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ORGANOCHLORINE PESTICIDE RESIDUES IN THE PRESTON RIVER WESTERN AUSTRALIA DECEMBER 1985 to MAY 1986

Leschenault Inlet Management Authority
Waterways Commission
Report Number 12
July 1989

184 St. George's Terrace, Perth, W.A. 6000

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1.0 INTRODUCTION

The Preston River discharges into Vittoria Bay in Leschenault Estuary. The river catchment is 603km² of which approximately 40% is cleared, mainly along the valleys. The principal land uses in the catchment are grazing and forestry with some intensive agriculture (orchards, potatoes and other vegetables), and dairy farming (Atkins, 1982). Summer river flow is controlled by the Glen Mervyn Dam with water being released for irrigation.

The use of pesticides in intensive agriculture may pose a threat to the environment, particularly aquatic ecosystems. A twelve month investigation into the levels of organochlorine residues in the waters of the Preston River was conducted by the Waterways Commission in 1980-81 (Atkins, 1982). The objectives of the 1980-81 study were to:

1. Assess the level of organochlorine pesticide input to the Leschenault Inlet from the Preston River.

2. Determine if there is a need to assess the impact of these pesticides on the aquatic ecosystem.

3. Determine the source of inputs and derive management recommendations to reduce inputs.

The conclusions drawn from that study were:

1. Mean yearly dieldrin levels in the Preston River had not decreased significantly since 1974 when the recommended uses of dieldrin were restricted to the control of African Black Beetle in potatoes as a pre-planting soil treatment.

2. Dieldrin levels were amongst the highest in rivers in south-west Australia but were low when compared to other Australian rivers.

3. All organochlorine pesticide criteria for maintenance and preservation of aquatic ecosystems (DCE, 1981) were exceeded from time to time throughout the study.

4. Analysis of sediments and fish flesh from the Leschenault Estuary showed no measurable accumulation of organochlorine pesticide residues. Pesticide levels did not exceed the limits for human consumption.

5. There was evidence that the application of pesticides throughout irrigation systems had led to contamination of the Preston River.

The study conducted in 1985-86 was undertaken as a follow up to the study reported above. In addition, a ban on dieldrin use as a soil pre-treatment for potatoes in July 1982 was predicted to reduce the dieldrin residues reaching the Preston River. The use of other organochlorine pesticides, as well as organophosphorus pesticides, to replace dieldrin use had the potential to result in increased residue levels in the Preston River.

1.1 Objectives

The objectives of the 1985-86 study were:

1. To monitor the predicted reduction of dieldrin residues reaching the Preston River.

2. To monitor levels of other organochlorine and organophosphorus pesticide residues to determine if supplementary use had resulted in increased levels in the water.

3. To monitor accumulation of organochlorine pesticide residues in Leschenault Inlet.

2.0 THE STUDY AREA AND SAMPLING SITES

The study area extended from Glen Mervyn Dam to the Glen Iris Road Bridge on South West Highway, a 60km section of the Preston River (Figure 1). The sampling sites used by Atkins (1982) were also used for this study to allow comparisons to be drawn (Figure 1). These sites related to the various land uses in the study area (Table 1).

SITE	LOCATION	LAND USE REPRESENTED
1	Glen Mervyn Dam	State Forest (control)
2	Mumballup Road Bridge	Grazing, few orchards and vegetables
3	Lowden Road Bridge	Orchards, potatoes and vegetables
4	Jackson's	Orchards, potatoes and vegetables
5	Giancono's	Fruit
6	Donnybrook Gauging Station	Concentrated orchards and potatoes
7	Boyanup Rail Bridge	Intensive orchards
8	Ferguson River : Picton Junction Road Bridge	General farming, some hobby orchards
9	Glen Iris Road Bridge	Upstream of tidal influence
10	Abattoir, Preston River	General farming

TABLE 1: Land Use Represented by Study Sites.

3.0 BACKGROUND INFORMATION ON THE PESTICIDES

3.1 Organophosphorus Pesticides

Organophosphorus pesticides have gradually replaced organochlorine compounds in agriculture, horticulture, etc. (Derache, 1977). Organophosphorus pesticides are chemically unstable and have a short residual life (Health Department, 1983). Organophosphorus pesticides have equal or higher levels of toxicity but are less persistent in soil than the organochlorine compounds.

Organophosphorus compounds are cholinesterase inhibitors. Cholinesterase is an important enzyme at nerve synapses maintaining the flow of nerve impulses along nerve fibres (Ware, 1986).

3.2 Organochlorine Pesticides

Organochlorine pesticides are chemically stable and are persistent in the soil, aquatic environments, animal and plant tissue over a long time. They are not readily broken down by micro-organisms, enzymes, heat or ultra-violet light (Ware, 1986). Organochlorines vary widely in toxicity but are generally considered to be highly toxic, aldrin, heptachlor and dieldrin being the most toxic.

Organochlorines affect the central nervous system by inhibiting transmission of nerve impulses in both insects and mammals, although the mode of action is unclear.

3.3 Registered Uses of Organochlorine Pesticides in W.A.

At the time of the 1985-86 survey some organochlorine pesticides were registered for agricultural use (Table 2) although their use was restricted. The use of dieldrin in agriculture, as a soil pre-treatment for potatoes, was banned in July 1982. After July 1982 dieldrin was only registered for termite control by sub-surface injection (Thurlow et al., 1986).

In June 1987, all organochlorine pesticides were de-registered for all agricultural uses.

3.4 Organochlorine Pesticide Application in the Preston River

Table 2 summarises the use and application times recommended by the Department of Agriculture for organochlorine pesticides in the Preston River Catchment at the time of the 1985-86 study.

PESTICIDE	CROP	PEST	APPLICATION	
			METHOD	TIME
Dieldrin	-	-	-	-
	-	Termites	Soil	-
DDT	Apples/Pears	Dimple Bug	Foliar	Sept-Oct
	Apples	Thrip	Foliar	Sept-Oct
	Apples/Pears	Cutworm	Foliar	Nov-Dec
	Apples	Curculio	Butt	Early Dec
Aldrin	-	Termites	Soil	-
Heptachlor	Apples	Curculio	Butt	Early Dec
	General Apples/ Pears Citrus Stone Fruit			
	Potatoes	African Black Beetle	Soil	May & Jan
	-	Termites	Soil	-

TABLE 2: Organochlorine Pesticide Application in the Preston River Catchment (during 1985-86 survey).

4.0 MATERIALS AND METHODS

4.1 Water Sampling

Monthly water samples for organophosphorus and organochlorine pesticide residue analysis were collected from the ten (10) sites between December 1985 and May 1986 (i.e. 6 sample sets). Samples were collected in 2¼L acid washed glass bottles and transported in polystyrene containers to the Government Chemical Laboratories (now the Chemical Centre of W.A.), Perth, for analysis.

4.2 Mussel Sampling

Twenty (20) specimens (two groups of ten) of the freshwater mussel Hyridella carteri were collected from Site 6 - Donnybrook Gauging Station on 5th March 1986. The samples were transported on ice to the Government Chemical Laboratories. The flesh was analysed for organochlorine and organophosphorus pesticide residues as an indication of the level of bioaccumulation within the Preston River system.

4.3 Limits of Detection and Environmental Criteria

The limit of detection in water used in this study for organochlorine pesticides was 0.001µg/L and for organophosphorus compounds was 0.05µg/L.

The organochlorine criteria (Table 3) used to indicate pesticide contamination are from "Water Quality Criteria for Marine and Estuarine Waters of Western Australia", Schedule 7(2) (DCE, 1981).

PESTICIDE	RECOMMENDED LEVEL (µg/L)
Aldrin	0.003
Chlordane	0.004
DDT & Metabolites	0.001
Dieldrin	0.003
Heptachlor	0.001
Aldrin & Dieldrin	0.003

TABLE 3: Pesticide Criteria for the Maintenance and Preservation of Aquatic Ecosystems (DCE, 1981).

4.4 Presentation of Results

The results of the tests for organochlorine pesticide residues are presented as time series plots (Figure 2), spatial plots (Figure 3) and in summary form (Appendix 1).

5.0 RESULTS AND DISCUSSION

5.1 Organophosphorus Residues

Organophosphorus residues were not detected (i.e. greater than detection limit) in any of the samples collected. Downstream of Donnybrook orchardists had altered their pesticide practices. In this area organophosphorus pesticides were used in preference to organochlorines. Organophosphorus pesticides are less persistent in the environment than organochlorine pesticides and are therefore more difficult to detect.

5.2 Organochlorine Residues

Aldrin, chlordane, DDT, dieldrin and heptachlor were the common organochlorine pesticides detected in this study. Chlordane and dieldrin were detected in all samples. Heptachlor and DDT were detected in 83% of samples. Aldrin (which oxidises to dieldrin) was detected in only 33% of samples and these were below the environmental criteria.

5.2.1 Aldrin

As stated above, aldrin was not frequently detected and levels measured were at or below the environmental criteria. As aldrin is oxidised to dieldrin and it is not recommended for any agricultural use, its presence should be low in this catchment.

5.2.2 Chlordane

Chlordane was not registered for any agricultural use. Although, commercial heptachlor consists of 40% chlordane, both these compounds are similar in chemical structure and action. Detection of chlordane in this agricultural catchment can therefore be attributed to heptachlor use for black beetle and curculio beetle control.

Levels of chlordane detected were generally below the environmental criteria. The highest chlordane concentrations were detected in the area of most intensive organochlorine use, downstream of Glen Mervyn Dam and upstream of Donnybrook. Peaks in chlordane levels reflected the use of heptachlor as a soil pre-treatment to control African Black Beetle and for curculio beetle control. Application of heptachlor for black beetle control was recommended during January and May and for curculio control in early December.

Levels of chlordane downstream of Donnybrook were below the environmental criteria.

5.2.3 DDT and Metabolites

Levels of DDT were generally below the environmental criteria (Table 3). Peaks were recorded at Lowden Road Bridge in January and March 1986. DDT was not recommended for use on fruit crops after December during this study. The possible sources of these levels may be soil erosion or misuse of the chemical.

5.2.4 Dieldrin

During this study dieldrin was not registered for any agricultural use. However, as organochlorines (including dieldrin) can become tightly bound to soil particles, areas which have a history of intensive use are likely to continue to yield soil-fixed dieldrin for some time. Also aldrin oxidises to dieldrin so any use of aldrin would be reflected in dieldrin levels. Levels of dieldrin recorded between Mumballup Road Bridge and Donnybrook (inclusive) initially exceeded the environmental criteria and gradually decreased during the survey. The commencement of the irrigation period in December may have resulted in soil-bound dieldrin being mobilised and transported to the Preston River. Illegal use of dieldrin in December and January may also be a source of the elevated levels recorded at the beginning of the study.

Dieldrin was spatially variable in water throughout the survey. Levels were generally at or around the environmental criteria.

Levels at the control site (Glen Mervyn Dam) and downstream of Donnybrook were below the environmental criteria throughout the investigation.

5.2.5 Heptachlor

The area upstream of Donnybrook (including Glen Mervyn Dam control site and Mumballup Road Bridge) exhibited levels of heptachlor in excess of the environmental criteria during April/May. Application of heptachlor as a soil pre-treatment for controlling African Black Beetle in potato crops was recommended during this time and is a probable source. The Lowden Road Bridge site exhibited high levels of heptachlor from January through to March. Possible sources include soil erosion, and early treatment of soil.

During the remainder of the study all levels were below or at the detection limit of all sites.

5.3 Pesticide Concentrations in Hyridella carteri

	ORGANOCHLORINE (mg/kg)			
	CHLORDANE	DDT	DIELDRIN	HEPTACHLOR
Sample 1	<0.001	0.001	0.001	<0.001
Sample 2	0.001	<0.001	0.001	<0.001

TABLE 4: Organochlorine Concentration (mg/kg) in the Flesh of the Freshwater Mussel, Hyridella carteri, collected at Donnybrook Gauging Station (Site 6) on 5th March 1988.

The concentrations of organochlorine residues in the mussel flesh were at or below the detection limit and did not indicate any accumulation within the biota. The mussels were suitable for human consumption with respect to DDT and metabolites (maximum residue limit 1mg/kg) and chlordane and dieldrin (US action limit 0.3mg/kg).

The organochlorine levels in the waters within the study area on the sampling date were generally low. However, elevated levels of DDT and metabolites, dieldrin and heptachlor were recorded at Lowden Road Bridge - Site 3.

6.0 COMPARISON WITH OTHER DATA

6.1 Comparison with 1980-1981 Data

Atkins' (1982) study covered a twelve (12) month period from May 1980 to May 1981. The study reported here was conducted from December 1985 to May 1986. Therefore, a comparison is based on the same periods during the two studies. The data presented in Table 5 represent the period December to May in 1980/81 and 1985-86. Flow data is presented in Figure 4.

The frequency of detection of heptachlor increased from 1980/81. Heptachlor (containing 40% chlordane) was largely substituted for dieldrin and it was expected to be detected more frequently. Chlordane was not detected in 1980-81 but was in 1985-86. Although the concentration range and mean for heptachlor had decreased, the percentage of recordings above the environmental criteria had increased. This reflects the change in recommended use of heptachlor.

The concentration range for dieldrin increased as a result of a single flyer of 0.062µg/L at Donnybrook Gauging Station. However, other aspects of dieldrin detection (mean, percentage detection and percentage greater than environmental criteria) showed decreases. The decline of dieldrin detection was expected as soil-stored dieldrin decreases with time. The results also indicate that dieldrin concentration in the water environment decreased during the five year period between the two surveys.

During 1980/81 elevated levels of dieldrin and DDT were recorded occasionally at all sites. During 1985/86 criteria were exceeded in the area between Mumballup Road Bridge and Donnybrook Gauging Station only. The use of organophosphorus pesticides downstream of Donnybrook was probably responsible for this trend.

Flow data recorded at Preston Bridge, Boyanup (Station 611004 - Figure 4, WAWA data) show that there was less river flow in 1985-86 than in 1980-81. This, combined with the lower concentrations of organochlorine pesticides recorded in 1985/86 means that less organochlorine pesticide residues are being transported to the Leschenault Estuary. There are potentially many reasons for the decrease in organochlorines. These include: leaching rates, application rates, drawing rate for irrigation, flushing rate, soil concentrations etc. For the purpose of this study it was concluded that further investigation into the recorded decrease in organochlorine concentrations was not warranted.

In general terms, organochlorine pesticide residues in the Preston River system had decreased. Levels of organochlorine pesticides were highest upstream of Donnybrook Gauging Station in 1985-86 where these pesticides were still intensively used. Downstream of Donnybrook horticulturalists had converted to using the less persistent organophosphorus pesticides.

ORGANOCHLORINE	% OF RECORDINGS ABOVE THE DETECTION LIMIT		CONCENTRATION RANGE µg/L		MEAN OF SAMPLES		% OF RECORDINGS EXCEEDING ENVIRONMENTAL CRITERIA		ENVIRONMENTAL CRITERIA
	80/81	85/86	80/81	85/86	80/81	85/86	80/81	85/86	
Aldrin	60	33	<0.001-0.007	<0.001-0.002	0.003	0.002	2	0	0.003
Chlordane	0	100	Not detected	<0.001-0.011	-	0.004	-	12	0.004
DDT and Metabolites	80	83	<0.001-0.015	<0.001-0.006	0.004	0.002	46	8	0.001
Dieldrin	100	100	<0.001-0.019	0.002-0.004*	0.006	0.003	58	13	0.003
Heptachlor	40	83	<0.001-0.071	<0.001-0.014	0.024	0.004	8	13	0.001
Aldrin and Dieldrin	100	100	<0.002-0.026	<0.002-0.062	0.014	0.004	64	59	0.003

TABLE 5: Comparison of 1985/86 Data with 1980/81 for Organochlorine Residues in the Preston River for the Period December to May. The number of samples collected in 1985/86 was six. For comparison the same period and, therefore, the same number of samples were used from the 1980/81 study.

* A flyer of 0.062 µg/L was recorded in December 1985, at Donnybrook Gauging Station. The result is an order of magnitude higher than the other data and is likely to be the results of inappropriate sampling techniques.

6.2 Comparison with Other River Systems

Organochlorine residues in the Preston River have shown a decrease over a five year period and are now generally comparable with other available data for other river systems (Appendix 1). The range of dieldrin residues are similar to levels in the Swan and Serpentine Rivers and tend to be higher than the remaining river systems.

7.0 CONCLUSIONS AND SUMMARY

1. Organochlorine pesticide residues in the Preston River system have decreased. A recent move away from organochlorine to organophosphorus pesticides, increased awareness of working practices and reduced soil storage are likely to have contributed to this decrease.

2. Organophosphorus residues were not detected in any samples collected. Organophosphorus pesticides are less persistent in the environment than organochlorine pesticides and are therefore more difficult to detect.

3. Aldrin was not frequently detected as it is rapidly oxidised to dieldrin.

4. The origin of chlordane levels was likely to be from commercial heptachlor (containing 40% chlordane). Levels were generally below environmental criteria.

5. Levels of DDT and metabolites were generally below the environmental criteria.

6. Levels of dieldrin in the upstream area of intensive horticulture initially exceeded the environmental criteria.

7. Heptachlor levels increased in April/May as a likely result of spraying for African Black Beetle.

8. Levels of organochlorines were highest upstream of Donnybrook Gauging Station where organochlorine pesticides were still intensively used. Downstream of Donnybrook horticulturalists had converted to using less persistent organosphosphorus pesticides.

9. Levels of organochlorine pesticides in the freshwater mussel *Hyridella carteri* were low and did not indicate any bioaccumulation. The mussels were suitable for human consumption based on available health criteria.

10. Dieldrin levels observed were amongst the highest recorded in south-west rivers. All other organochlorine residues were comparable to other systems and generally of low concern.

11. All organochlorine pesticides are now not permitted for agricultural use. Therefore, there should be a reduction in the residue levels of all forms from now on.

8.0 RECOMMENDATION

All organochlorine pesticides were de-registered for agricultural use in July 1987. It is recommended that another survey be conducted during 1992 to assess the success of this de-registration. This survey should also include analysis for some common organophosphorus pesticides.

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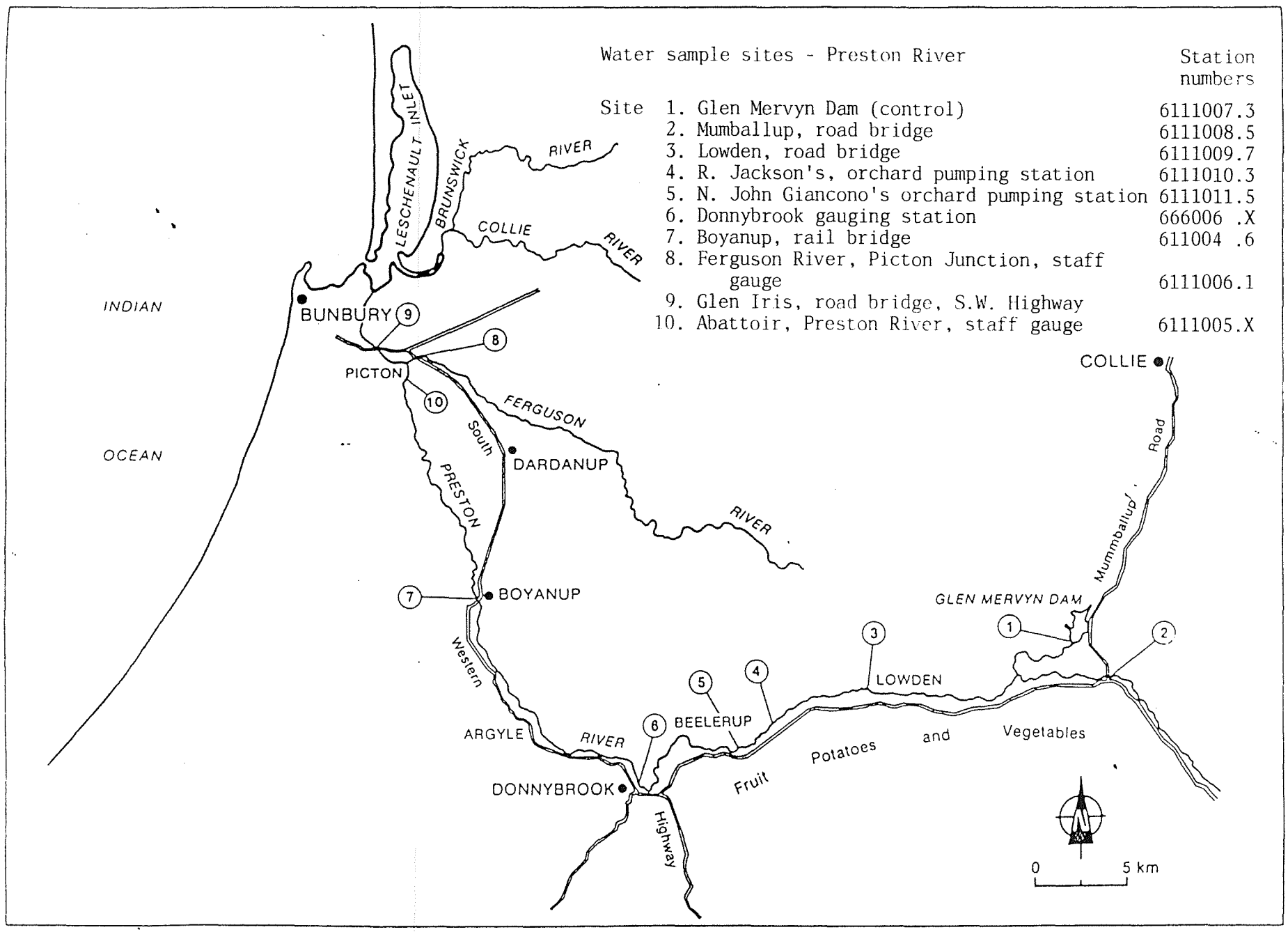


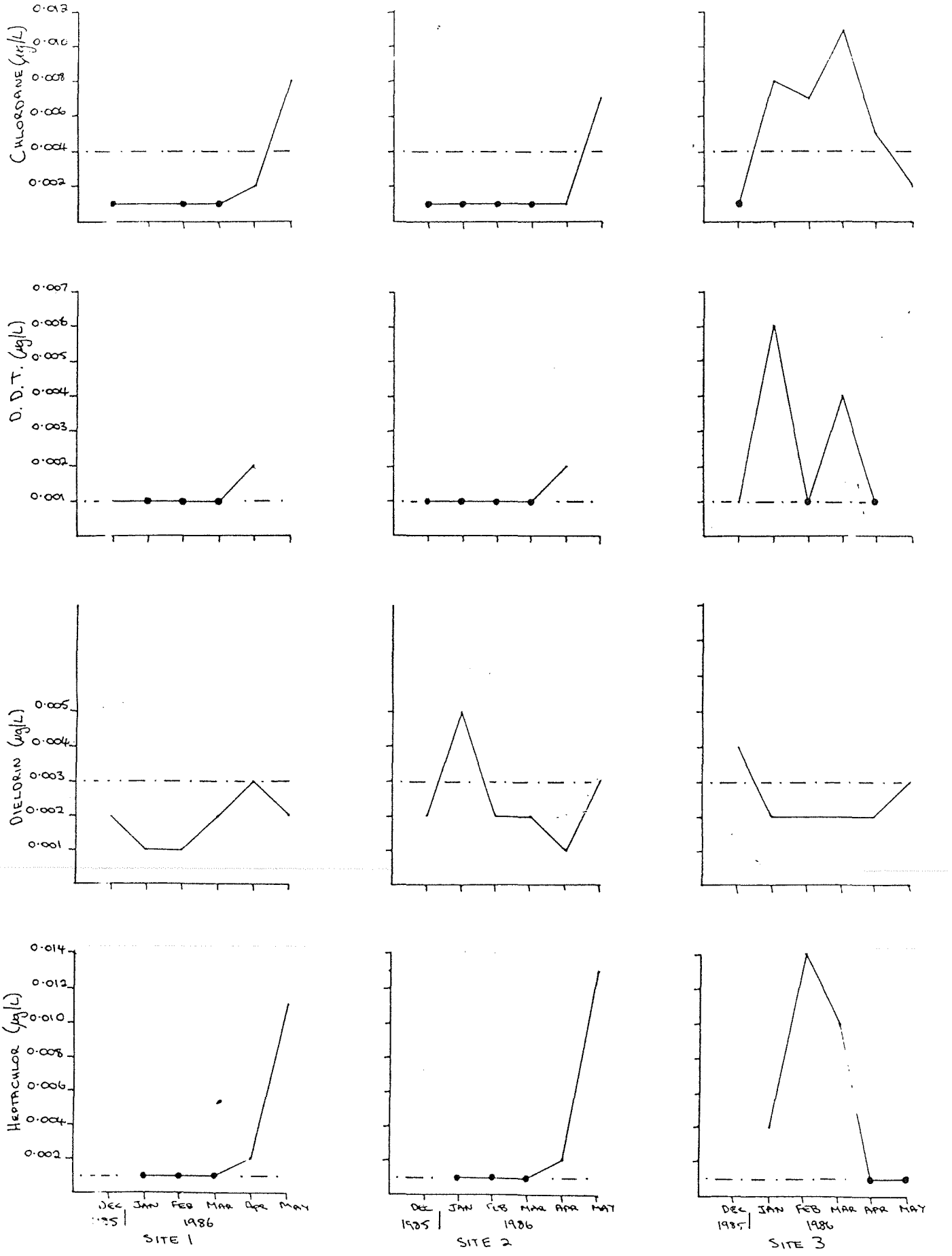
Figure 1 : Sites Sampled for Organochlorine Pesticides

FIGURE 2: Organochlorine Pesticide Results for the Preston River Sites for the Period December 1985 to May 1986.

KEY

● Less than detectable limit

—·— Environmental criteria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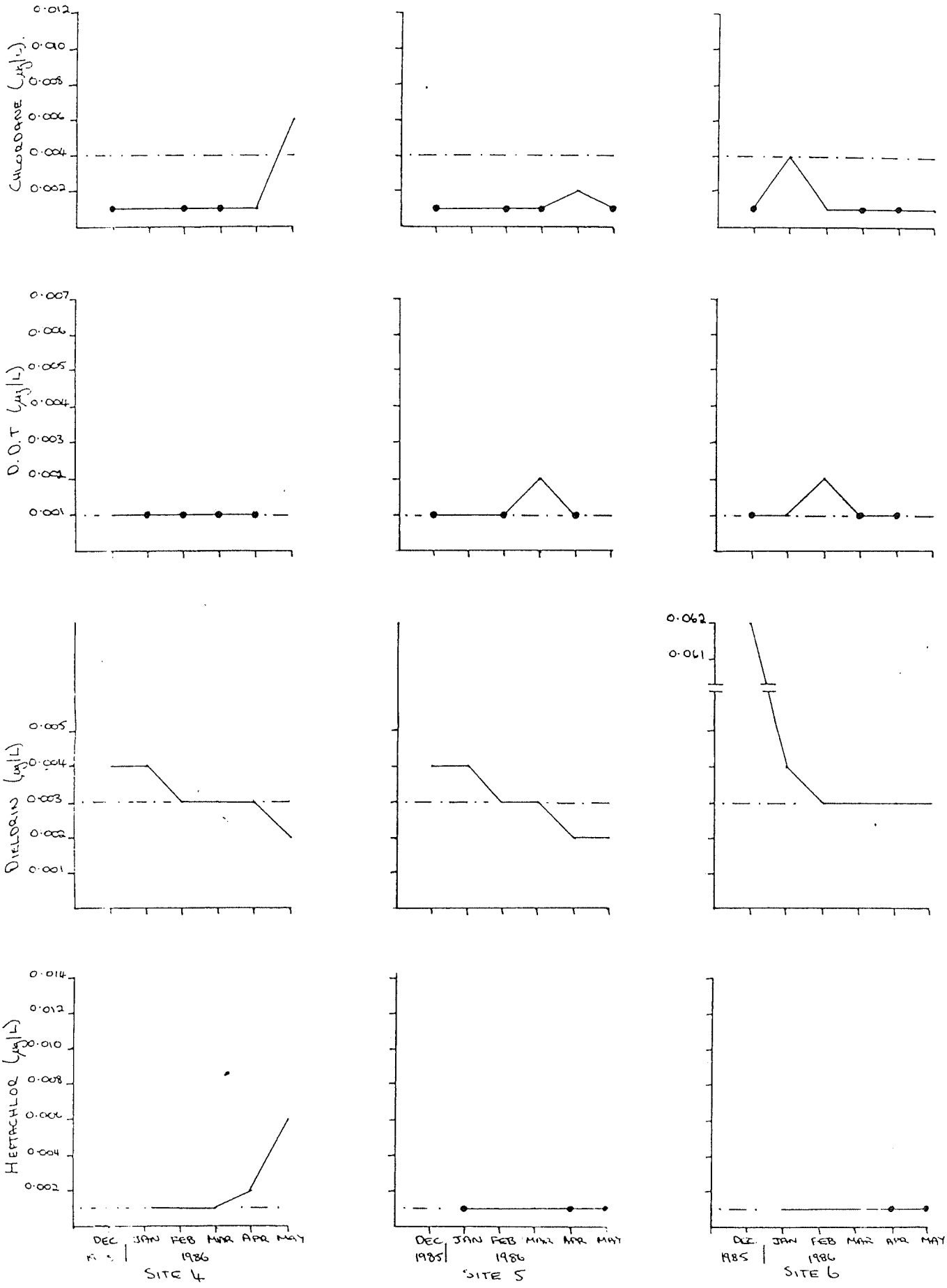
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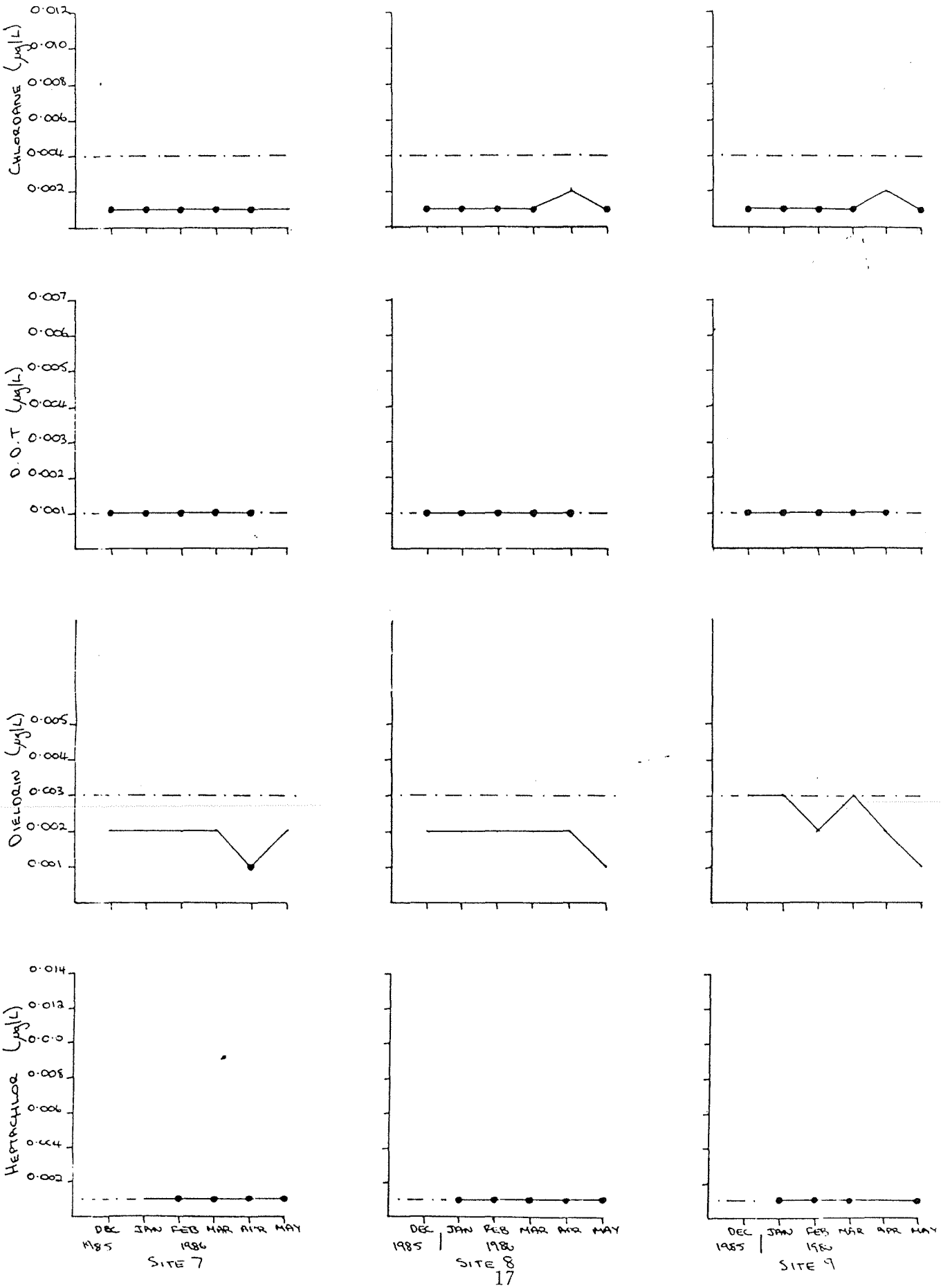
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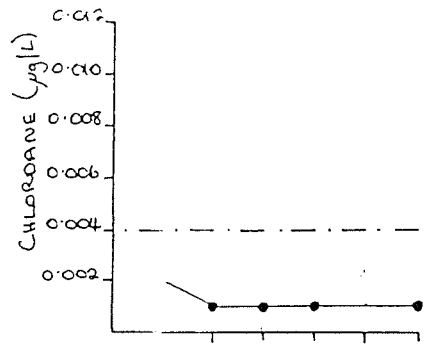
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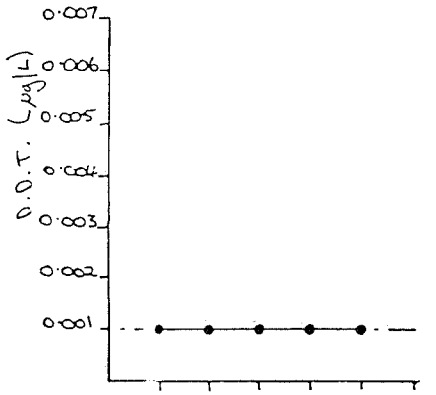
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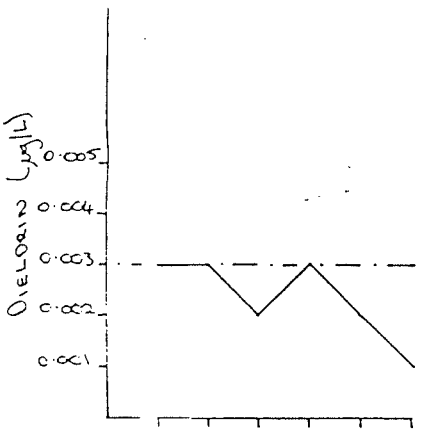
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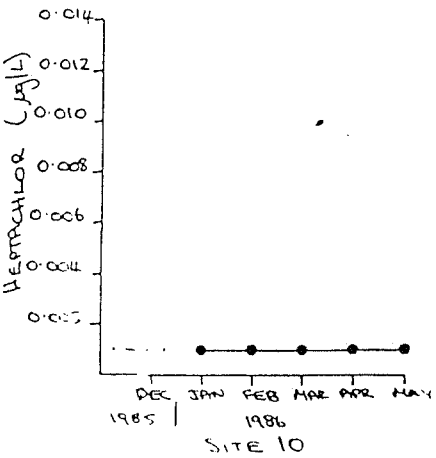
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1986

SITE 10

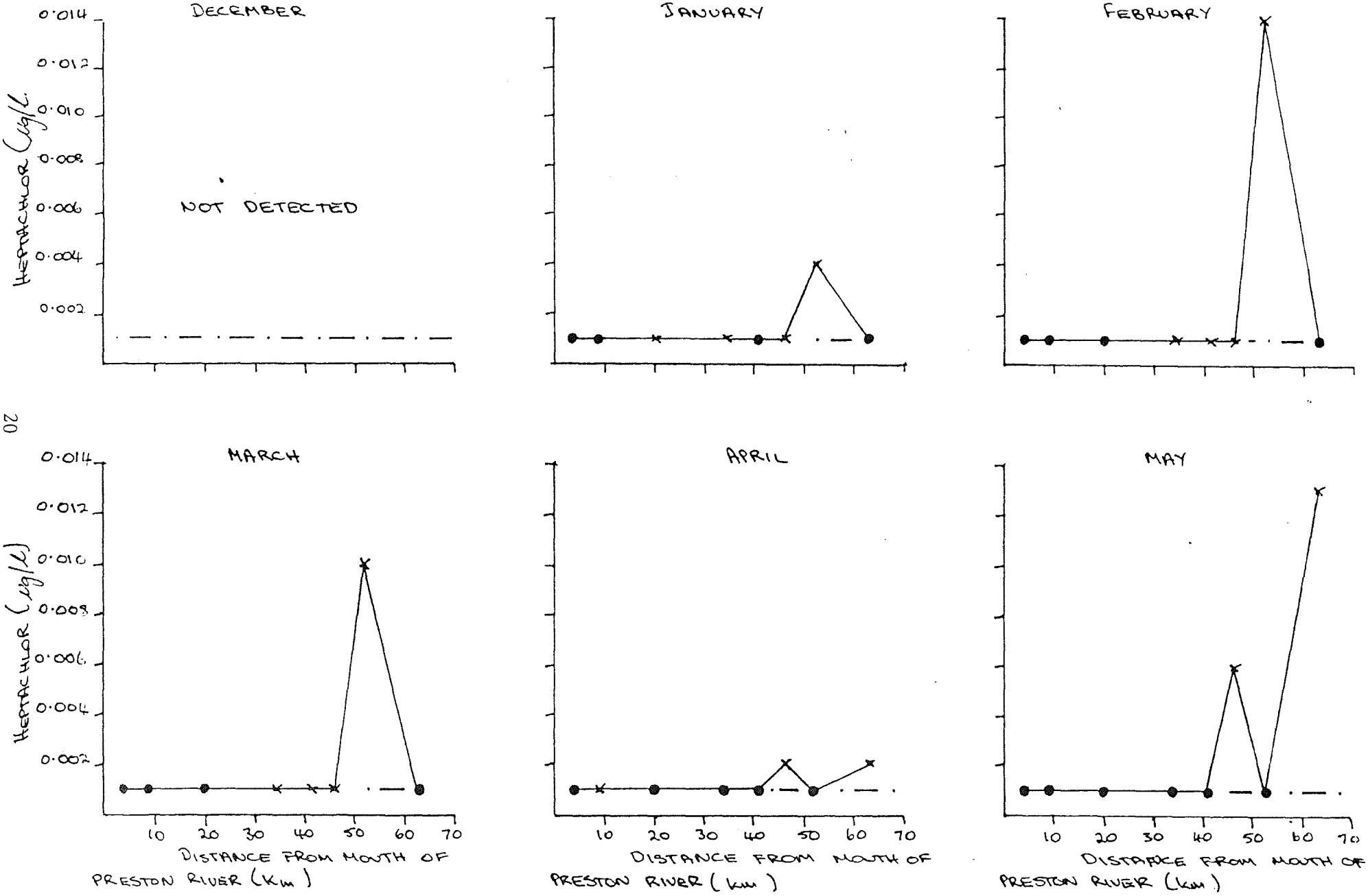
FIGURE 3: Variability of Organochlorine Pesticide Results along the Preston River for the Period December 1985 to May 1986.

KEY

● Less than detection limit

●; X Site location

_._. Environmental criteria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FEBRUARY
MARCH
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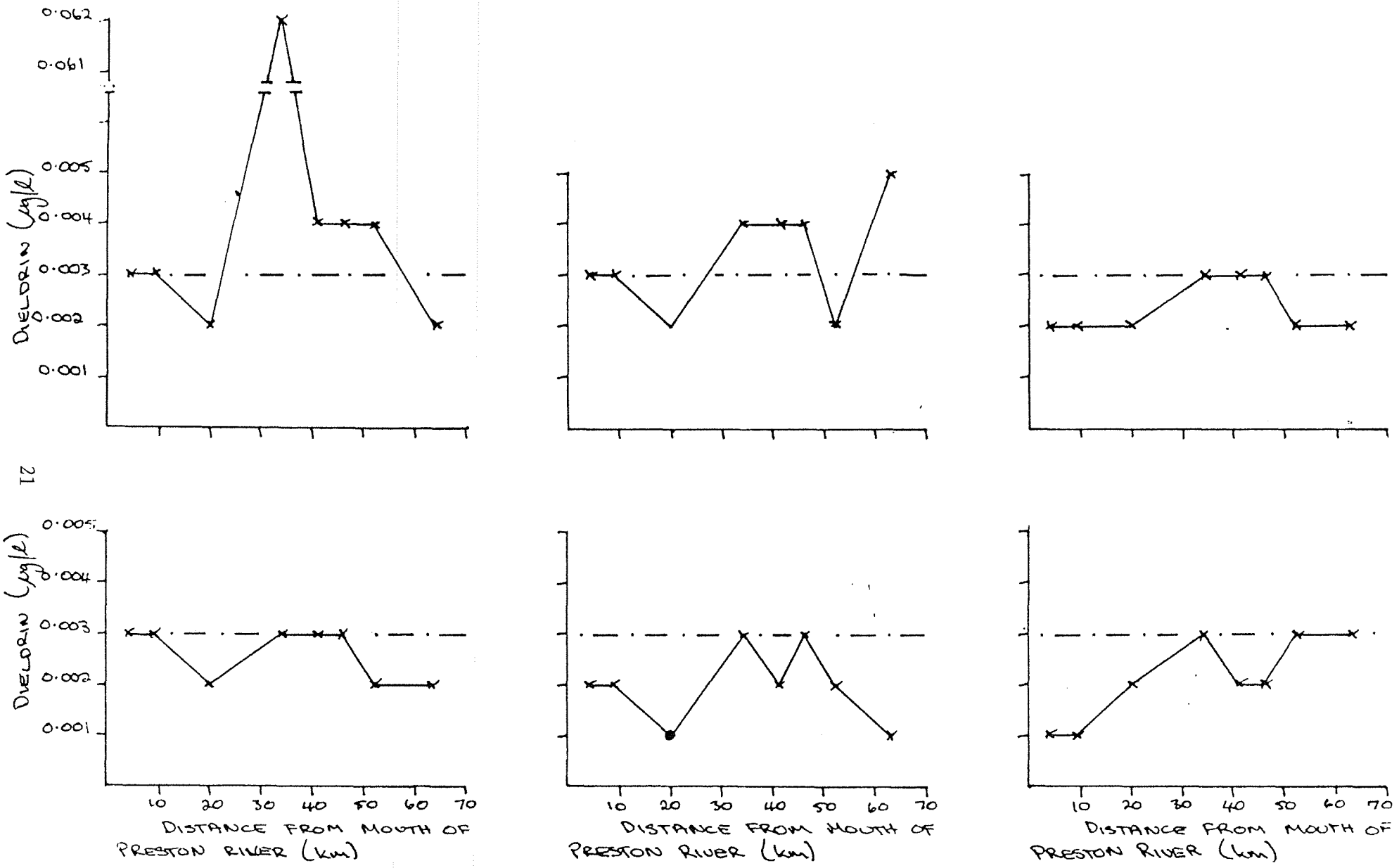
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DIELDRIN (µg/L)
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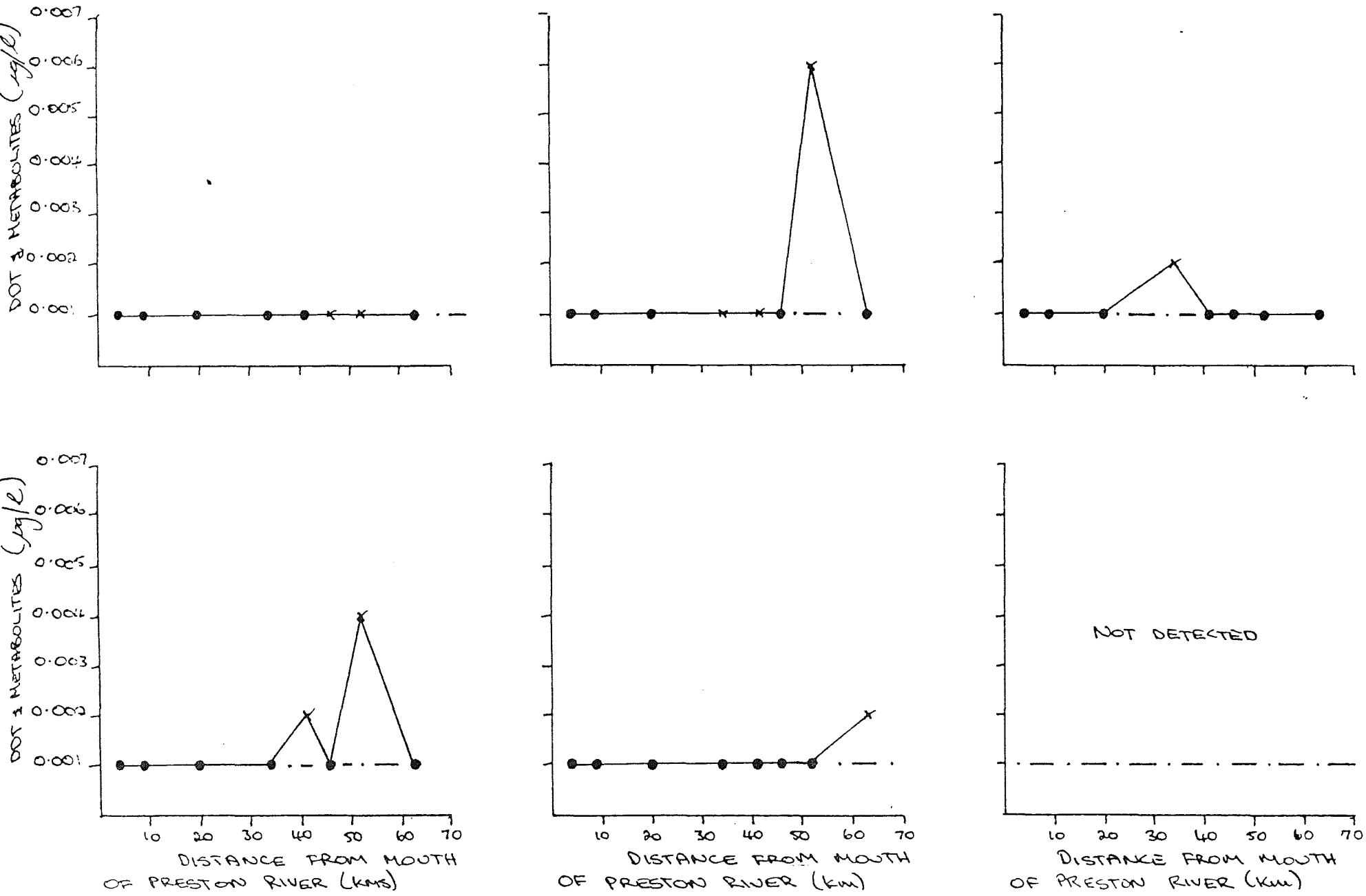
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DISTANCE FROM MOUTH OF PRESTON RIVER (KMS)
DISTANCE FROM MOUTH OF PRESTON RIVER (KM)
NOT DETECTED

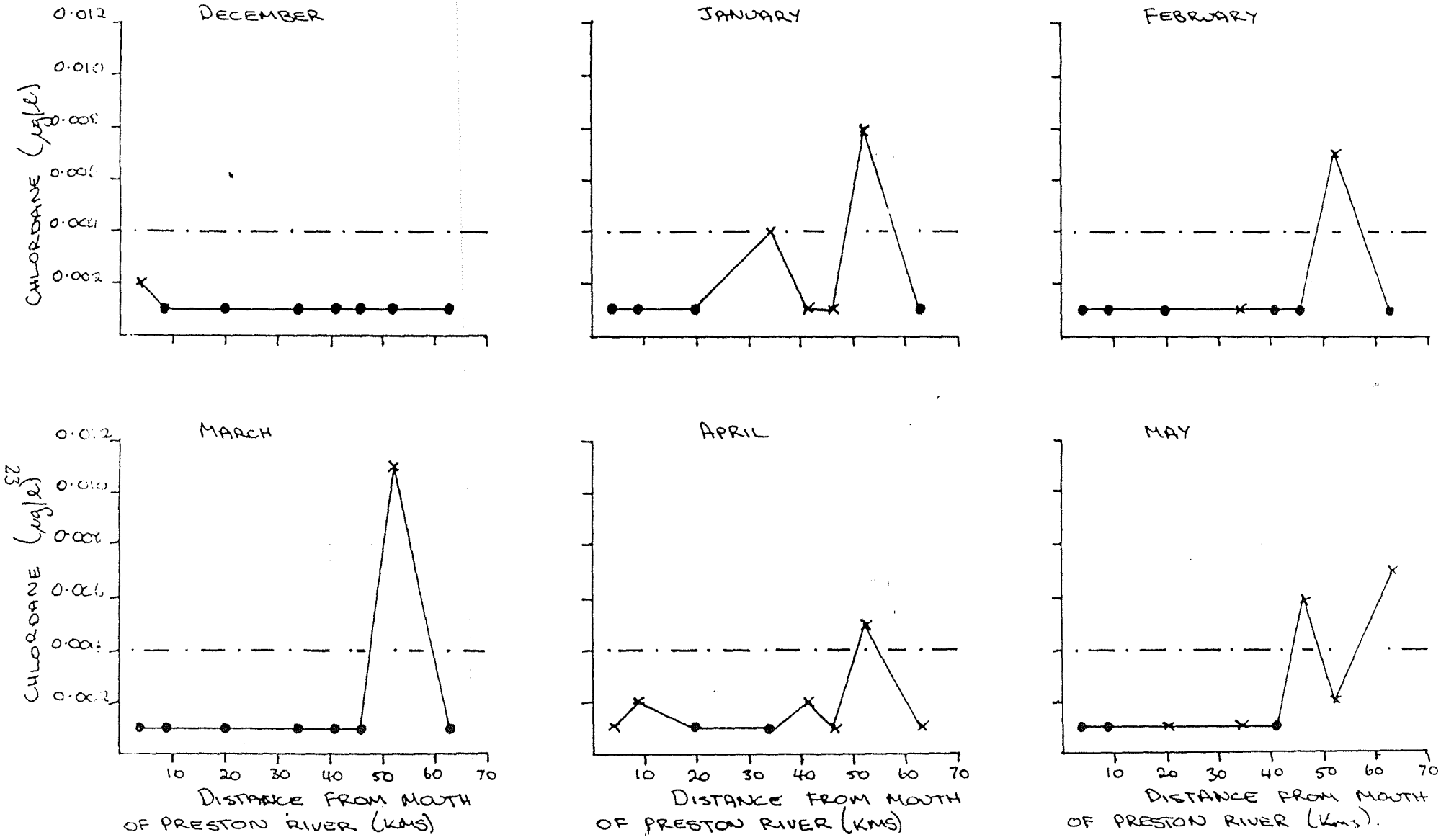
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
CHLORDANE (µg/L)
0·012
0·010
0·008
0·006
0·004
0·002
10
20
30
40
50
60
70
DISTANCE FROM MOUTH OF PRESTON RIVER (KMS)

FIGURE 4: Flow Data for the Preston River at Preston Bridge (611004) for the Periods December 1980 to May 1981 and December 1985 to May 1986 (WAWA).

APPENDIX 1

COMPARISON OF PRESTON RIVER DATA WITH OTHER RIVER SYSTEMS

KEY

* Thurlow et al., 1986

X Shewchuk, 1981

Δ GCL data, after that reported by Shewchuk

Other data, Waterways Commission

ALDRIN

RIVER SYSTEM	YEARS	RANGE µg/L	NUMBER OF OF SAMPLES	PERCENTAGE ABOVE 0.003 µg/L
Swan River*				
Causeway	1974-1985	Summer mean 0.001 Winter mean 0.003	25 24	4 8
Fremantle Traffic Bridge	1974-1985	Summer mean 0.001 Winter mean 0.003	25 24	 4
Collie River[Δ]				
	1977-1985	Three detections Range 0.001-0.20	3	33
Preston River				
	1980-1981	Concentration Range <0.001-0.007 Mean 0.003	120	2
	1985-1986	6 months concentration Range <0.001-0.002 Mean 0.002	60	0

CHLORDANE

RIVER SYSTEM	YEARS	RANGE µg/L	NUMBER OF SAMPLES	PERCENTAGE ABOVE 0.004 µg/L
Swan River*				
Causeway	1974-1985	Summer mean 0.001 Winter mean 0.001	25 24	4 0
Fremantle Traffic Bridge	1974-1985	Summer mean 0.001 Winter mean 0.001	25 24	0 0
Preston River				
	1984-1986	Range 0.001-0.004 Mean 0.001	10	0
	1980-1981	Not detected	120	0
	1985-1986	<0.001-0.011 mean 0.004	60	12

DDT & METABOLITES

RIVER SYSTEM	YEAR	RANGE µg/L	NUMBER OF SAMPLES	PERCENTAGE ABOVE 0.001 µg/L
Swan River*				
Causeway	1974-1985	Summer mean 0.002 Winter mean 0.002	25 24	12 29
Fremantle Traffic Bridge	1974-1985	Summer mean 0.002 Winter mean 0.004	25 24	20 17
Collie River$^{\Delta}$				
	1977-1985	Range <0.001-0.019	28	21
Preston River				
	1984-1986	Range 0.001-0.033	10	80
	1980-1981	Range <0.001-0.015 Mean 0.004	120	46
	1985-1986	Range <0.001-0.006 Mean 0.002	60	8

DIELDRIN

SOURCE		YEAR	RANGE OF MEANS µg/L	NUMBER OF SAMPLES	PERCENTAGE ABOVE 0.003 µg/L
Brunswick	x	1974-79	0.001-0.02	49	5
Collie River (Roelands)	x	1974-80	0.001-0.003	60	20
	Δ	1981-85	0.002-0.003	17	18
Ferguson River	x	1974-79	0.002-0.004	53	35
Harvey River	x	1974-79	0.001-0.003	98	15
Margaret River	x	1986	<0.001	20	10
Serpentine River	x	1975-79	0.001-0.01	40	10
Swan River					
- Causeway	x	1974-80	0.002-0.017	31	75
	Δ	1981-85	0.002-0.007	19	37
- Fremantle Traffic Bridge	x	1974-80	0.001-0.009	29	30
	Δ	1981-85	0.001-0.016	19	6
Preston River	x	1974-80	0.003-0.014	116	60
	Δ	1981-85	0.002-0.003	17	18
		1985-86	0.002-0.013	60	13

(From Shewchuk, 1981)

x Shewchuk 1981
GCL data, after that reported by Shewchuk
o This study

HEPTACHLOR

RIVER SYSTEM	YEAR	RANGE µg/L	NUMBER OF OF SAMPLES	PERCENTAGE ABOVE 0.001 µg/L
Swan River*				
Causeway	1974-1985	Summer mean 0.001 Winter mean 0.003	25 24	4 12.5
Fremantle Traffic Bridge	1974-1985	Summer mean 0.001 Winter mean 0.003	25 24	8 4
Collie River				
	1977-1985	Only detected three times: <0.001-0.005	28	3.6
Preston River				
	1984-1985	Range 0.001-0.007	10	60
	1980-1981	<0.001-0.071 Mean 0.024	120	8
	1985-1986	<0.001-0.014 Mean 0.004	60	13