. 13, 1976	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	4.1	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
0600.0100	June 4, 1975	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	10.1	< 3.0	< 5.0
0604.0200	June 19, 1974	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	8.0	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	June 24, 1975	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	June 29, 1976	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50	< 1.0	< 20	< 3.0	< 2.0	< .5	< 5.0	< 3.0	< 3.0	< 5.0
0610.0200	June 17, 1974	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	21	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	June 16, 1975	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
0802.0100	July 3, 1974	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 2.0	< 5.0	< 3.0	< 3.0	< 5.0
	July 12, 1976	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 2.0	< 5.0	< 3.0	< 3.0	< 5.0
	Oct. 18, 1976	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 2.0	< 5.0	< 3.0	< 3.0	< 5.0

APPENDIX C
Pesticide Concentrations in Fresh Water Sediment Samples Collected by the Texas Department of Water Resources at Statewide Monitoring Network Stations (µg/kg)–Continued

Station	Date	Heptachlor	Heptachlor epoxide	Lindane	Methoxychlor	Parathion	Methyl Parathion	Toxaphene	PCBs	Aldrin	Chlordane	DDD	DDE	DDT	Diazinon	Dieldrin	Endrin	Malathion
0803.0025	July 27, 1976	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
0803.0200	July 9, 1974	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	29	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	July 29, 1975	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	15	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	July 27, 1976	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50	< 1.0	< 20	< 3.0	< 2.0	< 2.0	< 5.0	< 3.0	< 3.0	< 5.0
0804.0300	Apr. 16, 1974	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	9.0	7.0	6.0	< 5.0	1.1	< 3.0	< 5.0
0804.0400	July 30, 1975	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	Nov. 30, 1976	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	68	< 1.0	< 20	< 3.0	7.4	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
0805.0100	Aug. 6, 1974	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	38	< 3.0	< 5.0
	June 26, 1975	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	7.5	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	Oct. 2, 1975	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	35	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
0806.0200	Aug. 25, 1977	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	41	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
0812.0100	Oct. 3, 1974	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	6.7	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	Nov. 5, 1974	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	4.0	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	Oct. 22, 1975	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	14	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
0824.0100	Aug. 14, 1974	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	19	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	July 8, 1975	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	6.4	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	Apr. 15, 1976	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	39	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
0831.0100	Nov. 5, 1974	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	3.5	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	Oct. 22, 1975	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	5.8	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
0834.0100	Mar. 25, 1976	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	39	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
1003.0100	July 3, 1974,	< 1.0	< 1.0	< .2	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	3.0	< .2	< 5.0	< 3.0	< 3.0	< 5.0
	Sept. 13, 1976	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
1004.0100	July 3, 1974	< .2	< .2	< .2	< 2.0	< 2.0	< 2.0	< 2.0	< 20	< .2	< 2.0	< .2	< .2	< .2	< .2	< .2	< .2	< 2.0
	Sept. 13, 1976	< .2	< .2	< .2	< 2.0	< 2.0	< 2.0	< 2.0	< 20	< .2	< 2.0	< .2	< .2	< .2	< .2	< .2	< .2	< 2.0
1012.0100	July 29, 1974	< .2	< .2	< 3.0	< 2.0	< 2.0	< 2.0	< 2.0	< 20	< .2	< 2.0	< .2	< .2	< .2	< .2	< .2	< .2	< 2.0
1012.0200	July 29, 1974	< .2	< .2	< .2	< 2.0	< 2.0	< 2.0	< 2.0	< 20	< .2	< 2.0	< .2	< .2	< .2	< .2	< .2	< .2	< 2.0
1102.0100	Sept. 15, 1976*	< 100	< 100	< 100	< 2,000	< 500	< 500	< 5,000	< 2,000	< 100	< 2,000	< 300	< 200	< 500	< 500	< 300	< 300	< 2.0
	Feb. 28, 1977	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< .2	< 2.0	< .2	< .2	1.2	< .2	< .2	< .2	< 2.0
1102.0200	Feb. 28, 1977	< .2	< .2	--	< 2.0	< 2.0	< 2.0	< 50	< 20	< .2	< 2.0	< .2	< .2	< .2	< .2	< .2	< .2	< 2.0
1200.0500	May 26, 1977	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	64	< 1.0	< 20	58	41	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
1200.1600	Mar. 12, 1975	< .2	< .2	< .2	< 2.0	< 2.0	< 2.0	< 2.0	< 20	< .2	< 2.0	< .2	< .2	< .2	< .2	< .2	< .2	< 2.0
	Oct. 15, 1975	< .2	< .2	< .2	< 2.0	< 2.0	< 2.0	< 2.0	< 20	< .2	< 2.0	< .2	< .2	< .2	< .2	< .2	< .2	< 2.0
	Aug. 2, 1976	< .2	< .2	< .2	< 2.0	< 2.0	< 2.0	< 2.0	< 20	< .2	< 2.0	< .2	5.0	< .2	< .2	< .2	< .2	< 2.0
1200.1800	Feb. 12, 1975	16.6	< .2	< .2	< 2.0	< 2.0	< 2.0	< 2.0	< 20	< .2	< 2.0	< .2	< .2	< .2	< .2	< .2	< .2	< 2.0
	Sept. 12, 1977	< .2	< .2	< .2	< 2.0	< 2.0	< 2.0	< 2.0	< 20	< .2	< 2.0	< .2	< .2	< .2	< .2	< .2	< .2	< 2.0
1200.2300	June 16, 1975	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< .5	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
1202.0100	Aug. 14, 1975	< .2	< .2	< .2	< 2.0	< 2.0	< 2.0	< 2.0	< 20	< .2	< 20	< .2	< .2	< .2	< .2	< .2	< .2	< 2.0
	Sept. 20, 1976	< .2	< .2	< .2	< 2.0	< 2.0	< 2.0	< 2.0	< 20	< .2	< 20	< .2	< .2	< .2	< .2	< .2	< .2	< 2.0
1202.0133	Jan. 30, 1975	< .2	< .2	< .2	< 2.0	< 2.0	< 2.0	< 2.0	< 20	< .2	< 20	< .2	< .2	< .2	< .2	< .2	< .2	< 2.0
	Aug. 2, 1976	< .2	< .2	< .2	< 2.0	< 2.0	< 2.0	< 2.0	< 20	< .2	< 20	< .2	< .2	< .2	< .2	< .2	< .2	< 2.0
1202.0166	Jan. 30, 1975	< .2	< .2	< .2	< 2.0	< 2.0	< 2.0	< 2.0	< 20	< .2	< 20	< .2	< .2	< .2	< .2	< .2	< .2	< 2.0
	Aug. 2, 1976	< .2	< .2	< .2	.18	< 2.0	< 2.0	< 2.0	< 20	< .2	< 20	3.6	1.0	< .2	< .2	< .2	< .2	< 2.0
1203.0300	June 11, 1974	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	9.0	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	Aug. 25, 1975	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
1204.0100	Oct. 31, 1977	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
1206.0300	July 10, 1974	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	18	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	Aug. 5, 1975	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	June 22, 1976	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0

* Oil and grease interference raised the detection limits of this analysis.

APPENDIX C
Pesticide Concentrations in Fresh Water Sediment Samples Collected by the Texas Department
of Water Resources at Statewide Monitoring Network Stations (µg/kg)–Continued

Station	Date	Heptachlor	Heptachlor epoxide	Lindane	Methoxychlor	Parathion	Methyl Parathion	Toxaphene	PCBs	Aldrin	Chlordane	DDD	DDE	DDT	Diazinon	Dieldrin	Endrin	Malathion
1208.0300	Oct. 16, 1974	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	13	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	Oct. 14, 1975	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	6.8	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	.6	< 3.0	< 5.0
1212.0200	June 12, 1975	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
1216.0200	June 25, 1974	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	6.0	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	June 12, 1975	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
1220.0300	June 24, 1974	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	5.0	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	June 12, 1975	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	1.2	.4	< 5.0	< 3.0	< 3.0	< 5.0
1225.0200	June 24, 1974	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	June 11, 1975	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
1225.0300	June 11, 1975	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	1.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
1232.0200	Nov. 18, 1976	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 2	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	July 19, 1977	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 2	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
1241.0100	Nov. 18, 1976	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
1400.0200	Nov. 17, 1976	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	34	< 1.0	< 20	< 3.0	5.5	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
1402.0200	Apr. 10, 1974	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	5.5	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	Apr. 8, 1976	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	15	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
1409.0100	Sept. 8, 1976	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	June 9, 1977	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	7.8	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
1412.0200	Nov. 16, 1976	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	July 27, 1977	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
1414.0100	Sept. 9, 1976	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	7.2	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	June 8, 1977	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	3.8	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
1417.0100	Sept. 14, 1977	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	180	190	< 5.0	< 5.0	30	< 3.0	< 5.0
1422.0100	Sept. 7, 1977	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	31	< 1.0	< 20	< 3.0	5.10	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
1423.0100	Sept. 7, 1977	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	32	< 1.0	< 20	< 3.0	100	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
1602.0200	Apr. 10, 1974	< .1	< .1	< .1	< .1	< .1	< .1	< 10.0	< 10.0	< 1.0	46.9	< .1	< .1	7.7	< .1	< .1	< .1	< 5.0
	May 14, 1975	< .1	< .1	< .1	< .1	< .1	< .1	< 10.0	< 10.0	< 1.0	< 1.0	< .1	< .1	< .1	< .1	< .1	< .1	< 5.0
	Apr. 7, 1976	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	36	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
1603.0800	Apr. 10, 1974	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	2.2	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	May 14, 1975	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 10	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	Apr. 7, 1976	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	9.0	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
1802.0100	June 14, 1977	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	5.1	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
1803.0200	Apr. 10, 1974	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	6.7	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	Apr. 7, 1976	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	57	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
1805.0400	July 26, 1974	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 14	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	June 12, 1975	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	Apr. 12, 1976	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	43	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
1806.0200	Sept. 19, 1977	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
1808.0100	Apr. 14, 1976	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	24	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	3.1	< 3.0	< 5.0
1901.0300	Apr. 10, 1974	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	14.7	< 1.0	16.1	1.3	1.4	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	Sept. 3, 1975	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	4.0	.7	.7	1.0	< 5.0	.2	< 3.0	< 5.0
	July 13, 1976	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	99	< 1.0	< 20	< 3.0	4.8	6.6	< 5.0	< 3.0	< 3.0	< 5.0
	May 24, 1977	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
1902.0100	Apr. 10, 1974	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	4.8	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	May 14, 1975	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	June 24, 1977	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
1903.0200	Sept. 25, 1974	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	10	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	June 20, 1975	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	Apr. 6, 1976	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	Sept. 28, 1977	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	54	< 1.0	42	5.5	6.8	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0

APPENDIX C

Pesticide Concentrations in Fresh Water Sediment Samples Collected by the Texas Department of Water Resources at Statewide Monitoring Network Stations (µg/kg)--Continued

Station	Date	Heptachlor	Heptachlor epoxide	Lindane	Methoxychlor	Parathion	Methyl Parathion	Toxaphene	PCBs	Aldrin	Chlordane	DDD	DDE	DDT	Diazinon	Dieldrin	Endrin	Malathion
1906.0100	Mar. 18, 1974	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	.4	1.2	2.4	< 5.0	< 3.0	< 3.0	< 5.0
2000.0500	Dec. 18, 1974	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	16	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	.5	< 3.0	< 5.0
2002.0100	Mar. 28, 1977	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	Nov. 9, 1977	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
2004.0100	Dec. 20, 1974	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	10	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
2103.0130	Mar. 17, 1975	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	29	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	June 10, 1976	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	130	< 1.0	< 20	3.0	9.1	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
2103.0200	June 10, 1976	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	50	< 1.0	< 20	< 3.0	11.9	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	Mar. 28, 1977	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	June 1, 1977	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
2107.0200	Mar. 18, 1974	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	.2	.2	.2	< 5.0	< 3.0	< 3.0	< 5.0
2302.0200	Sept. 30, 1976	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	June 30, 1977	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	25	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
2303.0100	June 18, 1974	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	11	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	Sept. 20, 1977	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	4.5	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
2304.0200	Sept. 15, 1976	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	Sept. 28, 1977	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
2306.0300	Dec. 4, 1974	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	Apr. 15, 1975	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	24	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	June 9, 1976	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	28	< 1.0	< 20	< 3.0	17.9	10.5	< 5.0	< 3.0	< 3.0	< 5.0
	Mar. 30, 1977	--	--	--	--	--	--	--	< 20	--	--	< 3.0	6.6	< 5.0	--	--	--	--
2307.0100	June 9, 1976	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	34	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
2308.0100	Sept. 15, 1976	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	Sept. 13, 1977	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	41	< 1.0	< 20	< 3.0	6.2	7.8	< 5.0	< 3.0	< 3.0	< 5.0
2311.0100	Oct. 7, 1976	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	2.9	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0
	Oct. 24, 1977	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20	< 1.0	< 20	< 3.0	3.3	< 5.0	< 5.0	< 3.0	< 3.0	< 5.0

APPENDIX D

Pesticide Concentrations in Estuarine Sediment Samples Collected by the Texas Department of Water Resources at Statewide Monitoring Network Stations (µg/kg)

(For locations of sampling stations see Figure 1 and Table 1.)

Station	Date	Silvex	Aldrin	Chlordane	DDD	DDE	DDT	Diazinon	Dieldrin	Endrin	Heptachlor	Heptachlor epoxide	Lindane	Methoxychlor	Methyl parathion	Parathion	Toxaphene	PCBs
0501.0100	May 14, 1974	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	13
	Aug. 7, 1975	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50
	Aug. 3, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50
0601.0100	June 10, 1974	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	40
	Apr. 9, 1975	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	69
0601.0500	Apr. 24, 1974	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	.2	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	42
	Apr. 9, 1975	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	62
0700.0100	July 3, 1974	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	2.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	35
	Apr. 10, 1975	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	1.7	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	68
0801.0100	July 3, 1974	< 20	< 1.0	< 20	< 3.0	< 2.0	2.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	2.0	< 20	< 5.0	< 5.0	< 50	< 50
	July 12, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	2.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50
	Oct. 18, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	2.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	27
1001.0100	May 18, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50
1001.0200	July 12, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50
1005.0100	May 15, 1974	< 20	7,290	< 20	< 3.0	2,300	4,920	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	9.0	< 20	< 5.0	< 5.0	< 50	< 50
	July 15, 1975	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50
	Aug. 18, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50
1006.0100	May 15, 1974	< 20	3,100	< 20	< 3.0	2,170	6,070	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	11.0	< 20	< 5.0	< 5.0	< 50	< 20
	July 15, 1975	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	4.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20
	Aug. 18, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20
1006.0200	July 15, 1975	< 20	< .2	< 20	226	< .2	< .2	< 5.0	< .2	< .2	< .2	< .2	< .2	< 2.0	< 5.0	< 5.0	< 2.0	< 20
	Aug. 17, 1976	< 20	< .2	< 20	< .2	< .2	< .2	< 5.0	< 2.0	< .2	< .2	< .2	< .2	< 2.0	< 5.0	< 5.0	< 2.0	< 20
1006.0300	July 15, 1975	< 20	< .2	< 20	< .2	< .2	< .2	< 5.0	< .2	< .2	< .2	< .2	< .2	< 2.0	< 5.0	< 5.0	< 2.0	< 20
	Aug. 17, 1976	< 20	157.8	< 20	< .2	< .2	< .2	< 5.0	< .2	< .2	< .2	< .2	< .2	< 2.0	< 5.0	< 5.0	< 2.0	1,101
	Sept. 15, 1977	< 20	< .2	< 20	< .2	< .2	< .2	< 5.0	< .2	< .2	< .2	< .2	< .2	< 2.0	< 5.0	< 5.0	< 2.0	371
1007.0100	May 15, 1974	< 20	< 2.0	< 20	< .2	< .2	< .2	< 5.0	19.0	< .2	< .2	< .2	< 2.0	< 2.0	< 5.0	< 5.0	< 2.0	< 20
	Aug. 17, 1976	< 20	< .2	< 20	< .2	< .2	< .2	< 5.0	51.0	< .2	< .2	< .2	< 2.0	< 2.0	< 5.0	< 5.0	< 2.0	< 20
	Sept. 15, 1977	< 20	< .2	< 20	< .2	< .2	< .2	< 5.0	< .2	< .2	< .2	< .2	< 2.0	< 2.0	< 5.0	< 5.0	< 2.0	< 7.75
1101.0100	Sept. 16, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 5.0	< 50	44
1103.0200	Oct. 24, 1973	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 5.0	< 50	< 50
	July 25, 1974	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 5.0	< 50	< 50
	Oct. 21, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 5.0	< 50	37
1107.0100	May 29, 1974	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50
	June 4, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50
1301.0100	July 25, 1974	< 20	< .2	< 20	< .2	< .2	< .2	< 5.0	< .2	< .2	< .2	< 0.2	< .2	< 2.0	< 5.0	< 5.0	< 2.0	< 20
1304.0100	July 25, 1974	< 20	< .2	< 20	< .2	< .2	< .2	< 5.0	< .2	< .2	< .2	< .2	< .2	< 20	< 5.0	< 5.0	< 2.0	< 20
	Sept. 20, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< .2	< .2	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50
	Sept. 20, 1977	< 20	< .2	--	4.56	4.38	< 5.0	--	< .2	< .2	< .2	< .2	< .2	--	< 5.0	< 5.0	< 2.0	< 20
1401.0100	May 6, 1975	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50
	May 4, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	7.0
1501.0100	June 23, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20
1700.0100	Mar. 24, 1975	< 20	< 1.0	12	2.6	8.1	2.5	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50
	June 23, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20
1700.0300	Aug. 3, 1976	< 20	< 1.0	< 20	5.8	10.2	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	78
1701.0200	Mar. 12, 1975	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	11
	June 2, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20
2001.0100	Apr. 29, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50

APPENDIX D

Pesticide Concentrations in Estuarine Sediment Samples Collected by the Texas Department of Water Resources at Statewide Monitoring Network Stations (µg/kg)–Continued

Station	Date	Silvex	Aldrin	Chlordane	DDD	DDE	DDT	Diazinon	Dieldrin	Endrin	Heptachlor	Heptachlor epoxide	Lindane	Methoxychlor	Methyl parathion	Parathion	Toxaphene	PCBs
2002.0100	Dec. 20, 1974	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	18
	Mar. 24, 1975	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	34
	Apr. 29, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50
2200.0100	Apr. 19, 1976	< 20	< 1.0	< 20	2.8	4.7	4.3	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50
2201.0100	Sept. 10, 1976	< 20	< 1.0	< 20	4.3	47	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	31
	June 22, 1977	< 20	< 1.0	< 20	< 3.0	39	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20
2201.0200	Mar. 18, 1977	< 20	< 1.0	< 20	< 3.0	47	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	39
	June 22, 1977	< 20	< 1.0	64	8.8	62	< 5.0	< 5.0	< 5.2	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20
	Aug. 9, 1977	< 20	< 1.0	130	< 3.0	78	< 5.0	< 5.0	< 4.9	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	182
2301.0100	Sept. 30, 1976	< 20	< 1.0	< 20	< 3.0	6.5	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20
	June 30, 1977	< 20	< 1.0	< 20	< 3.0	10	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20
2411.0100	Sept. 18, 1975	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50
2412.0200	July 3, 1974	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	15
	July 10, 1975	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50
	July 13, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50
2421.0400	May 7, 1974	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50
	May 29, 1975	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50
	Sept. 14, 1977	< 20	< .2	< 20	< .2	< .2	< .2	< 5.0	< .2	< .2	< .2	< .2	< .2	< 2.0	< 5.0	< 5.0	< 2.0	< 20
2423.0100	May 7, 1974	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50
	May 29, 1975	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50
	Aug. 10, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50
	Sept. 14, 1977	< 20	< .2	< 20	< .2	< .2	< .2	< 5.0	< .2	< .2	< .2	< .2	< .2	< 2.0	< 5.0	< 5.0	< 2.0	< 20
2424.0100	May 21, 1974	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50
	May 20, 1975	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50
	May 14, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50
2431.0100	Aug. 10, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50
2434.0100	May 29, 1974	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50
	June 4, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50
	Aug. 19, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50
2441.0100	May 6, 1975	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50
	May 4, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	9.0
2451.0200	May 3, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	30
	Aug. 3, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	22
2452.0100	May 6, 1975	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50
	May 4, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	5.0
2453.0100	Aug. 3, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	46
2453.0200	May 3, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	10
	Aug. 3, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20
2453.0300	May 3, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20
	Aug. 3, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	39
2454.0100	May 5, 1975	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50
	May 3, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20
2455.0100	May 5, 1975	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50
	May 3, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	8.0
2456.0100	May 6, 1975	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50
	May 4, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	2.0
2461.0100	May 7, 1975	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50
	Aug. 5, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20

APPENDIX D

Pesticide Concentrations in Estuarine Sediment Samples Collected by the Texas Department of Water Resources at Statewide Monitoring Network Stations (µg/kg)--Continued

Station	Date	Silvex	Aldrin	Chlordane	DDD	DDE	DDT	Diazinon	Dieldrin	Endrin	Heptachlor	Heptachlor epoxide	Lindane	Methoxychlor	Methyl parathion	Parathion	Toxaphene	PCBs
2462.0100	Mar. 11, 1975	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	24
	June 2, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	25
2462.0300	Mar. 11, 1975	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	15
2463.0100	June 4, 1975	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50
2471.0100	Apr. 23, 1975	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	9.8
	Apr. 20, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	17
2472.0100	Mar. 18, 1975	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	14
	Aug. 31, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20
	July 19, 1977	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20
2481.0100	Feb. 21, 1974	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50
	Apr. 20, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	85
2481.0400	Apr. 20, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	49
2481.0500	Apr. 15, 1975	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50
	July 26, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	45
2482.0100	Apr. 12, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	47
2482.0200	Apr. 12, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	10
2482.0300	Apr. 14, 1975	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	17
	Apr. 12, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	25
	Sept. 14, 1977	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	22
2482.0400	Apr. 12, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	10
2483.0100	Apr. 23, 1975	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	19
	Apr. 20, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50
2484.0100	Feb. 21, 1974	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	91
	Apr. 6, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	390
	Sept. 14, 1977	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	47
2484.0200	Feb. 21, 1974	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	71
	Apr. 6, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	84
	Apr. 5, 1977	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	66
	July 5, 1977	< 20	< 1.0	< 20	< 3.0	6.7	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	92
	Sept. 14, 1977	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 13.0	< 5.0	< 50	92
2484.0300	June 28, 1974	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	.6	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	64
	Apr. 6, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	130
	Sept. 14, 1977	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	33
2491.0200	Apr. 9, 1975	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	86
	Apr. 26, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	147
	Sept. 7, 1977	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 50
2492.0200	Apr. 9, 1975	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	120
	July 6, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20
2494.0100	Sept. 29, 1976	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	< 20
2501.0400	July 28, 1975	< 20	< 1.0	< 20	< 3.0	< 2.0	< 5.0	< 5.0	< 3.0	< 3.0	< 1.0	< 1.0	< 1.0	< 20	< 5.0	< 5.0	< 50	12

APPENDIX E

Highest Concentrations of DDT, DDD, and DDE Found in Repetitive* Sampling of Fish and Oyster Tissue, and Concentrations of DDE in Pelican Tissue—Selected Results From Samples Collected by the Texas Parks and Wildlife Department. Data are from Table 5 of Childress (1970).

Organism and part	Highest Concentration found (μg/kg) DDT	DDD	DDE	Corresponding location
Menhaden, whole body	2,000	1,900	5,400	Lower Laguna Madre
Mullet, whole body	1,500	900	820	San Antonio Bay (DDT and DDD) and Lower Laguna Madre (DDE)
Killifish, whole body	180	370	410	Corpus Christi Bay (DDT and DDE) and Matagorda Bay (DDD)
Speckled seatrout, eggs	380	430	3,400	Lower Laguna Madre
Speckled seatrout, ovaries	950	960	6,800	Do.
Speckled seatrout, gonads	1,200	1,200	5,200	Do.
Speckled seatrout, body flesh	180	460	1,400	Do.
Speckled seatrout, brain	71	47	840	Do.
Speckled seatrout, liver	3,200	2,900	6,600	Corpus Christi Bay (DDT and DDD) and Lower Laguna Madre (DDE)
Speckled seatrout, skin	130	260	1,600	Lower Laguna Madre
Anchovy, whole body	550	750	5,200	Do.
Black drum, liver	51	180	1,200	Do.
Gizzard shad, whole body	26	330	93	San Antonio Bay
Mojarra, whole body	49	32	55	Corpus Christi Bay
Spot croaker, whole body	62	190	630	Do.
Yellow catfish, body flesh	410	780	550	San Antonio River
Sun perch, whole body	62	110	95	Galveston Bay
Crappie, whole body	99	140	100	Do.
Alligator gar, whole body	30	290	240	Do.

APPENDIX E—Continued

Organism and part	Highest Concentration found (μg/kg) DDT	DDD	DDE	Corresponding location
Oyster, whole body	270	590	330	Matagorda Bay (DDT and DDD) and Lower Laguna Madre (DDE)
White pelican, body tissue	—	—	84,000	Corpus Christi Bay
White pelican, liver	—	—	120,000	Do.
White pelican, brain	—	—	18,000	Do.
White pelican, heart	—	—	31,000	Do.
White pelican, kidney	—	—	16,000	Do.

*Bay fish samples were collected monthly from January 1967 through 1969, and bay oyster samples monthly from August 1965 through 1969.

APPENDIX F

Concentrations of DDT, DDD, and DDE in Fish Tissue at Sites in and Near the Rio Grande and Arroyo Colorado—Samples Collected by the U.S. Fish and Wildlife Service.

Location	Date	Organism and part*	Concentration** (µg/kg) DDT	DDD	DDE
Rio Grande at McNary	1976-77	Gizzard shad, whole (10)	40	465	1,635
Rio Grande at Indian Hot Springs	do	Carp, whole (8)	ND	90	760
Rio Grande at Ruidosa	do	Carp, whole (2)	ND	30	580
Rio Grande at Presidio	do	Carp, whole (5)	20	60	610
Do.	do	Longnose gar, whole (5)	32	52	6,170
Mouth of Pecos River	do	Channel catfish, whole (10)	ND	ND	560
Do.	do	Smallmouth buffalo, whole (4)	100	200	410
Do.	do	Carp, whole (4)	ND	ND	230
Amistad Reservoir	do	Gizzard shad, whole (5)	ND	ND	190
Do.	do	Smallmouth buffalo, whole (3)	10	20	330
Do.	do	White bass, whole (5)	ND	ND	70
Rio Grande at Eagle Pass	do	Carp, whole (10)	25	105	1,615
Do.	do	Gizzard shad, whole (5)	10	10	30
Falcon Reservoir	do	Carp, whole (10)	ND	30	540
Do.	do	Largemouth bass, whole (5)	30	50	740
Rio Grande at Roma	do	Drum, whole (1)	50	40	450
Do.	do	Largemouth bass, whole (3)	70	170	730
Do.	do	Carp sucker, whole (1)	170	170	900
Rio Grande at Mission	do	Gizzard shad, whole (10)	70	60	1,650
Do.	do	Channel catfish, whole (3)	30	50	1,700
Bentsen Lake	1978	Blue catfish, whole (1)	ND	130	2,640
Do.	do	Crappie, whole (3)	ND	75	1,285

APPENDIX F—Continued

Location	Date	Organism and part*	Concentration** (μg/kg) DDT	 DDD	 DDE
Rio Grande at Anzalduas Dam	1977	Blue catfish, whole (1)	ND	170	3,330
Do.	do	Gizzard shad, whole (3)	65	260	2,720
Arroyo Colorado at McAllen	do	Blue Catfish, whole (1)	ND	ND	16,700
Do.	do	Gizzard shad, whole (3)	ND	ND	16,000
Arroyo Colorado at San Juan	do	Blue catfish, whole (1)	ND	ND	11,200
Do.	do	Gizzard shad, whole (3)	ND	ND	15,250
Llano Grande Lake on Arroyo Colorado	1976-77	Rio Grande Perch, whole (6)	1,710	2,150	27,960
Do.	do	Gizzard shad, whole (10)	1,360	1,305	16,215
Do.	1978	Blue catfish, whole (1)	ND	ND	17,400
Do.	do	Gizzard shad, whole (3)	ND	ND	15,550
Do.	do	Blue catfish, fillet	ND	ND	7,300
Arroyo Colorado at Harlingen	do	Blue catfish, whole (1)	ND	ND	10,600
Do.	do	Gizzard shad, whole (1)	ND	ND	20,800
Arroyo Colorado at Port of Harlingen	do	Blue catfish, whole (1)	ND	ND	24,100
Do.	do	Gizzard shad, whole (3)	ND	ND	19,350
Arroyo Colorado at Rio Hondo	do	Salt catfish, whole (3)	ND	ND	355
Arroyo Colorado at Arroyo City	do	Sea trout, whole (1)	ND	ND	140
Do.	do	Sea catfish, whole (3)	ND	35	415
Delta Lake	1976-77	Gizzard shad, whole (10)	50	55	1,015
Do.	do	White bass, whole (6)	20	30	780
Laguna Atascosa	do	Black drum, whole (4)	60	90	1,520
Do.	do	Carp, whole (3)	120	80	1,350

*Shown in parentheses is the number of organisms composited for analysis.

**ND indicates none detected.

APPENDIX G

Concentrations of DDT, DDD, and DDE in Fish Tissue Samples Collected by the Texas Department of Water Resources

Location	Date	Organism and part	Concentration* (μg/kg)		
			DDT	DDD	DDE
Trout Creek in Jasper County	1976	Plankton feeders, whole	11	ND	10
Do.	do	Bottom feeders, edible tissue	ND	ND	10
Do.	do	Piscivorous, edible tissue	ND	ND	2
Victor Braunig Lake	1977	Channel catfish, edible tissue	ND	65	ND
Leon Creek, segment 1906 in San Antonio	1976	Minnows and perch, whole	622	305	283
San Antonio River station 1901.0300	1978	Spotted gar, whole	ND	ND	430
Pecan Bayou, segment 1417 in Brownwood	1976	Minnows and fish, whole	249	3,150	20
Do.	do	Bottom feeders, edible tissue	ND	ND	16,200
Do.	do	Piscivorous, edible tissue	ND	ND	ND
North Fork Double Mountain Fork Brazos River in Lubbock	1978	Sunfish, whole	ND	ND	ND
Do.	do	Minnows and whole bullhead catfish tissue	ND	110	ND
Buffalo Springs Lake, station 1200.0500	1978	Largemouth bass, edible tissue	ND	ND	ND
Do.	do	Channel catfish, edible tissue	ND	45.8	90.2
Do.	do	White crappie, edible tissue	ND	ND	15.6
Prairie Dog Town Fork Red River in Childress County	1977	Minnows, whole	163	96	753
Prairie Dog Town Fork Red River in Hardeman County	do	do	98	39	459
Groesbeck Creek in Hardeman County	do	do	83	145	1,232
Pease River in Wilbarger County	do	do	112	63	232

APPENDIX G—Continued

Location	Date	Organism and part	Concentration* (µg/kg) DDT	DDD	DDE
Red River in Wilbarger County	1977	Minnows, whole	288	73	264
Wichita River in Wichita County	do	do	18	6	26
Red River in Wichita County	do	do	91	58	269
Corpus Christi Inner Harbor, station 2484.0200	do	Sea catfish, edible tissue	ND	ND	87
Do.	do	Blue crab, whole	ND	ND	4.5
Do.	1978	Menhaden, whole	ND	ND	6.2
Do.	do	Sea catfish, edible tissue	ND	ND	39
Do.	do	Spanish mackerel, edible tissue	ND	ND	130
Rio Grande, station 2306.0300	1977	Minnows, whole	169	56	633
Rio Grande below Rio Conchos (Mexico) confluence near Presidio	1979	Blue suckers, whole	170	170	1,700
Do.	do	Channel and blue catfish, whole	1,760	1,040	20,000
Do.	do	Longnose gar, whole	2,300	1,400	5,900
Do.	do	Carp, whole	5.8	21	120
Arroyo Colorado Tidal, station 2201.0200	1977	Blue catfish, edible tissue	ND	ND	700

*ND indicates none detected.

APPENDIX H

Concentrations of PCBs in Fish Tissue Samples Collected by the Texas Department of Water Resources

Location	Date	Organism and part	PCB concentration (μg/kg)
Neches River Tidal	1978	Mixed small fish, whole	47
Buffalo Springs Lake, Lubbock County	do	White crappie, edible tissue	27.5
Do.	do	Channel catfish, edible tissue	103.5
North Fork Double Mountain Fork Brazos River in Lubbock	do	Minnows, whole	890
Pecan Bayou, segment 1417 in Brownwood	1976	Minnows and sunfish, whole	50
Do.	do	Bottom feeders, edible tissue	325
San Antonio River, station 1901.0300	1978	Spotted gar, whole (2)	1,110
Corpus Christi Inner Harbor, station 2484.0200	1977	Sea catfish, edible tissue	370
Do.	do	Spot Crooker, whole	33
Do.	1978	Mullet, whole	185
Do.	do	Spot Crooker, whole	21
Do.	do	Blue crab, whole	35
Do.	do	Ladyfish, whole	32
Do.	do	Menhaden, whole	110
Do.	do	Sea catfish, edible tissue	220
Do.	do	Speckled trout, edible tissue	40
Do.	do	Sea catfish, edible tissue	65
Do.	do	Spanish mackerel, edible tissue	1,200
Do.	do	Mullet, whole	1,000
Rio Grande station, 2306.0300	1977-78	Carp, whole Minnows, whole	260 350

APPENDIX I

U.S. Environmental Protection Agency 1980 Revisions of Water Quality Criteria for Protection of Fresh Water Aquatic Life and Marine Life for Pesticide Concentrations. These supercede 1976 criteria in "Quality Criteria for Water", and are published in the Federal Register, v. 45, no. 231, November 28, 1980, and in ambient water quality criteria for toxic pollutants documents.

	Protection of Fresh Water Aquatic Life (μg/l)		Protection of Marine Life (μg/l)	
Pesticide	**Concentration not to be exceeded at any time**	**Concentration not to be exceeded on a 24-hour average**	**Concentration not to be exceeded at any time**	**Concentration not to be exceeded on a 24-hour average**
Aldrin	3.0	–	1.3	–
Dieldrin	2.5	0.0019	.71	0.0019
Chlordane	2.4	.0043	.09	.0040
DDT, DDD, and DDE	1.1	.0010	.13	.0010
Endrin	.18	.0023	.037	.0023
Heptachlor	.52	.0038	.053	.0036
Lindane	2.0	.080	.16	–
PCBs	2.0	.014	10.0	.030
Toxaphene	1.6	.013	.070	–