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Publication No. 83-e26

WA-37-1048

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MEMORANDUM
July 8, 1983

To: Dick Cunningham

From: Joe Joy

Subject: Review of Available DDT Data, Especially as Related to the Yakima River and Recent Elevated Residues Found in Samples from Birchfield (Moxee) Drain

A recent survey of the Yakima River from Selah Gap to Union Gap showed elevated concentrations of DDT, DDE, and DDD in sediment and water samples from the mouth of the Birchfield (Moxee) Drain (Johnson and Newman, 1983). The sediment sample contained 261 μg/Kg ΣDDT (DDT + DDD + DDE). Rocky substrate prevented the collection of sediment samples at other locations during the survey. The water sample contained 0.074 μg/L ΣDDT, a concentration exceeding the EPA chronic toxicity criterion of 0.001 μg/L, but not the acute toxicity criterion of 1.1 μg/L for freshwater samples. Two other water samples collected during the survey contained detectable levels of ΣDDT. Although the samples taken from Wide Hollow Creek and the Boise Cascade Canal also exceeded the EPA chronic toxicity criterion, at 0.015 μg/L and 0.005 μg/L, respectively, they were at substantially lower levels than the Birchfield Drain sample.

This report summarizes information on DDT contamination, especially as related to the Yakima River basin. Also discussed are possible monitoring activities, should this be deemed the next appropriate action to take.

Background

The use and production of DDT in the U.S. has been severely restricted since 1972. Prior to that time, it was the most widely used pesticide in the country. It was applied to agricultural crops and forests for insect control, and to waterways and city sewer systems for mosquito control. Only under emergency situations has it been used since then; e.g., the tussock moth outbreak in Washington, Oregon, and Idaho in 1974.

DDT was restricted because of its resistance to degradation, its bio-accumulative tendencies, and its toxic effects on non-target organisms -- particularly predator species high on the food chain. It has been shown that DDT is highly mobile and now is present throughout the world in air, water, sediment, and animal tissue (Edwards, 1973; EPA, 1980). Concentrations of DDT in these media are expected to diminish, but rates of metabolic breakdown, evaporation, hydrolysis, and photolysis proceed very slowly. For example, orchard soils applied with ≈ 19.5 lbs DDT/acre/yr. for 21 years were then tested for DDT and metabolite concentrations for ten years afterwards (Tinsley, 1979). The initial concentration was 40 mg/Kg ΣDDT with ≈ 80 percent as p,p'-DDT. After 10 years, 25 mg/Kg ΣDDT remained (62 percent), with 56 percent as p,p'-DDT and 23 percent as DDE. Similar results have been found in experimental watershed and farms (Dimond, et al., 1971; Edwards, 1973).

The Yakima River basin is heavily used for agricultural and silvicultural activities. Roughly 17 percent is cropland, 42 percent forest, and 36 percent rangeland (USDA, et al., 1978). It may be assumed that DDT was applied there prior to 1972.

Four sets of DDT sampling results concerning DDT residues in the Yakima River were found. The most extensive fish tissue data available are from the National Pesticide Monitoring Program (NPMP) activities at Granger (Schmitt, Ludke, and Walsh, 1981). From 1969 to 1974, four to six adult fish were collected annually and analyzed for p,p'-DDT, p,p'-DDE and p,p'-DDD, among other pesticides. The 1970-1974 data are summarized in Table 1.

The USGS has had a Basic Water Monitoring Program (BWMP) station on the Yakima River at Kiona. Analytical results from 1968-1980 for ΣDDT concentrations in whole water and benthic sediment samples are summarized in Table 2. Data are also available from the BWMP fish tissue collections conducted by WDOE. And finally, water, tissue, and sediment data collected by EPA are available from STORET under the file name EPATOX. These last two sets of data are from statewide monitoring programs involving over 150 samples . These data are currently being summarized (Joy, in prep.). The Yakima River data from this summary along with the data from the Gap-to-Gap survey are presented in Table 3. Statewide averages from the BWMP/EPATOX results are summarized in Table 4. Approximate locations of the sampling sites for all the Yakima data mentioned above are shown in Figure 1.

Discussion

The following discussion will show that DDT contamination has been a chronic problem in the Yakima River basin. The former widespread

application of DDT is reflected in the data presented in Tables 1-3. Although the data do not directly address the question of high residues in the water and sediment sample taken from the Birchfield Drain, they graphically indicate that substantial amounts of DDT and its metabolites have been and are currently present in the Yakima system.

On the whole, the observation by Johnson that the Birchfield Drain sediment and water concentrations of DDT are "...in the upper end of the concentration ranges reported by other investigators." is also true for tissue and sediment residues from the mid and lower Yakima (Johnson and Newman, 1983). The concentrations have been consistently higher than national averages for tissue (Table 1), and statewide averages for tissue and sediment (Tables 3 and 4).

The available data from water samples taken on the Yakima River and statewide suggest that DDT and its metabolites are now rarely detected in the water column (Tables 2, 3, 4). No DDT has been detected in water samples taken from the Yakima at Kiona since 1973. No EPATOX water samples taken from the Yakima and Naches rivers had detectable levels of DDT or its metabolites (Table 3). Less than 20 percent of the EPATOX water samples taken statewide contained ΣDDT (Joy, in prep.). The concentration of ΣDDT detected in the Birchfield Drain water sample is similar to some of those detected at Kiona in the late 1960s (Table 2). However, the water samples from the 1960s are also different in that the primary metabolite identified was DDT, whereas DDE was the primary metabolite in the drain sample (Table 3). This difference may indicate that the DDT in the drain water sample is from degraded and resuspended DDT associated with contaminated sediments. The high suspended solids concentration noted in the Birchfield Drain sample also supports the notion of sediments as the source of contamination in the water sample (Johnson and Newman, 1983).

The Birchfield Drain sediment sample has a higher ΣDDT concentration than sediment samples collected under the monitoring programs previously mentioned (Tables 2, 3, and 4). In addition, the EPATOX data indicate that Yakima basin sediments contain higher ΣDDT concentrations than most others in the state (Tables 3 and 4). However, the USGS sediment data indicate that maximum sediment ΣDDT concentrations can fluctuate greatly at a single station (Table 2). In localized areas, investigators have found sediment concentrations of DDT as high as those detected in Birchfield Drain sample. For example, sediment samples taken at McNary Wildlife Refuge in 1964 had DDT concentrations from 1-4 mg/Kg, or 1000-4000 μg/Kg (reported in Kent and Johnson, 1979). Urban soils from 25 sites in Portland had 30-7640 μg/Kg ΣDDT with arithmetic and geometric means of 670 and 92 μg/Kg, respectively (Carey, Wiersma, and Tai, 1976). Sediments in southern Lake Michigan had a maximum ΣDDT concentration of 175 μg/Kg (Leland, Bruce, and Shimp, 1973). Sediments at the base of a stormwater outfall at Madison Park in Seattle had up to 3164 μg/Kg ΣDDT (as reported in Konasewich, et al., 1982).

It is clear from the data collected in the various monitoring programs that fish in the Yakima River have had, and continue to have higher ΣDDT residues than most other fish collected nationwide and statewide (Tables 1, 3, and 4). In addition, there does not appear to be a difference in ΣDDT concentrations in the fish collected from the lower Yakima River in 1970 and those collected in 1980 (Tables 1 and 3). Residues have not steadily declined over the past 10 years.

As with the water and sediment samples, there is a difference in the makeup of the ΣDDT concentration in fish from 1970 and those from 1980. There has been an increase in the DDE fraction over the years. This increase in DDE versus DDT was also detected by statistical analysis of the nationwide NPMP data from 1970 to 1974 (Schmitt, Ludke and Walsh, 1981). DDE is considered more environmentally stable than DDT or DDD, so that it is expected to remain for many years to come.

The fish tissue samples taken from the Yakima River under the monitoring programs mentioned above have not contained ΣDDT in excess of the 5 mg/Kg FDA limit. However, some sturgeon taken in Lake Wallula, where the Yakima and the Columbia rivers meet, have had fillet DDT concentrations greater than the FDA standard (Bosley and Gately, 1981). The World Health Organization recommended standard of 0.005 mg/Kg body weight may be exceeded for people consuming large quantities of fish that contain DDT residues greater than ≈ 1.0 mg/Kg. The lower Yakima River fish, in general, have DDT residues exceeding this criterion.

However, the 5 mg/Kg and 0.005 mg/Kg body weight DDT limits refer to edible tissue portions only. The whole-tissue values may be somewhat misleading when compared to edible tissue criteria since whole tissue has a higher lipid content than fillets or muscle tissue (Schmitt, Ludke, and Walsh, 1981). DDT is highly associated with lipid content in animal tissues.

The Yakima fish tissue concentrations of DDT may pose an environmental hazard to pisciverous birds, fish, and mammals. It is recommended that whole-body DDT residues not exceed 1 mg/Kg for protection of wildlife (NAS, 1973). Some NPMP, EPA, and BWMP tissue samples have exceeded this guideline (Tables 1 and 2).

Since the Birchfield Drain is an irrigation wastewater return, one would expect high levels of certain pollutants applied to the agricultural lands using the drain. Hydrophobic, non-degrading pollutants like DDT would tend to leach-out or erode with sediments and concentrate wherever sediments settled out.

The mouth of Birchfield Drain is quite similar to the Madison Park stormwater outfall mentioned above. Highly elevated concentrations of pollutants are present in sediments at the mouth of such structures where velocities are slowed by the receiving body of water, so that sediments laden with DDT and other hydrophobic pollutants settle out of the water column.

These localized areas of contaminated sediments are reservoirs for the delayed release of pollutants. The pollutants and sediments may be resuspended under certain hydraulic conditions, or pollutants may slowly leach-out of the sediments as benthic chemistry changes.

These pollutants may then be taken up by aquatic organisms directly from the water or in food organisms. The rate of bioaccumulation is dependent upon the chemical state of the pollutant; the species, age, sex, trophic level, lipid content of the organism; and the season of the year (Phillips, 1980). Even while taking these and other variables into account, researchers investigating DDT bioaccumulation have found that there is not always a direct relationship between DDT sediment and water concentrations, and fish tissue residues (Kent and Johnson, 1979; Phillips, 1980).

Future sediment and tissue samples taken from the lower Yakima River and localized areas of contamination will continue to have detectable, if not relatively elevated, levels of DDT. Not enough is known to predict when the residues in fish will remain below criteria levels. In the meantime, the data suggest that more information concerning DDT sinks and areas of possible human health and environmental hazard are needed.

It must be cautioned that the fish samples taken to date have not been taken from the vicinity of Birchfield Drain (Figure 1). Therefore, we do not know whether or not resident fish at the mouth of the drain have elevated DDT residues and pose a human health or environmental hazard. A tissue collection from below the drain was planned in 1982, but could not be performed for lack of nearby boat-launching facilities (Clark, 1983).

It must also be cautioned that one sediment sample is not statistically representative of the Birchfield (Moxee) Drain. As was stated in the initial report, more tissue and sediment samples should be taken to assess the degree of DDT contamination in the drain (Johnson and Newman, 1983).

Future sampling strategies should be designed to answer the most important questions raised by the Birchfield Drain samples. These questions are as follows:

1. Were the sediment and water samples taken at Birchfield Drain anomalies?

2. Do fish in the vicinity of the drain pose human health or environmental hazards?

3. Are water, fish, and sediment in the Yakima River manistem below the drain also contaminated?

The answers to these questions would give WDOE a better grasp as to the possible extent of DDT contamination in the vicinity of Birchfield Drain. The answers could also lead to future studies concerning DDT in other wasteways in the Yakima and Columbia rivers, and they could provide insight into the design of such investigations.

JJ:cp

Attachments

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Table 1. National Pesticide Monitoring Program fish tissue data for the Yakima River at Granger, including the station ΣDDT annual mean concentrations and the annual mean and maximum from all samples collected nationwide (Schmitt, Ludke and Walsh, 1981). Results for DDT and metabolites -- concentrations are mg/Kg wet weight for whole-tissue composites from individual specimens.

Year	Species	Percent Lipid	DDE	DDD	DDT	ΣDDT	Percent DDE	Station Annual Mean	Station Annual Geo. Mean	National[1] Geo. Mean	National[1] Maximum
1970	Bridgelip Sucker	7.9	0.66	0.48	1.03	2.17	30.4				
	Carp	5.6	0.89	0.03	0.15	1.07	83.2				
	Carp	5.0	1.07	0.35	0.17	1.59	67.3				
	Largemouth Bass	3.9	1.66	0.51	0.42	2.59	64.1				
								1.86	1.76	0.98	13.02
1971	Black Crappie	1.9	0.49	0.14	0.18	0.81	60.4				
	Black Crappie	2.3	0.55	0.14	0.16	0.85	64.7				
	Carp	4.4	1.07	0.25	0.17	1.49	71.8				
	Carp	5.0	1.02	0.38	0.08	1.48	68.9				
	Largescale Sucker	4.9	1.12	0.52	1.04	2.68	41.8				
	Largescale Sucker	5.4	0.71	0.38	0.55	1.64	43.3				
								1.49	1.37	0.73	13.13
1972	Carp	6.4	2.20	0.42	0.14	2.76	79.7				
	Largescale Sucker	4.3	0.92	0.44	0.64	2.00	46.0				
	Largescale Sucker	4.2	1.10	0.55	0.78	2.43	45.3				
	Northern Squawfish	3.8	2.70	0.34	0.01	3.05	88.5				
								2.56	2.52	0.64	21.8
1973	Carp	5.4	0.52	0.00	0.00	0.52	100				
	Largescale Sucker	6.0	0.88	0.39	0.51	1.79	49.4				
	Largescale Sucker	12.0	1.00	0.47	0.67	2.14	46.7				
	Largemouth Bass	4.2	0.77	0.14	0.11	1.02	75.5				
								1.36	1.19	0.44	48.0
1974	Carp	4.9	3.10	0.08	0.44	3.62	85.6				
	Carp	4.9	2.20	0.55	0.19	2.94	74.8				
	Largescale Sucker	5.1	1.10	0.69	0.54	2.33	47.2				
	Smallmouth Bass	4.8	1.40	0.39	0.31	2.10	66.7				
								2.75	2.69	0.52	16.2

[1]The following numbers of samples were collected nationwide: 1970 - 394; 1981 - 585; 1972 - 390; 1973 - 402; 1974 - 335.

Table 2. A summary of water and benthic sediment data from USGS samples collected from the Yakima River at Kiona from 1968 to 1980. Water in μg/L; sediment in μg/Kg, dry weight.

Year	Medium	No. of Samples	No. ΣDDT Detected	Range	Mean	Geo. Mean	$\overline{X}$ % DDE
1968	Water	7	7	0.01 - 0.05	0.04	0.03	15.5
1969	Water	11	4	0.00 - 0.06	0.02	0.02	12.0
1970	Water	11	5	0.00 - 0.05	0.01	0.01	18.5
1971	Water	7	1	0.00 - 0.03	0.004	0.004	66
1972	Water	4	1	0.00 - 0.01	0.002	0.002	100
	Sediment	2	1	<0.2 - 4.8	2.4	0.22	25.0
1973	Water	4	2	0.00 - 0.01	0.005	0.005	0
	Sediment	2	2	5.2 - 34.8	20	13.4	52.4
1974	Water	3	0	0.00	--	--	
	Sediment	2	2	1.1 - 64	32.6	8.4	43
1975		NO DATA					
1976	Water	6	0	0.00			
	Sediment	2	2	4.6 - 25.8	14.7	9.6	73.6
	Sediment*	4	4	1.5 - 20	8.0	5.3	4.2
1977	Water	3	0	0.00			
1978	Water	4	0	0.00			
1979	Water	4	0	0.00			
1980	Water	3	0	0.00			

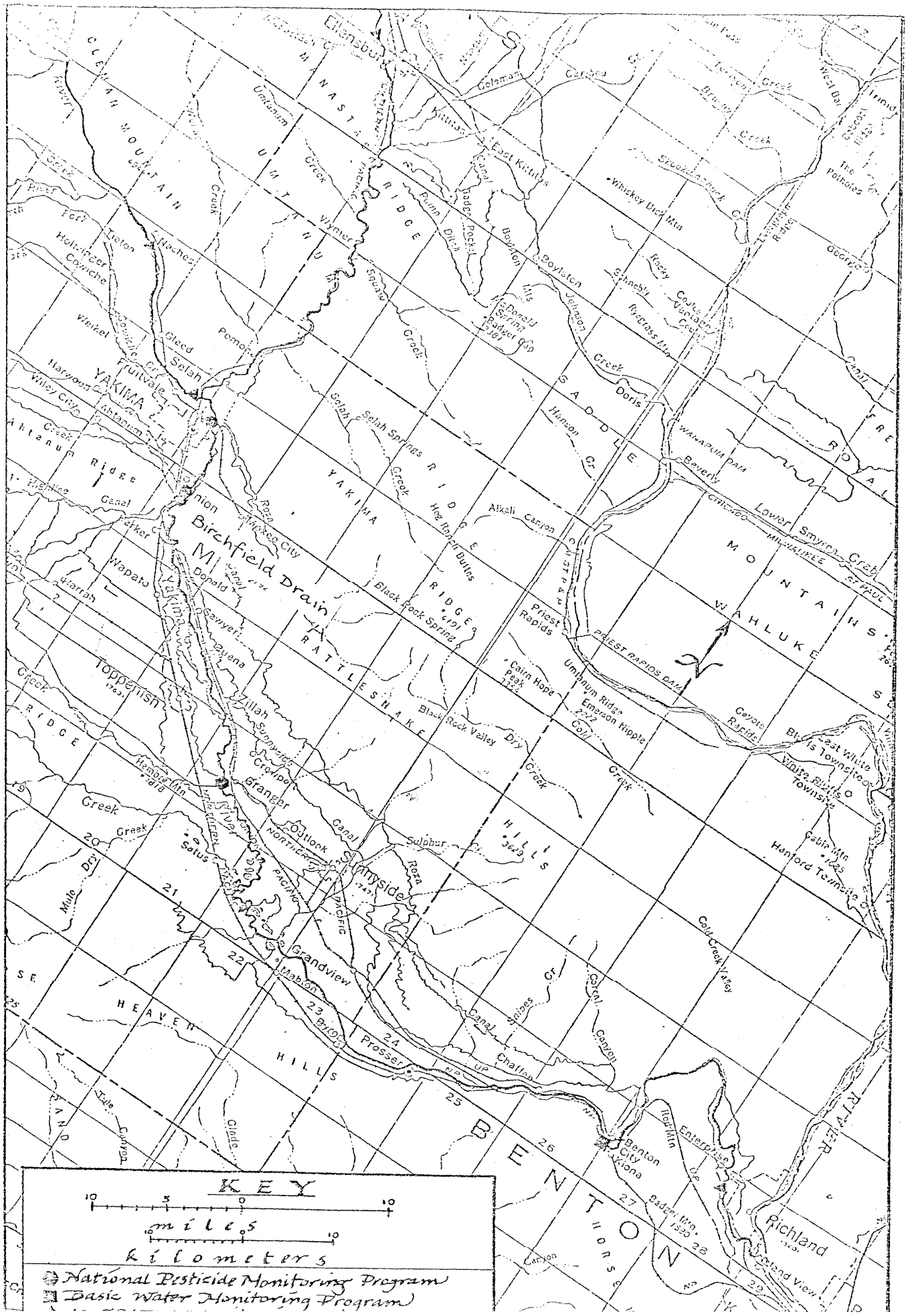
*p,p'-ΣDDT only.

Table 3. Yakima River basin DDT concentrations from the Basic Water Monitoring Program (BWMP) fish tissue, EPATOX sediment and tissue, and the Gap-to-Gap water and sediment samples. All tissue concentrations are in mg/Kg wet weight; sediment in µg/Kg dry weight; and water in µg/L.

Date	Media/Species	Percent Lipid	Percent Solids	p,p'-DDE	p,p'-DDD	p,p'-DDT	ΣDDT	% DDE
BWMP - Yakima at Kiona (27A090)								
9/16/80	Smallmouth Bass	3	28	0.460	0.076	0.040	0.576	79.9
9/16/80	Bridgelip Sucker	7	29	0.670	0.170	0.057	0.897	74.7
8/20/81	Northern Squawfish	7.4	37	1.100	0.110	0.047	1.257	87.5
8/20/81	Largescale Sucker	13	45	2.100	0.390	0.590	3.080	68.2
EPA - Yakima at Ellensburg (04A001)								
3/05/78	Largescale Sucker	--	--	0.08	--	--	0.08	100
EPA - Naches at Yakima Water Treatment Plant (04F001)								
7/23/80	Rainbow Trout and Round Whitefish	--	--	0.321	0.037	0.049	0.407	78.9
EPA - Naches River at Mouth at Twin Bridges (04F002)								
7/22/80	Rainbow Trout	--	--	0.069	0.042	0.091	0.202	34.2
7/22/80	Sediment			5	--	4	9	55.6
EPA - Yakima at Highway 224 Bridge near Richland (04A002)								
7/22/80	Largescale Sucker	--	--	1.55	0.279	0.183	2.012	77.0
7/22/80	Sediment			13	11	--	24	54.2
WDOE - Birchfield (Moxee) Drain								
7/07/82	Water			0.04	0.01	0.024	0.074	54.1
7/07/82	Sediment			170	60	31	261	65.1
WDOE - Boise Cascade Canal								
7/07/82	Water			0.005	--	--	0.005	100
WDOE - Wide Hollow Creek								
7/07/82	Water			0.008	0.005	0.002	0.015	53.3

Table 4. Mean, geometric mean, and range of DDT and metabolite concentrations in EPATOX and BWMP+EPATOX media. Water in μg/L; sediment in μg/Kg dry weight; tissue in mg/Kg wet weight (whole).

Pollutant	Media	No. of Positive Samples	% of Total Samples Taken	Range	Mean	Geometric Mean
EPATOX DATA						
p,p'-DDD	Water	6	11.5	(0.001-0.007)	0.003	0.002
	Sediment	5	14.3	(1-11)	4.0	2.6
	Tissue	10	35.7	(0.002-0.66)	0.109	0.027
p,p'-DDE	Water	6	11.5	(0.001-0.003)	0.002	0.002
	Sediment	21	60	(2-15)	3.9	3.1
	Tissue	25	89.3	(0.008-1.55)	0.281	0.112
p,p'-DDT	Water	10	18.5	(0.003-0.027)	0.010	0.007
	Sediment	13	37.1	(1-12)	3.5	2.7
	Tissue	14	50	(0.004-0.216)	0.079	0.051
Σp,p'-DDT	Water	10	18.5	(0.001-0.034)	0.012	0.008
	Sediment	19	54.3	(2-24)	7.4	5.3
	Tissue	26	92.9	(0.01-2.01)	0.660	0.211
EPATOX + 1978-1981 BWMP DATA						
ΣDDT	Tissue	55	96.5	(0.0008-3.08)	0.35	0.13


KEY
miles
kilometers
National Pesticide Monitoring Program
Basic Water Monitoring Program
Ellensburg
Kittitas
East Kittitas
Whiskey Dick Mtn
Boylston
Selah
Union Gap
Birchfield Drain
Wapato
Toppenish
Granger
Outlook
Sunnyside
Grandview
Mabton
Prosser
Benton City
Kiona
Richland
Priest Rapids
Umtanum Ridge
Emerson Hippie
Cain Hope Peak
Coyote Rapids
Hanford Townsite
Beverly
Doris
Alkali Canyon
Black Rock Spring
Black Rock Valley
Dry Creek
Cold Creek Valley
Chaffee
Satus
Toppenish Ridge
Yakima Ridge
Rattlesnake Hills
Saddle Mountains
Wahluke
Horse Heaven Hills
Yakima Mountain
Selah Springs Ridge
Hog Ranch Buttes
Lower Snyder Creek
Yakima River
Columbia River
Wenatchee
Ellensburg
Yakima
Richland