Development of an Aquatic Pesticide Toxicity Index for Use in Alberta

Alberta Environment

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Alberta Environment
Environmental Assurance

April 2008

W0803

ISBN: 978-0-7785-7362-3 (Printed Edition)
ISBN: 978-0-7785-7363-0 (On-Line Edition)
Web Site: http://environment.gov.ab.ca/info/home.asp

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EXECUTIVE SUMMARY

A pesticide toxicity index for use in Alberta (APTI) is proposed to describe the potential toxicity to aquatic life of pesticide mixtures in Alberta surface waters.

The APTI is derived from the PTI developed by Munn and Gilliom (2001). It relies on the concentration addition model which assumes that the toxicity of multiple compounds is additive; it does not account for possible antagonistic or synergistic interactions. In the United States, the PTI has been used to compare the relative toxicity of pesticide mixtures among sites and over time and to identify pesticides that have the greatest potential toxicity to aquatic life in surface water samples.

The original PTI uses acute toxicity endpoints such as LC_{50} and EC_{50} and is calculated for separate test species or groups of test species. The primary source of pesticide toxicity data is the ECOTOX database, which is maintained by the USEPA.

The main modifications proposed for the Alberta PTI involve:

- The calculation of a general PTI which is based on the lowest EC_{50} reported on ECOTOX for cladoceran and algal test species (APTI EC_{50}), or lowest LC_{50} reported for invertebrate or fish test species (APTI LC_{50}).
- The use of an additional endpoint qualified as an 'approximation' of the no observable effects concentration (NOEC) and defined as 1% of the lowest LC_{50} or EC_{50}.

Recognizing that a PTI value of 1 or greater indicates a toxicity risk equivalent to that of the chosen endpoint, PTI values were assigned to three classes differing in potential risk for toxicity. When PTI values based on EC_{50} or LC_{50} are greater than one, the risk for toxic responses is qualified as '*high*'. The risk is '*low*' for PTI values derived from NOEC that are less than one. Samples with PTI values between the two thresholds present a '*moderate*' risk of being toxic.

The APTI was tested on an extensive pesticide data set for Alberta surface waters, totaling over 3000 samples and including long-term monitoring sites on large rivers, agricultural streams and urban drains. In large rivers, the risk for toxicity was rated '*low'* in 94%, and moderate in 6% of the samples. The rating for agricultural stream samples was similar, although the percentage of samples having a '*moderate*' risk for toxicity was higher (6 to 9%) and some samples (<1% overall) had a '*high*' risk rating. Samples with a 'high' risk rating originated from streams draining land farmed with high intensity, especially irrigated land. Urban streams and drains had a much lower proportion of samples with a '*low*' risk rating (42 and 59% for APTI derived from EC_{50} and LC_{50}, respectively).

As a descriptive tool the APTI provides information on the relative toxicity of pesticide mixtures in surface waters and would be a useful complement to the pesticide sub-index of the Alberta River Water Quality Index (ARWQI), which only reports on occurrence and concentrations.

The APTI has potential applications as a risk screening tool which could influence the management of pesticides on the land.

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ACKNOWLEDGEMENTS

Mary Raven, Leah Girhiny and Raina Namsechi downloaded and organized toxicity data from the ECOTOX Database. Mary Raven formatted the report and figures.

Discussions and exchanges of information with Michelle Williamson (Environment Canada) have helped in the development of the proposed pesticide toxicity index for Alberta.

This report has benefited from the input and review comments from several limnologists within Alberta Environment (Leigh Noton, Richard Casey, Wendell Koning, Chris Teichreb, Al Sosiak, Kim Westcott, Thorsten Hebben, Darcy McDonald and Craig Emmerton) and Agriculture and Rural Development (Sarah Depoe). Their input is greatly appreciated.

ABBREVIATIONS AND ACRONYMS

AESA	Alberta Environmentally Sustainable Agriculture
APTI	Alberta Pesticide Toxicity Index
ARWQI	Alberta River Water Quality Index
CAESA	Canadian Alberta Environmentally Sustainable Agriculture Agreement
EC50	concentration of a substance that is lethal to 50% of the test organisms
LC50	concentration of a substance expected to produce a certain effect in 50% of the test organisms
LTRN	Long-term River Network
NOEC	highest concentration of a substance that is expected to result in No Observable Effects in test organisms
PTI	Pesticide Toxicity Index

1.0 INTRODUCTION

1.1 Background

Pesticides are common contaminants of surface waters in Alberta (Anderson 2005). Concentrations are generally well below available guidelines for the protection of aquatic life, but co-occurrence of several pesticides is common. Toxicity to aquatic life of low level pesticide mixtures and other contaminants is a subject of worldwide research (*e.g.,* Chevre *et al*. 2006, Altenburger *et al.* 2004, Levitan *et al*. 1995, Larsen *et al.* 1999).

Indices are popular communication tools used to summarize complex information into simple numerical or verbal ratings for the public and resource managers. Alberta Environment has developed and applied a River Water Quality Index (ARWQI) to report on water quality at long-term river monitoring sites since 1995. The index is based on the average of four sub-indices (*i.e.,* nutrients, bacteria, metals and pesticides). The sub-indices compare ambient concentrations with objectives and incorporate the number, magnitude and frequency of objectives exceedences (see: http://www.environment.alberta.ca/1777.html). Alberta surface water quality guidelines (Alberta Environmental Protection 1999) are used as objectives in the calculation of three of the four sub-indices, while analytical detection limits are used as objectives in the pesticide sub-index. This difference in objectives stems from the fact that several pesticides detected in Alberta surface waters do not have guidelines for the protection of aquatic life. The pesticide sub-index is an indicator of pesticide occurrence and concentrations, but it does not give a measure of potential toxicity. This is where an index of pesticide toxicity would prove most valuable.

Munn and Gilliom (2001), later updated in Munn *et al.* (2006), describe the development and potential application of a pesticide toxicity index (PTI), which is based on the Concentration Addition (CA) model, to evaluate the potential toxicity to aquatic organisms of pesticides that co-occur in water.

The index uses LC_{50} (concentrations at which 50% mortality occurred in test organisms) or EC_{50} (concentrations at which 50% of test organisms exhibited a response; typically this involves an effect on behaviour, such as immobilization in cladocerans). The LC_{50} and EC_{50} are referred to as toxicity concentrations, or endpoints. The PTI is the sum of toxicity quotients for each pesticide measured in a water sample.

$$PTI = \sum_{i=1}^{n} \frac{c_i}{EC_{xi}}$$

where c_i is the concentration of compound 'i'
n is the number of compounds detected
EC_{xi} is the effect endpoint associated with compound 'i' (*e.g.,* LC_{50} or EC_{50})

Typically the index is calculated for individual samples.

Munn *et al.* (2006) present the PTI as a descriptive tool that can be used to rank and compare the toxicity of samples among different sites and over time. The relative contribution of each pesticide to the PTI can be used to determine which pesticides are of greatest potential concern. Munn *et al.* (2006) list some limitations of the PTI:

- The PTI is a relative ranking system which indicates that one sample is '*likely*' to be more or less toxic than another sample but does not necessarily indicate '*actual*' toxicity.
- Toxicity values used in the PTI are based on short-term (acute) toxicity endpoints from laboratory experiments such as EC_{50} (sublethal response) or LC_{50} (mortality). The PTI does not incorporate longer-term (chronic) endpoints.
- Environmental factors, including dissolved organic carbon, suspended sediments and temperature which are not accounted for by the PTI can modify the toxicity and availability of pesticides.
- The PTI is based on the assumption that pesticide toxicity is additive among pesticides (CA model) and there are no chemical interactions (synergism and antagonism). This may not be the case in the aquatic environment – especially for complex mixtures of pesticides from different chemical classes, which often have different modes of action. However, there is limited understanding of the interactions and toxicity of pesticide mixtures. The concentration addition model appears to be valid for more than 90% of 202 mixtures in 26 studies (Deneer 2000). According to Warne (2003), the CA model may underestimate (synergistic), or overestimate (antagonistic) the toxic effect in 10 to 15% of mixtures of compounds with different modes of action. However, according to Cedergreen (2008), both the CA and the 'independent action' model (a more complex model thought to be the most correct reference model for predicting the joint effect of mixtures of chemicals) have similar performance and could not correctly describe half of the experiments on 98 different mixtures.
- The PTI is limited to pesticides measured in the water column. Therefore, the potential toxicity of hydrophobic pesticides, including ones which bioaccumulate, is not accounted for using the PTI. This applies mostly to organochlorine pesticides.
- One of the primary limitations of the PTI is the sparseness, or lack, of available aquatic toxicity data for many pesticides currently in use. As a result, there is greater uncertainty regarding the relative toxicity of compounds that have a low number of comparable toxicity studies. Furthermore, variability in toxicity data from multiple sources is due to many factors associated with test conditions (*e.g.,* pesticide formulation tested, species tested, water quality, testing environment such as flow through or static).

In addition, it should be noted that most toxicity information for pesticides applies to the active ingredients and not to the commercial formulations, which may contain constituents that are more toxic than the active ingredient.

Despite these limitations, the PTI has proven useful as a screening and reporting tool in research projects and national monitoring programs in the US (*e.g.,* Battaglin and Fairchild 2002, Gilliom *et al*. 2006).

1.2 Report Objectives

The main objective of this report is to apply the PTI formulation proposed by Munn and Gilliom (2001) and Munn *et al.* (2006) to Alberta pesticide data and to explore the value of this index as a relative measure of potential toxicity for Alberta surface waters. Some modifications to data handling and presentation of the original PTI are proposed.

2.0 METHODS

Climate-induced differences in crops and pests between Canada and the USA result in differences in pesticide use and surface water contamination patterns. Alberta Environment monitors 69 pesticides routinely, while others, such as glyphosate, its primary degradation product aminomethylphosphonic acid (AMPA), and gluphosinate, are part of more specialized monitoring. Over two thirds of these pesticides have been detected at least once in Alberta surface waters. Many of these pesticides are not listed in Munn and Gilliom (2001), or Munn *et al.* (2006). Our work on the APTI began in spring 2006, before the publication of Munn *et al*. (2006), and there was a need to update the pesticide toxicity information provided in the original PTI description.

As in Munn and Gilliom (2001) and Munn *et al.* (2006), the ecotoxicology database (ECOTOX), created and maintained by the USEPA was the main source of single pesticide toxicity endpoints for aquatic life. In a few instances, the Pesticide Action Network (PAN) pesticide database was used (Appendix 1). Table 1 lists pesticides of relevance in Alberta (*i.e.,* which are monitored and detected, Anderson 2005) and toxicity endpoints. Marine and exotic species were eliminated from ECOTOX data downloads in an attempt to retain species relevant to Alberta. Some exceptions involved fishes which were common test species. Units for toxicity endpoints were checked and, where necessary, converted to µg/L (ppb). Data were grouped according to test species and broad taxonomic groups (*i.e.,* cladocerans, algae, macrophytes, invertebrates, and fishes, Table2).

Initially EC_{50}, LC_{50} and no observable effects concentration (NOEC) were retained for all species within these groups, but it was apparent that there was insufficient information on NOEC to attempt to use this endpoint in a PTI. Similarly, toxicity data for macrophytes were insufficient to derive a meaningful index. Finally, LC_{50} for cladocerans and algae, and EC_{50} for invertebrates and fishes were available too inconsistently to derive an index. Hence, APTI development incorporated only EC_{50} for cladocerans and algae and LC_{50} for invertebrates and fishes (Table 1). Note that endpoints were not available for each pesticide and each taxonomic group. Pesticides with missing endpoints are not included in the PTI calculation, even if they are detected in a sample.

For cladocerans, the EC_{50} endpoint is immobilization. EC_{50} data for algae are, for the most part, population effects measured as changes in growth or biomass; some tests involved measurement of photosynthesis (Appendix 1). For invertebrates and fishes LC_{50} were, by definition, the measurement of mortality.

EC_{50} data for cladocerans and algae, and LC_{50} data for invertebrates and fishes were screened and the lowest reported value for each group was used in the APTI. These values, listed in Table 1, were compared to the minima listed in Munn *et al.* (2006) and the lowest value was retained for each pesticide as the endpoint in the APTI (Table 1). Table 2 summarizes the species from which the endpoints in Table 1 were derived; further details are provided in Appendix 1.

The approach that was taken here is, in some cases, slightly different from that described in Munn and Gilliom (2001) and Munn *et al.* (2006). To avoid confusion, reference will be made to the Alberta PTI (APTI) when these differences are incorporated.

- The use of the lowest recorded value departs from Munn and Gilliom (2001) who used a median value. The lowest reported value was used to ensure that the resulting index would be of relevance to sensitive species (*i.e.,* more conservative).
- Toxicity data for algae are used here to generate a PTI but were not included in Munn and Gilliom (2001) or Munn *et al.* (2006).
- The concept of a 'general index' based on the lowest overall EC_{50} and the lowest overall LC_{50} is another proposed modification to the original paper. As mentioned earlier, pesticides for which endpoints are not available are not incorporated in the calculation of the index. A benefit to using a general index is that more pesticides are assigned an endpoint value (because species groups are combined, thereby increasing the chance of having an endpoint) and, hence, included in the calculations, than by working with individual species or species groups.
- An approach to rate the potential risk for toxicity is proposed here. While Munn *et al.* (2002) cautiously emphasize the fact that the PTI is only a relative measure of potential toxicity, several attempts have been made at setting thresholds related to the likelihood of effects (*e.g.*, Battaglin and Fairchild 2002, Williamson and Nadec-Experts Conseils Inc. 2007). Implied in the concept of the CA model is that a cumulative ratio >1 is indicative of a probable effect corresponding to the chosen endpoint. Hence, a PTI that equals or exceeds one can justifiably be viewed as a threshold above which effects become increasingly probable. It is more difficult to agree on meaningful thresholds *below which* effects are unlikely. Battaglin and Fairchild (2002) regard PTI values >1, >0.5 and >0.1 as indicating 'probable', 'potential' and 'limited' toxicity, respectively, but do not document the justification for these thresholds.

  The option proposed here is to rely on the thresholds defined by the value of '1' for a PTI derived from LC_{50} or EC_{50}, and for a PTI derived from an approximation of NOEC, defined as 1% of the LC_{50} or EC_{50} . This approach would allow the ranking of samples according to their risk for causing toxic responses. Proposed risk classes are: 'High' (PTI $LC_{50\text{ or }}EC_{50}$>1), 'Low' ($PTI_{NOEC}$<1); and 'Moderate' for samples ranking in between. The choice of 1% of the LC_{50} or EC_{50} is based on Kenega (1982) who proposed that chronic NOEC can be approximated from acute effects levels by dividing EC_{50} or LC_{50} by 100. It is recognized that this approximation may over-, or under-estimate the NOEC and that scientifically based approximations such as CCME guidelines would be more appropriate if they were available for all pesticides involved. NADEC-Experts Conseils Inc. (2007b) used this approach in the testing of an Ideal Performance Measure (IPS) for pesticide mixtures on Prairie wetland data.

Table 1 Endpoint selection for the calculations of APTI for various taxonomic groups of test organisms

All endpoint values are in ug/L

List of pesticides	Cladocera			Algae		Benthic Invertebrates			Fish			Lowest Overall	
	EC_{50} (1)	EC_{50} (2)	EC_{50} (3)	EC_{50} (1)	EC_{50} (3)	LC_{50} (1)	LC_{50} (2)	LC_{50} (3)	LC_{50} (1)	LC_{50} (2)	LC_{50} (3)	EC_{50} Cladocera and Algae (3)	LC_{50} Invertebrates and fish (3)
FUNGICIDES													
CARBATHIIN	73000	-	73000	330	330	-	-	-	1000	-	1000	330	-
IPRODIONE	310	-	310	130	130	-	-	-	2100	3060	2100	130	2100
METALAXYL-M	113000	-	113000	-	-	-	-	-	210	18400	210	113000	210
VINCLOZOLIN	3650	-	3650	870	870	-	-	-	3400	-	3400	870	3400
HERBICIDES													
2,4-D	2400	3200	2400	2020	2020	1600	1600	1600	2800	1400	1400	2020	1400
2,4-DB	21000	25000	21000	60000	60000	10000	15000	10000	1200	2000	1200	21000	1200
2,4-DP = dichlorprop	-	5400	5400	65	65	-	320	320	600	66	66	65	66
AMPA	-	-	-	-	-	-	-	-	-	-		-	-
ATRAZINE	3000	6900	3000	0.82	0.82	1	94	1	27	2000	27	0.82	1
BENTAZON	4600	-	4600	4100	4100	132500	-	132500	99000	978000	99000	4100	99000
BROMACIL	13000	121000	13000	5.9	5.9	40000	-	40000	-	36000	36000	5.9	36000
BROMOXYNIL	34	41	34	1400	1400	1580	-	1580	1670	2090	1670	34	1580
CLOPYRALID	225000	-	225000	-	-	750200	-	750200		-	-	225000	750200
CYANAZINE	36000	35500	35500	2.8	2.8	3800	2000	2000	3.1	9000	3.1	2.8	3.1
DEISOPROPYL ATRAZINE	-	-	-	10000	10000	-	-	-	-	-	-	10000	-
DESETHYL ATRAZINE	-	-	-	720	720	-	-	-	-	-	-	720	-
DICAMBA	96800	110700	96800	10	10	3100	3900	3100	40000	28000	28000	10	3100
DICLOFOP-METHYL	190	-	190	-	-	-	-	-	130	-	130	190	130
DIURON	900	1400	900	1.3	1.3	130	160	130	530	500	500	1.3	130
ETHALFLURALIN	16.6	60	16.6	25.3	25.3	-	-	-	22	32	22	16.6	22
ETHOFUMESATE	49000	-	49000	2760	2760	-	-	-	100	-	100	2760	100
FLUROXYPYR	100000	-	100000	1800	1800	-	-	-	11900	-	11900	1800	11900
GLYPHOSATE	2600	-	2600	3000	3000	28000	-	28000	1300	-	1300	2600	1300
IMAZAMETHABENZ	110000	-	110000	78100	78100	-	-	-	100000	-	100000	78100	100000
IMAZAMOX	122000	-	122000	-	-	-	-	-	119000	-	119000	122000	119000
IMAZETHAPYR	1000000	-	1000000	54500	54500	-	-	-	180000	240000	180000	54500	180000
MCPA	100000	-	100000	17800	17800	11000	-	11000	1510	25000	1510	17800	1510
MCPP	100000	-	100000	115000	115000	-	-	-	92000	-	92000	100000	92000
METRIBUZIN	2950	-	2950	6.3	6.3	25000	-	25000	17650	3400	3400	6.3	3400
PICLORAM	59000	-	59000	18400	18400	10800	27	10800	700	1400	700	18400	700
QUINCLORAC	23800	-	23800	500	500	50400	-	50400	26700	-	26700	500	26700
QUIZALOFOP	2120	-	2120	98	98	-	-	-	390	-	390	98	390
SIMAZINE	560	-	560	0.512	0.512	900	1900	900	3500	90	90	0.512	90
TRIALLATE	60	91	60	3.6	3.6	360	-	360	440	1200	440	3.6	360
TRICLOPYR	1200	-	1200	2560	2560	4000	-	4000	760	260	260	1200	260
TRIFLURALIN	320	240	240	6.7	6.7	50	37	37	36	8.4	8.4	6.7	8.4
INSECTICIDES													
ALDICARB	45	51	45	50000	50000	4	420	4	34	41	34	45	4
ALPHA-BHC	50	800	50	10000	10000	150	-	150	120	-	120	50	120
AZINOPHOS-METHYL	0.22	1.1	0.22	-	-	0.07	?	0.07	0.27	-	0.27	0.22	0.07
CHLORPYRIFOS	0.02	0.1	0.02	65000	65000	0.024	0.04	0.024	0.17	0.58	0.17	0.02	0.024
DIAZINON	0.2	0.5	0.2	10000	10000	0.01	0.03	0.01	80	22	22	0.2	0.01
DIMETHOATE	80		80	5500	5500	2	-	2	130	-	130	80	2
LINDANE	39	100	39	1280	1280	0.4	1	0.4	1	1.1	1	39	0.4
MALATHION	0.074	0.59	0.074	17880	17880	0.2	0.5	0.2	2.2	1.9	1.9	0.074	0.2
METHOMYL	4.1	7.6	7.3	210000	210000	43	29	29	100	300	100	7.3	29
METHOXYCHLOR	0.57	-	0.57	-	-	0.085	-	0.085	1.23	-	1.23	0.57	0.085
TERBUFOS	0.27	0.31	0.27	-	-	0.08	0.17	0.08	0.71	0.77	0.71	0.27	0.08

1. Endpoints downloaded from ECOTOX and other sources between June 2006 and May 2007
2. Endpoints provided in Munn et al. 2006
3. Endpoints used in the calculation of PTI for Alberta data

" - " indicates no available endpoint value

Table 2 List of species with EC_{50} or LC_{50} data downloaded from the ECOTOX database and incorporated in APTI calculations

PTI group	Taxonomic Group	Species
Algae (EC_{50})		
	Cyanobacteria	*Anabaena flosaquae*
		Anabaena variabilis
		Microcystis aeruginosa
	Green algae	*Ankistrodesmus falcatus*
		Ankistrodesmus falcatus
		Chlamydomonas noctigama
		Chlamydomonas reinhardtii
		Chlorella fusca
		Chlorella pyrenoidosa
		Dunaliella tertiolecta
		Pseudokirchneriella subcapitata
		Selenastrum capricornutum
	Diatom	*Navicula pelliculosa*
		Skeletonema costatum
Cladocerans (EC_{50})		
	Cladocerans	*Ceriodaphnia dubia*
		Daphnia magna
		Daphnia pulex
		Daphnia sp.
		Moina macrocopa
		Simocephalus vetulus
Invertebrates (LC_{50})		
	Oposum shrimp	*Americamysis bahia*
	Midge	*Chironomus plumosus*
		Chironomus sp.
		Chironomus tentans
		Chironomus thummi
	Cyclopoid copepod	*Cyclops strenuus*
	Scud	*Gammarus fasciatus*
		Gammarus lacustris
		Gammarus pseudolimnaeus
		Gammarus pseudolimnaeus
		Hyalella azteca
	Mayfly	*Isonychia sp.*
	Mayfly	*Cloeon dipterum*
	Caddisfly	*Limnephilus lunatus*
	Stonefly	*Isoperla sp.*
	Stonefly	*Pteronarcys californicus*
		Taeniopteryx nivalis
	Crayfish	*Procambarus simulans*
Fish (LC_{50})		
	Goldfish	*Carassius auratus*
	Sheepshead minnow	*Cyprinodon variegatus*
	Common carp	*Cyprinus carpio*
	Northern pike	*Esox lucius*
	Western mosquitofish	*Gambusia affinis*
	Channel catfish	*Ictalurus punctatus*
	Pumpkinseed	*Lepomis gibbosus*
	Bluegill	*Lepomis macrochirus*
	Rainbow trout,donaldson trout	*Oncorhynchus mykiss*
	Chinook salmon	*Oncorhynchus tshawytscha*
	Brown trout	*Salmo trutta*

3.0 RESULTS AND DISCUSSION

Pesticide data used to test and calculate the APTI were obtained from Alberta surface waters from 1995 to 2005, inclusive. Data are stored in the Alberta Environment Water Data System (WDS). Data collected in the period 1995- 2002, as well as details of the quality assurance program have been summarized and evaluated by Anderson (2005).

The following steps describe the development and application of the APTI:

- Graphical presentation of the index for surface waters in Alberta;
- Incorporation of the concept of toxicity risk classes;
- Illustration of the information contributed by the APTI as compared to occurrence and concentration data, including a proposal to use the APTI as a complement to the pesticide sub-index of the Alberta River Water Quality Index (ARWQI)

3.1 General Patterns in APTI Applied to Alberta Surface Waters

Results of APTI calculation are illustrated for pesticide samples collected from the long-term river network (LTRN) sites, a selection of agricultural streams, and a selection of urban streams and drains to depict spatial patterns.

APTI at LTRN sites

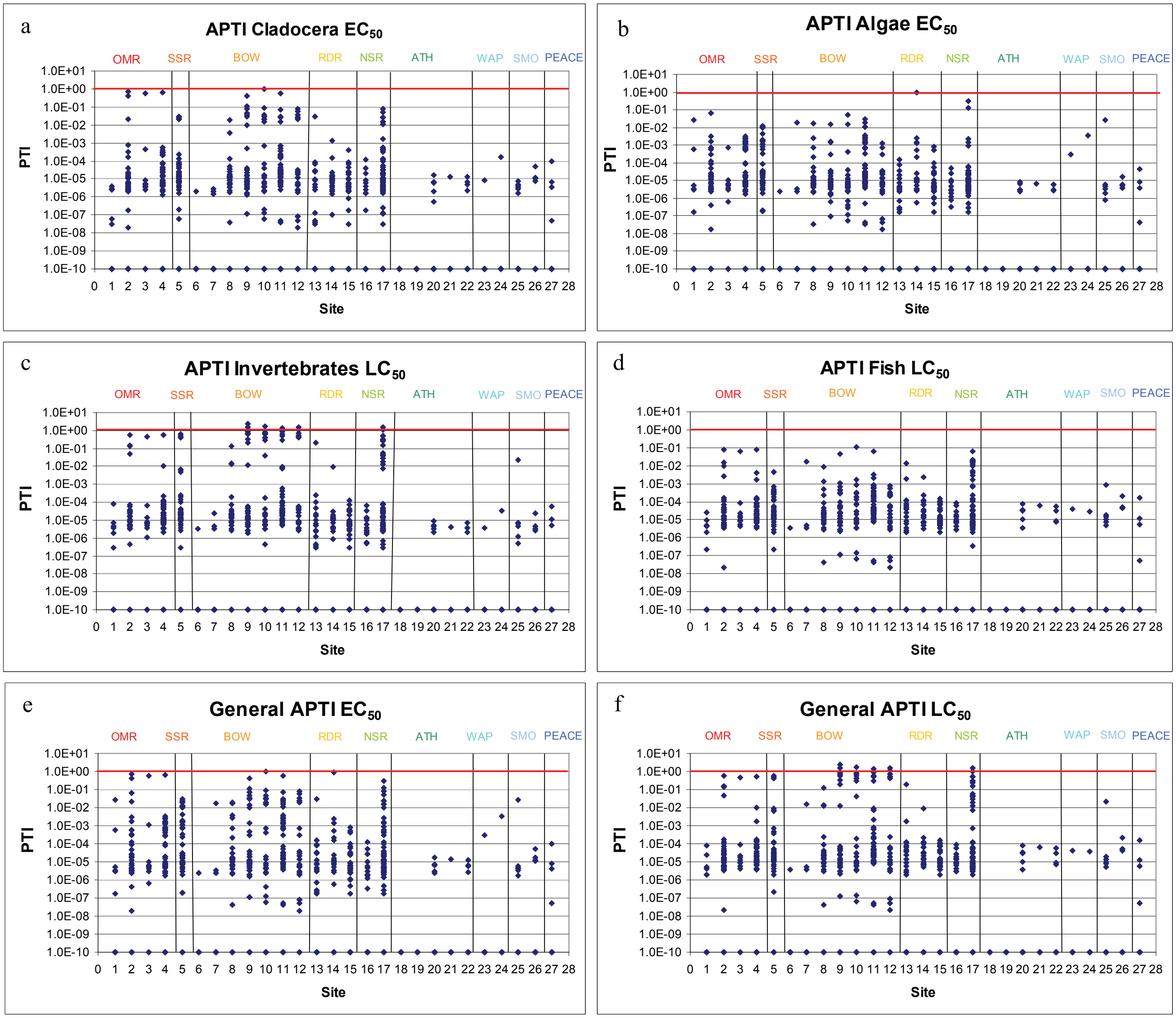
The results of APTI calculations at LTRN sites are shown in Figure 1.
Each point on a graph represents the APTI value for one sample. Samples over a 10-year period are grouped by site. All of the APTI plots (Figures *a* to *f*) exhibit a similar pattern, with southern rivers (Oldman, South Saskatchewan, Bow, Red Deer and North Saskatchewan) having a wider range of APTI values than northern rivers (Athabasca, Wapiti, Smoky, and Peace); APTI values in the northern rivers are generally much lower.

For all taxonomic groups, except fishes, at least some APTI values in southern rivers approach or exceed 1. In essence, this means that potential cumulative pesticide toxicity in these samples approached or exceeded an effects level equivalent to the assigned endpoint (*i.e.,* EC_{50} or LC_{50}). In the Bow and North Saskatchewan rivers APTI values greater than 1 were due to diazinon and lindane detections, respectively.

Overall, APTI patterns exhibited at provincial LTRN sites correspond well with our knowledge of pesticide occurrence across Alberta.

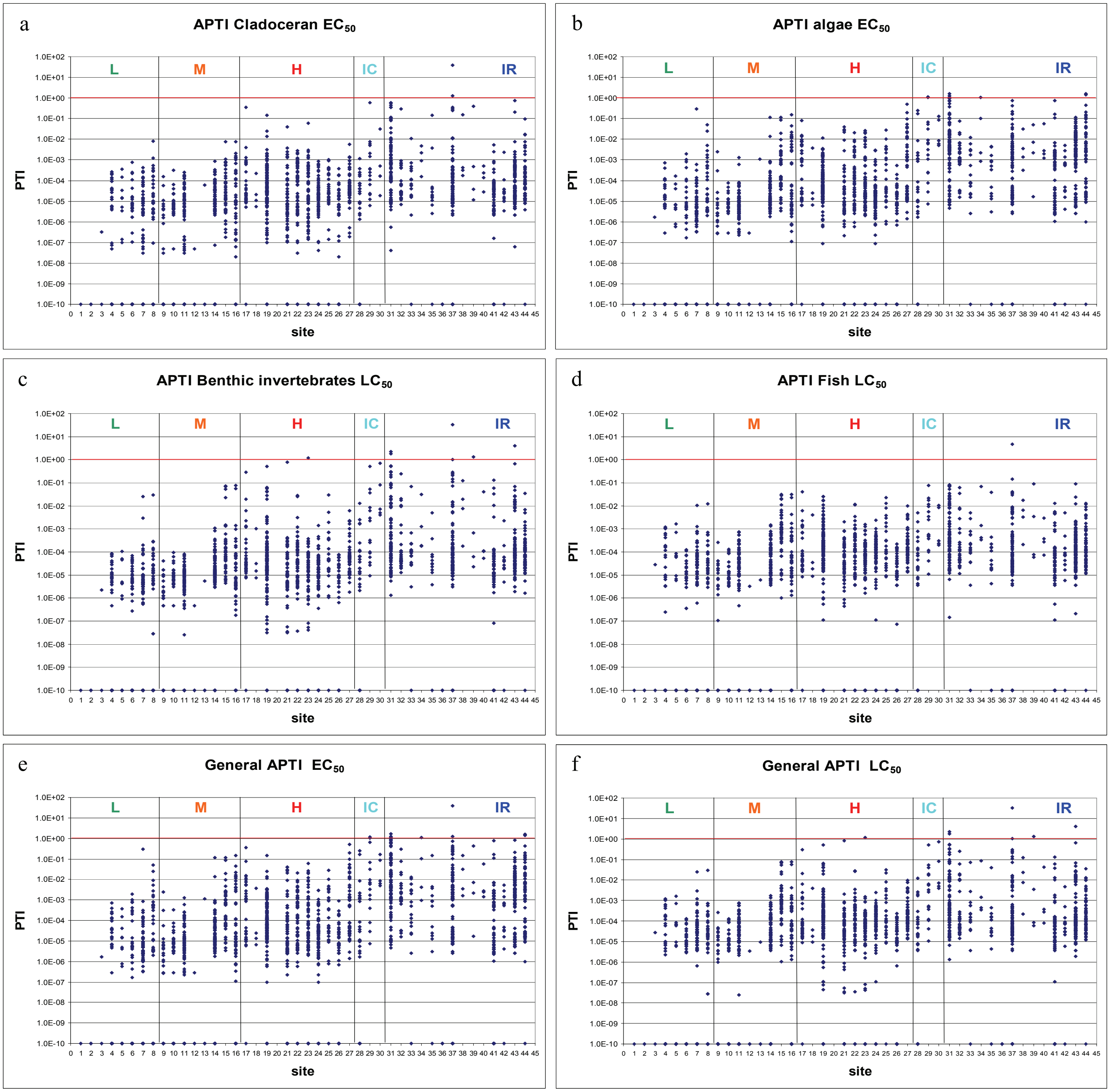
Agricultural Streams

Results of APTI calculations for a wide selection of agricultural streams are summarized in Figure 2. Dry land (crop production does not rely on irrigation) watersheds from which surface water quality data were obtained are grouped in three classes ‘Low’, ‘Medium’ and ‘High’ agricultural intensity. These stream data were for the most part generated under the Canada Alberta Environmentally Sustainable Agriculture (CAESA) and Alberta Environmentally Sustainable Agriculture (AESA) monitoring programs and span a period of 10 or more years for many streams. Agricultural intensity in the watershed was defined by manure production, chemical (mostly pesticide) use, and fertilizer expenses (Anderson 1998, Anderson and Cooke 1999). Sampling of



Basin	Site	Station
Oldman	1	NEAR BROCKET – LEFT BANK
	2	ABOVE LETHBRIDGE AT HWY 3
	3	U/S OF LETHBRIDGE (POPSON PARK)
	4	AT HWY 36 BRIDGE NORTH OF TABER
South Saskatchewan	5	ABOVE MEDICINE HAT
Bow	6	U/S OF EXSHAW CREEK – L;EFT BANK
	7	AT COCHRANE
	8	AT 9TH AVE BRIDGE
	9	BELOW CARSELAND DAM
	10	AT CLUNY
	11	RONALANE
	12	BOW CITY
Red Deer	13	HWY 2 U/S RED DEER
	14	NEVIS
	15	MORRIN
North Saskatchewan	16	DEVON
	17	PAKAN
Athabasca	18	OLD ENTRANCE
	19	U/S OF HINTON
	20	ATHABASCA
	21	U/S FORT MCMURRAY
	22	OLD FORT
Wapiti	23	HIGHWAY #40
	24	75 M D/S HWY 40
Smoky	25	AT WATINO
	26	U/S CONFLUENCE WITH SMOKY RIVER
Peace	27	FORT VERMILLION

Figure 1 Pesticide Toxicity Index (APTI) values for individual samples at Long-term River Network (LTRN) sites (1995-2005)



Agricultural Intensity	Site Number	Site Name
Low (L)	1	SAKWATAMAU RIVER
	2	CHRISTMAS CREEK
	3	LITTLE PADDLE RIVER
	4	PADDLE RIVER
	5	HINES CREEK
	6	WILLOW CREEK
	7	ROSE CREEK
	8	PRAIRIE BLOOD COULEE
Moderate (M)	9	TROUT CREEK
	10	MEADOW CREEK
	11	BLINDMAN RIVER
	12	BLOCK CREEK
	13	LLOYD CREEK
	14	TOMAHAWK CREEK
	15	KLESKUN HILLS MAIN DRAIN
	16	GRANDE PRAIRIE CREEK
High (H)	17	LITTLE BOW RIVER
	18	WEST ARROWWOOD CREEK
	19	HAYNES CREEK
	20	HAYNES CREEN AT MOUTH
	21	RAY CREEK
	22	RENWICK CREEK
	23	THREEHILLS CREEK
	24	STRAWBERRY CREEK
	25	STRETTON CREEK
	26	BUFFALO CREEK
	27	WABASH CREEK
Irrigation Canals (IC)	28	LNID Multiple sites
	29	SIX MILE COULEE - multiple sites
	30	W.I.D. AT MAX BELL ARENA
Irrigation returns (IR)	31	SIX MILE COULEE - multiple sites
	32	EXPANSE COULEE
	33	PIYAMI DRAIN
	34	TIFFIN DRAIN
	35	HANEY DRAIN
	36	ETZIKOM COULEE
	37	BATTERSEA DRAIN
	38	BOUNTIFUL COULEE
	39	DRAIN T-2
	40	DRAIN T-11
	41	DRAIN S-6
	42	ST MARY IRRIGATION DISTRICT
	43	CROWFOOT CREEK
	44	NEW WEST COULEE

Figure 2 Pesticide Toxicity Index (APTI) values for individual samples in agricultural streams (1995-2005)

surface waters in irrigation canals and return flows has been part of various monitoring programs by Alberta Environment and the AESA stream monitoring program.

APTI values tend to increase with agricultural intensity and tend to be highest in irrigation return flows. This pattern corresponds to patterns in pesticide occurrence, detection frequency, and concentrations. In the stream group with high agricultural intensity, and especially in the irrigation return flows, several samples have APTI values greater than one. In particular, one sample (June 10, 1999) from Battersea Drain (Figure 2, Site 37) contained 0.781 µg/L chlorpyrifos, an organophosphate insecticide highly toxic to cladocerans and invertebrates. That detection was the main reason for the high APTI values derived from cladoceran EC_{50} and invertebrate LC_{50} (Figures 2*a* and 2*c*; APTI = 39.0 and 32.5, respectively).

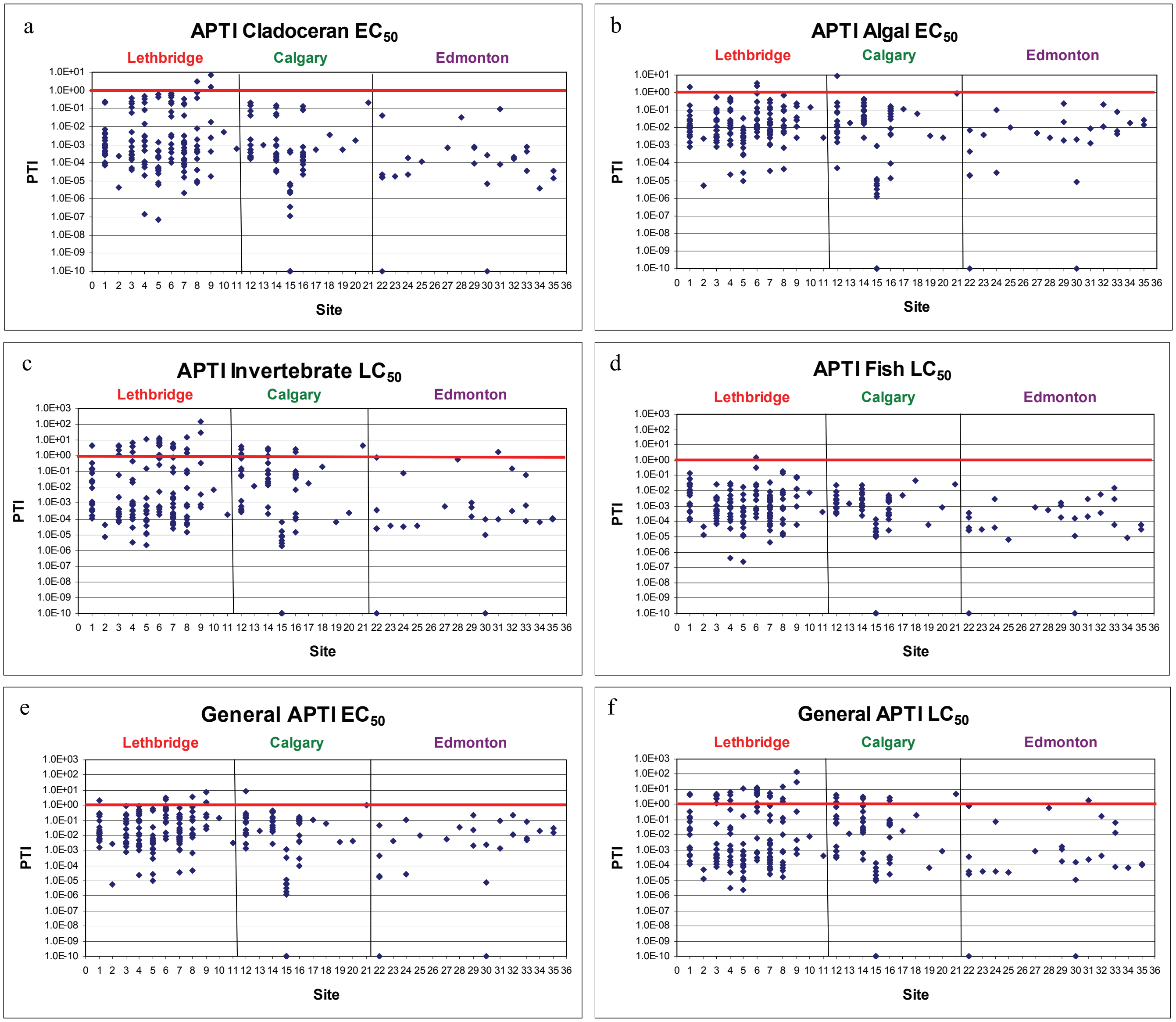
Urban Streams and Drains

Results of APTI calculations for pesticide samples from urban streams and drains in Lethbridge, Calgary and Edmonton are shown in Figure 3. Many samples exceeded the index value of one in urban streams from Lethbridge. However, it is important to note that the sampling program in the Lethbridge area was considerably more intense and targeted (hence, more likely to reveal issues) than those in the two other cities. This probably accounts, at least to some extent, for the higher index values observed in Lethbridge drains.

One sample from Storm Drain N-2 (18 June, 2001) in the Lethbridge area, had very high levels of the herbicides 2,4-D, dicamba and MCPP, and a total pesticide concentration of 1047.319 µg/L (this is the highest total pesticide concentration on record in WDS). APTI values for algae exceeded one (3.3), but they were comparatively low for cladocerans (0.2), and fishes (0.3). The index value for invertebrates was also low (0.3), but it is incomplete because MCPP was not incorporated in the calculation due to lack of LC_{50} data. APTI values for this sample suggest that, despite the high herbicide concentration, the water was probably not acutely toxic to cladocerans and fishes. However, concentrations of 2,4-D and dicamba exceeded the guideline for the protection of aquatic life (PAL; 4 and 10 µg/L, respectively) by more than a factor of 10, suggesting the possibility of chronic effects. There is no PAL guideline available for MCPP.

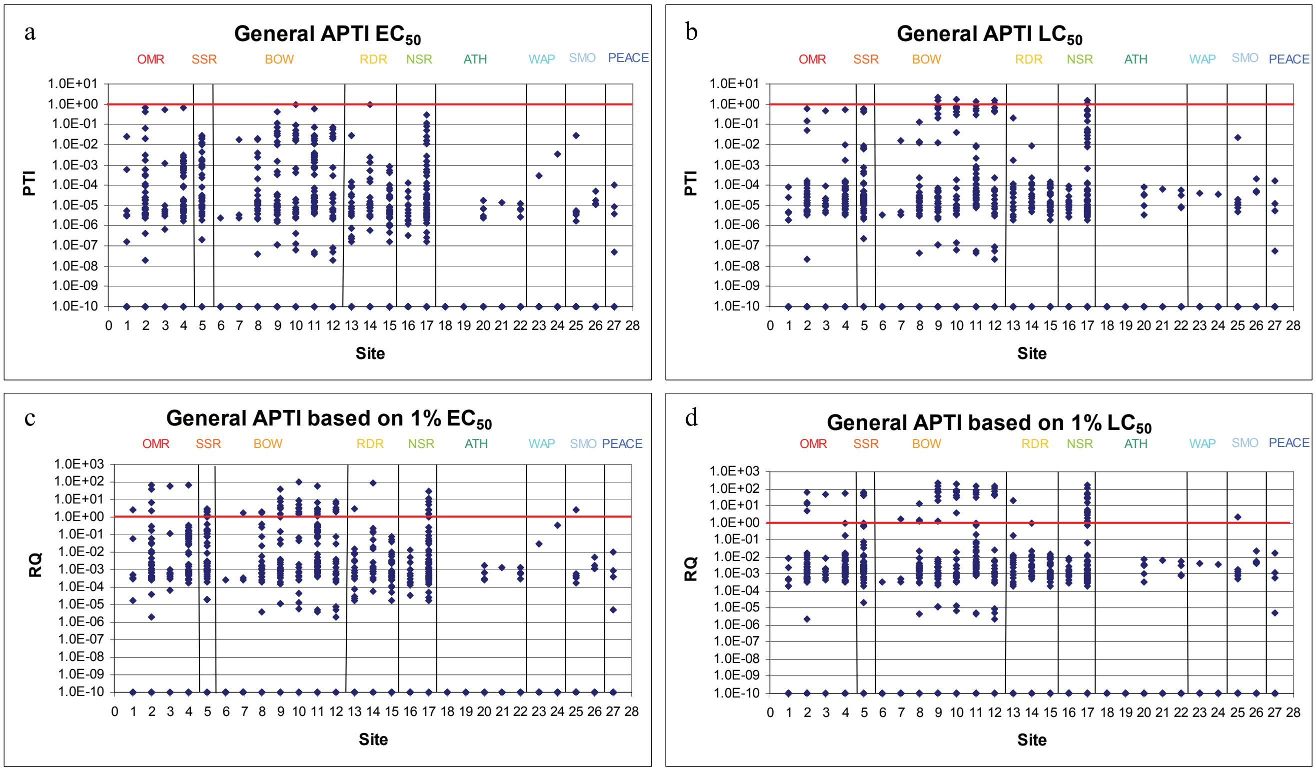
3.2 APTI Values and Likelihood of Toxic Responses

Figure 4 illustrates the ranking of samples from the long-term river network according to the risk classes defined earlier. The general APTI values derived from EC_{50} and LC_{50} are presented in Figures 4*a* and 4*b,* respectively. The APTI based on endpoints approximating the NOEC (*i.e.,* 1/100th of the EC_{50} and LC_{50}) is shown in Figures 4c and 4d. Essentially, Figures 4a and 4c indicate that 93.8% of samples taken at LTRN sites between 1995 and 2005 had a 'low' toxicity risk rating based on cladoceran mobility or algal growth, while 6.2% of the samples had a 'moderate' toxicity risk rating, and no samples had a 'high' risk rating. Similarly, Figures 4b and 4d illustrate that 94.1 % of the samples had a 'low' risk rating based on LC_{50} for invertebrates and fishes, but 5.9 % received a 'moderate', and 0.8% a 'high' risk rating.



Site Number	Site Name	Site Number	Site Name
	LETHBRIDGE		EDMONTON
1	STORM DRAIN 94-S8 ENTERING SIX MILE COULEE	22	WHITEMUD CREEK
2	NATURAL DRAIN	23	MILL CREEK UPSTREAM OF NSR OUTFALL
3	STORM DRAIN S-7	24	MILL CREEK AT MILL WOODS GOLF COURSE
4	STORM DRAIN S-5/6	25	MILL CREEK AT 17 ST
5	STORM DRAIN S-3	26	MILL CREEK AT MOUTH
6	STORM DRAIN N-2	27	GOLD BAR CREEK
7	STORM DRAIN W-3	28	HORSEHILLS CREEK
8	STORM DRAIN D5028418AG1	29	EDMONTON - QUESNELL STORM SEWER
9	STORM DRAIN D5088820AA3	30	EDMONTON - GROAT ROAD STORM SEWER
10	OLDMAN RIVER STORM DRAIN N-9	31	EDMONTON STORM SEWER AT 30TH AVE
11	MANHOLE AT INTERSECTION OF 2 AVE NORTH AND 8, 22, 28 and 36 St.	32	EDMONTON – RAT CREEK COMBINEDSEWER
	CALGARY		
12	NOSE CREEK BELOW AIRDRIE	33	CAPILANO COMBINED SEWER
13	NOSE CREEK U/S COUNTRY HILLS BLVD	34	EDMONTON - KENNEDALE STORM SEWER
14	NOSE CREEK NEAR MOUTH	35	CLAREVIEW STORM OUTFALL
15	WEST NOSE CREEK	36	BEAUMARIS LAKE
16	EAST NOSE CREEK	37	HOLLICK KENYON LAKE
17	STORM OUTFALL IC-08 NEAR CALGARY CANOE CLUB		
18	STORM OUTFALL IC-17 AT 72 AVE SE		
19	STORM OUTFALL IC-21, BARLOW TRAIL		
20	STORM OUTFALL IC-21A AT 40 ST SE		
21	STORM SEWER AT 68TH. ST. POND OUTFALL		

Figure 3 Pesticide Toxicity Index for urban streams and drains



	N	%>1	%≤1
General APTI (EC50)	1003	0	100
RQ	1003	6.2	93.8

Risk for Toxicity
High
Moderate
Low

	n	%>1	%≤1
General APTI (LC50)	1003	0.8	99.2
RQ	1003	5.9	94.1

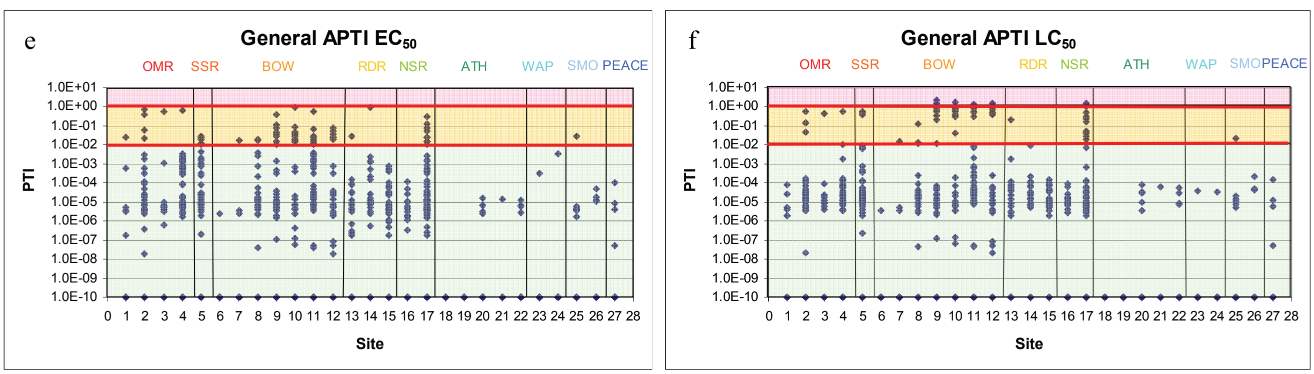


Figure 4 Likelihood of toxic responses illustrated with LTRN data (1995-2005)

Note that the only difference between Figures 4*a* and 4*c*, and 4b and 4d is the scale of the y-axis and the associated threshold. Hence, Figures 4*e* and 4*f* are appropriate to summarize the information.

Figure 5 provides another option to summarize pesticide toxicity risk. The risk for toxicity in samples from the LTRN was rated 'low' in 93 to 94% and 'moderate' in 6% of the samples. There were 8 samples (1%) with a 'high' toxicity risk rating based on APTI LC_{50}. The rating for agricultural stream samples was similar in the sense that the majority of samples received a 'low' risk rating. The relative number of samples that received a 'moderate' rating increased with agricultural intensity. Some (<1%) of samples from streams with high agricultural intensity, and 2% of samples from irrigation return flows received a 'high' risk rating. In urban streams and drains of both Lethbridge and Calgary, the proportion of samples with a 'moderate' and 'high' toxicity risk rating was the highest of all water bodies for which the APTI was calculated.

3.3 Application of the APTI in the Analysis and Interpretation of Pesticide Data

By its very nature, the APTI complements data on pesticide occurrence with information on potential toxicity and provides a means of determining which pesticides most strongly account for the potential toxicity. Figure 6 illustrates the added value of incorporating toxicity information with concentration and detection frequency information which, until now, formed the basis of conventional pesticide data analysis. Data from two LTRN sites on the Oldman River are used here (OMR @ Hwy 3, upstream of Lethbridge; and OMR @ Hwy 36, downstream of Lethbridge).

Total concentrations (Figure 6*a*) at the two sites are below 0.250 µg/L in most samples, except in a June 6, 1995 (1.479 µg/L) and a June 11, 2002 (3.191 µg/L) sample from Hwy 3. Total concentrations, number of pesticides detected per sample (Figure *b*) and detection frequency (Figure *c*) tend to be somewhat higher at Hwy 36. Accordingly, the ARWQI-pesticide sub-index (*d*) tends to be slightly lower (worse) at Hwy 36. The 'marginal' sub-index rating for 1995-96 at Hwy 3 is cause for concern, but in most other years the ratings are 'fair' to 'good' and in 97-98 'excellent'.

Overall the APTI (both general EC_{50} and LC_{50}) values for Hwy 36 tend to be slightly higher (worse) than those for Hwy3. At both sites, APTI values are mostly below 0.01 and this indicates that for those samples the risk for toxicity is 'low'. This information is consistent with the outcome of conventional analysis. However, there are some notable exceptions where the APTI provides additional insights. For example, 5 samples (4 from Hwy 3, and 1 from Hwy 36), have an APTI between 0.01 and 1 and represent a 'moderate' risk for toxicity.

The ARWQI pesticide sub-index integrates all data from one year into one number; consequently, it represents 'average' conditions. When toxic substances, such as pesticides, are involved this could misrepresent actual conditions. In an extreme situation, elevated levels of pesticides on a single sampling could have serious negative effects on aquatic life. This would be captured in the APTI, but would likely be 'diluted

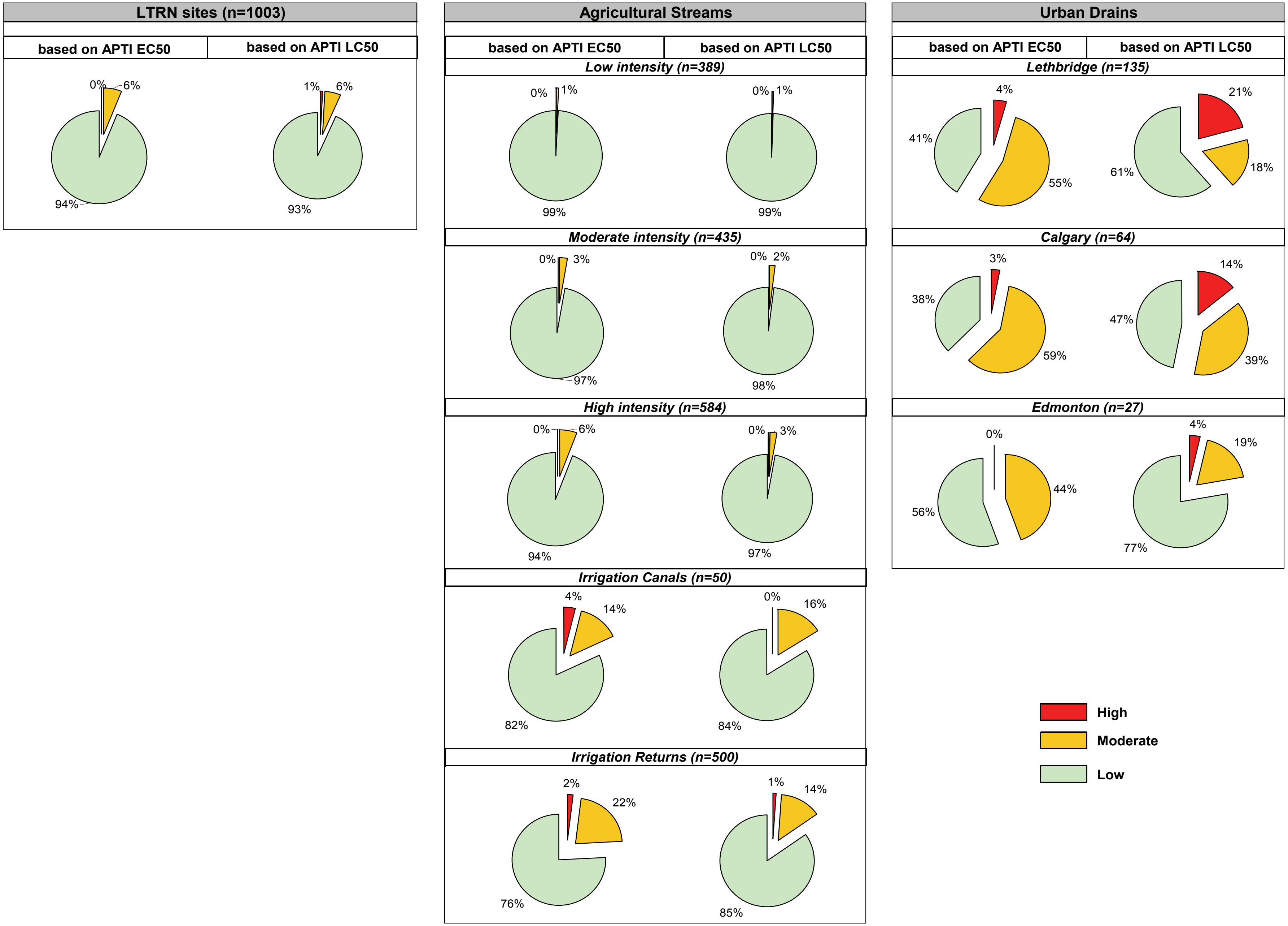


Figure 5 Potential risk for pesticide toxicity

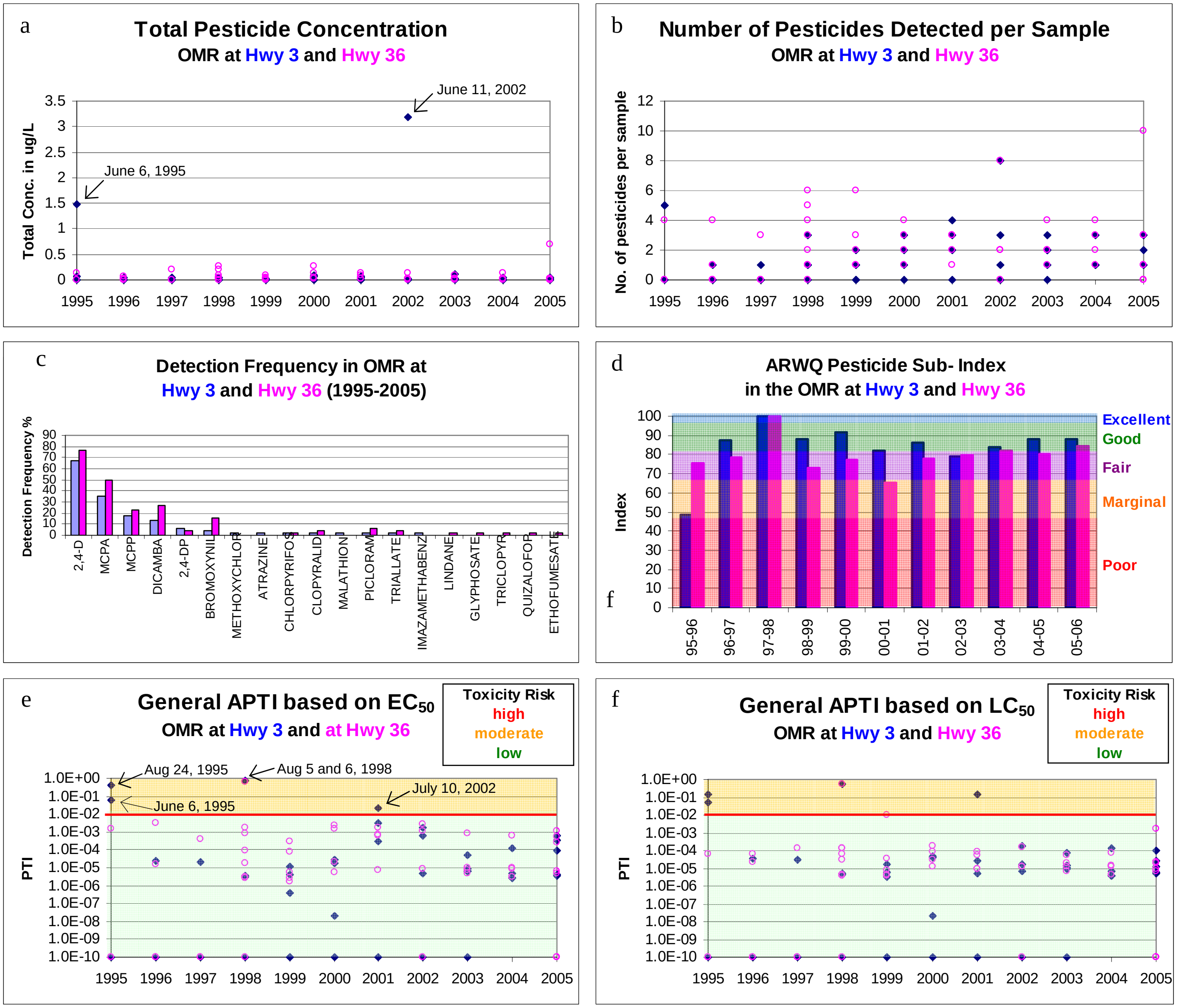


Figure 6 **Combining information from APTI with conventional approaches to pesticide data analysis.** *Example based on Oldman River (OMR) data*

in the pesticide sub-index. In this respect, it is a rather unique instance that in 1995-96 both the ARWQI pesticide sub-index and the APTI flagged marginal conditions at Hwy 3.

Complementing the pesticide sub-index ratings with information on the APTI would provide added value. One simple option would be to indicate the percentage of samples that have 'low', 'moderate', and 'high' toxicity, as illustrated in Figure 5.

A closer look at pesticides recorded in samples flagged with a 'moderate' toxicity risk rating is warranted. Figure 7 indicates that 12 pesticides were recorded in these five samples. Of these, the herbicides 2,4-D, MCPA, and clopyralid contributed most to the total pesticide concentrations (Figure 7*a*). However, the pesticides that contributed most to the absolute value of the APTI (Figure *7b* and 7*c*) were malathion, atrazine, and chlorpyrifos. The two insecticides and the triazine herbicide have, because of their high toxicity, been flagged as a concern for aquatic life in other studies where the PTI was applied (*e.g*., Battaglin and Fairchild 2002, Gilliom 2006). The limited relationship between pesticide concentrations and pesticide toxicity is illustrated further in Figures 7 *a,* 7*b* and 7*c*. Note for instance the relatively high pesticide concentrations (Figure 7*a*) measured on 6/11/2002 at Hwy 3, but the low PTI corresponding with that sample (Figures 7*b* and 7*c*). Figures 7*d* and 7*e* provide further details on which pesticides contribute to the relative toxicity of the samples, regardless of the absolute value of the APTI. Dicamba and chlopyralid contribute most to the general APTI EC_{50} for July 10, 2001 and June 11, 2002, while 2,4-D, dicamba, MCPA, and 2,4DP contribute most to the general APTI LC_{50} on these dates.

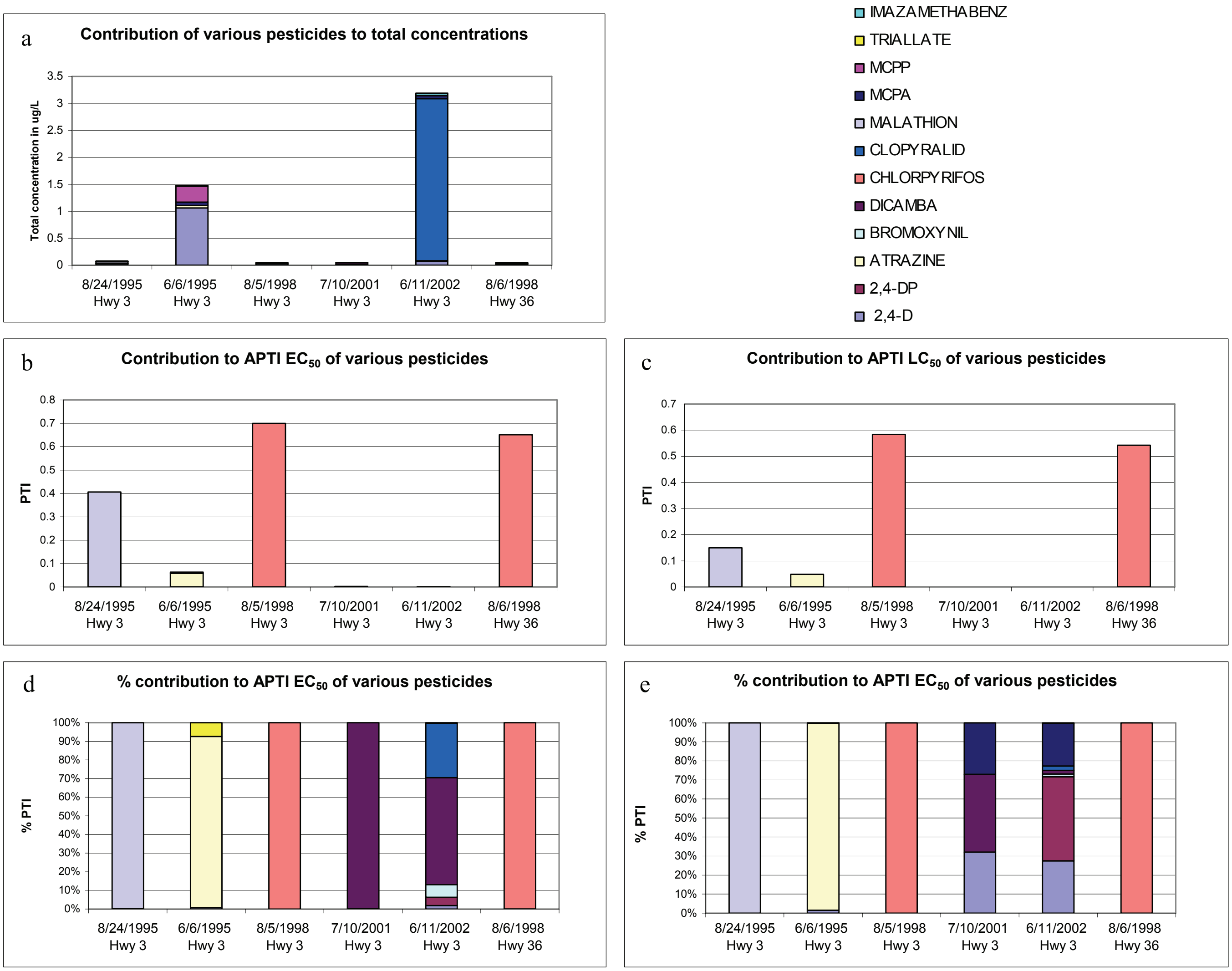


Figure 7 **Contributions to the APTI from various pesticides present in a selection of samples at Hwy 3 and Hwy 36 on the Oldman River**

4.0 GENERAL DISCUSSION AND RECOMMENDATIONS

APTI as a communication tool

- APTI values derived from different groups of test species provide valuable, detailed information on the relative sensitivity of test species to pesticide mixtures, but the generic APTI incorporates much of this information and offers a simpler approach for routine reporting.
- Because it supplies information on potential toxicity of pesticide mixtures, the "general APTI" is an informative complement to the pesticide sub-index in the Alberta River Water Quality Index, which only provides a measure of pesticide occurrence and concentrations. It is suggested that the APTI be included in the annual report of the ARWQI (*e.g.,* as the proportion of samples among risk classes).
- Although indices have a recognized value as communication tools, misuse can greatly reduce their reliability. In this respect, it is important to note that the index value will be influenced not only by the concentration endpoints, but also by multiple aspects of the study design, such as the number and types of pesticides analyzed, detection limits, sampling frequency and timing. Because of such differences, it would be inappropriate to compare PTI results presented in this report with PTI results generated in the USA, or with the Risk Quotient proposed by Williamson and Nadec Conseils Inc. (2007).

APTI as a management tool

Although the APTI is primarily intended as a descriptive reporting tool, it has potential applications as a risk screening tool for toxicity. As such it could trigger enhanced monitoring and improved management of pesticides on land to protect surface waters. For example:

- When APTI EC_{50} or LC_{50} exceed one and flag a high probability for toxic effects, pesticides which most strongly account most for the elevated PTI need to be identified and the potential for alternate pest management control measures should be considered.
- Pesticide use and management should be reassessed in drainage basins where samples often, or increasingly exceed a PTI EC_{50} or LC_{50} value of one.

The value of the APTI as a water quality-based management tool for pesticide management on land should be investigated further.

Technical considerations about the APTI

- The limitations flagged by Munn and Gilliom (2001) and Munn *et al*. (2006) all apply to this index and should be taken into account when interpreting the data. (see section 1.1)

- It is important to emphasize that the index does not take into account effects such as endocrine disruption, carcinogenicity, or other subtle effects.
- The selected values for toxicity endpoints used in this document will need to be updated periodically to incorporate new toxicity information as it becomes available.
- Endpoints used to identify the threshold below which effects are unlikely (*i.e.,* approximation of NOEC) could eventually be replaced by CCME guidelines when these have been established for pesticides of relevance in Alberta.
- Similarly, to ensure the continued value of the APTI, regular updates of the pesticide monitoring program are needed. As discussed in detail by Anderson (2005), this involves the review of sales data, the screening of pesticides for their likelihood to enter surface waters and exert effects, the development of analytical methods, and the implementation of coordinated standardized monitoring programs. The importance of this has been recognized for some time, but would be even greater if the APTI was used as a complementary evaluation and reporting tool.
- It is important to consider QA/QC aspects of the actual pesticide data. Recovery rates for pesticides are typically low and variable; thus the use of raw data could result in an underestimate of the PTI. Consideration should be given to using pesticide concentrations corrected for recovery.

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Appendix 1 Documentation for endpoints used in Pesticide Toxicity Index

Compound	Species	Taxonomic Group	Endpoint	Effect	Effect Measure-ment	Author	Year	Title	Reference Source	Source
Carbathiin										
	Daphnia magna	Water flea	EC50	ITX	IMBL	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
	Pseudokirchneriella subcapitata	Green algae	EC50	POP	ABND	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
	Lepomis macrochirus	Bluegill	LC50	MOR	MORT	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
iprodione										
	Daphnia magna	Water flea	EC50	ITX	IMBL	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
	Pseudokirchneriella subcapitata	Green algae	EC50	POP	ABND	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
	Procambarus simulans	Crayfish	LC50	MOR	MORT	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	PAN Pesticides Database - Chemical Toxicity Studies on Aquatic Organisms (PAN)
	Ictalurus punctatus	Channel catfish	LC50	MOR	MORT	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
vinclozolin										
	Daphnia magna	Water flea	EC50	ITX	IMBL	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
	Skeletonema costatum	Diatom	EC50	POP	ABND	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
	No aquatic invertebrate toxicity data									
	Lepomis gibbosus	Pumpkinseed	LC50	MOR	MORT	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
Metalaxyl-M										
	Daphnia magna	Water flea	EC50	ITX	IMBL	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
	Selenastrum capricornutum	Green algae	EC50	POP	ABND	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	PAN
	No aquatic invertebrate toxicity data									
	Lepomis macrochirus	Bluegill	LC50	MOR	MORT	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
2,4-D										
	Daphnia pulex	Water flea	EC50	ITX	IMBL	Sanders, H.O., and O.B. Cope	1966	Toxicities of Several Pesticides to Two Species of Cladocerans	Trans.Am.Fish.Soc. 95(2):165-169 (Author Communication Used) (Publ in Part As 6797)	
	Anabaena flosaquae	Blue-green algae	EC50	POP	ABND	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
	Pteronarcys californicus	Stonefly	LC50	MOR	MORT	Cope, O.B.	1965	Sport Fishery Investigations	In: Fish and Wildl.Serv.Cicr.226, Effects of Pesticides on Fish and Wildlife - 1964 Research Findings of the Fish and Wildlife Service, Washington, D.C. :51-63 (Publ in Part As 6797)	
	for fish used Munn & Gilliom (2001)									
2,4-DB										
	Daphnia magna	Water flea	EC50	ITX	IMBL	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
	Ankistrodesmus falcatus	Green algae	EC50	GRO	GGRO	Tscheu-Schluter, M.	1974	Acute Toxicity of Herbicides for Selected Aquatic Organisms. I. Synthetic Growth-Promoting Herbicides, Phenoxycarboxylic Acids	Acta Hydrochim.Hydrobiol. 2(2):139-159 (GER) (OECDG Data File)	
	Pteronarcys californicus	Stonefly	LC50	MOR	MORT	Mayer, F.L.Jr., and M.R. Ellersieck	1986	Manual of Acute Toxicity: Interpretation and Data Base for 410 Chemicals and 66 Species of Freshwater Animals	Resour.Publ.No.160, U.S.Dep.Interior, Fish Wildl.Serv., Washington, DC :505 p. (USGS Data File)	
	Oncorhynchus mykiss	Rainbow trout, donaldson trout	LC50	MOR	MORT	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
2,4-DP										
	Cladocera see Munn and Gillion (2001)									
	Selenastrum capricornutum	Green algae	EC50	POP	ABND	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	PAN
	invertebrates see Munn and Gilliom (2001)									
	fish see Munn and Gilliom (2001)									
Atrazine										
	Ceriodaphnia dubia	Water flea	EC50	ITX	IMBL	"Foster, S., M. Thomas, and W. Korth"	1998	Laboratory-Derived Acute Toxicity of Selected Pesticides to Ceriodaphnia dubia	Australas.J.Ecotoxicol. 4(1):53-59	
	Pseudokirchneriella subcapitata	Green algae	EC50	POP	ABND	"Hoberg, J.R."	1991	Atrazine Technical - Toxicity to the Freshwater Green Alga Selenastrum capricornutum	"Final SLI Rep.No.#91-1-3600, Springborn Lab.Inc., Environ.Sci.Div., Wareham, MA :50 p."	
	Hyalella azteca	Scud	LC50	MOR	MORT	"Bowman, M.C., W.L. Oller, T. Cairns, A.B. Gosnell, and K.H. Oliver"	1981	Stressed Bioassay Systems for Rapid Screening of Pesticide Residues. Part I: Evaluation of Bioassay Systems	Arch.Environ.Contam.Toxicol. 10(1):9-24	
	Ruppia maritima	Brown trout	LC50	MOR	MORT	"Grande, M., S. Andersen, and D. Berge"	1994	Effects of Pesticides on Fish. Experimental and Field Studies	Norw.J.Agric.Sci. Suppl.13:195-209	

Compound	Species	Taxonomic Group	Endpoint	Effect	Effect Measure-ment	Author	Year	Title	Reference Source	Source
Carbathiin										
	Daphnia magna	Water flea	EC50	ITX	IMBL	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
	Pseudokirchneriella subcapitata	Green algae	EC50	POP	ABND	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
	Lepomis macrochirus	Bluegill	LC50	MOR	MORT	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
iprodione										
	Daphnia magna	Water flea	EC50	ITX	IMBL	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
Bromacil										
	Ceriodaphnia dubia	Water flea	EC50	ITX	IMBL	Foster, S., M. Thomas, and W. Korth	1998	Laboratory-Derived Acute Toxicity of Selected Pesticides to Ceriodaphnia dubia	Australas.J.Ecotoxicol. 4(1):53-59	
	Pseudokirchneriella subcapitata	Green algae	EC50	POP	ABND	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
	Americanysis bahia	Oposum Shrimp	LC50	MOR	MORT	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	PAN
	Oncorhynchus mykiss	Rainbow trout, donaldson trout	LC50	MOR	MORT	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
Bromoxynil										
	Daphnia magna	Water flea	EC50	ITX	IMBL	Buhl, K.J., S.J. Hamilton, and J.C. Schmulbach	1993	Acute Toxicity of the Herbicide Bromoxynil to Daphnia magna	Environ.Toxicol.Chem. 12:1455-1468	
	Pseudokirchneriella subcapitata	Green algae	EC50	POP	ABND	St.Laurent, D., C. Blaise, P. MacQuarrie, R. Scroggins, and B. Trottier	1992	Comparative Assessment of Herbicide Phytotoxicity to Selenastrum capricornutum Using Microplate and Flask Bioassay Procedures	Environ.Toxicol.Water Qual. 7:35-48	
	Chironomus thummi	Midge	EC50	ITX	IMBL	Buhl, K.J., and N.L. Faerber	1989	Acute Toxicity of Selected Herbicides and Surfactants to Larvae of the Midge Chironomus riparius	Arch.Environ.Contam.Toxicol. 18(4):530-536	
	Oncorhynchus mykiss	Rainbow trout, donaldson trout	LC50	MOR	MORT	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
Cyanazine										
	cladocera see Munn and Gilliom (2001)									
	Navicula pelliculosa	Diatom	EC50	POP	ABND	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
	Gammarus fasciatus	Scud	LC50	MOR	MORT	Mayer, F.L.Jr., and M.R. Ellersieck	1986	Manual of Acute Toxicity: Interpretation and Data Base for 410 Chemicals and 66 Species of Freshwater Animals	Resour.Publ.No.160, U.S.Dep.Interior, Fish Wildl.Serv., Washington, DC :505 p. (USGS Data File)	
	Oncorhynchus mykiss	Rainbow trout, donaldson trout	LC50	MOR	MORT	Davies, P.E., L.S.J. Cook, and D. Goenarso	1994	Sublethal Responses to Pesticides of Several Species of Australian Freshwater Fish and Crustaceans and Rainbow Trout	Environ.Toxicol.Chem. 13(8):1341-1354 (OECDG Data File)	
Dicamba										
	Moina macrocopa	Water flea	LC50*	MOR	MORT	Nishiuchi, Y., and Y. Hashimoto	1967	Toxicity of Pesticide Ingredients to Some Fresh Water Organisms	Sci.Pest Control (Botyu-Kagaku) 32(1):5-11 (JPN) (ENG ABS) (Author Communication Used)	
	Anabaena flosaquae	Blue-green algae	EC50	POP	ABND	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
	Gammarus lacustris	Scud	LC50	MOR	MORT	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
	fish see Munn and Gilliom (2001)									
Diuron										
	Ceriodaphnia dubia	Water flea	EC50			Foster, S., M. Thomas, and W. Korth	1998	Laboratory-Derived Acute Toxicity of Selected Pesticides to Ceriodaphnia dubia	Aust.J.Ecotoxicol. 4(1):53-59	
	Chlorella pyrenoidosa	Green algae	EC50			Ma, J., W. Liang, L. Xu, S. Wang, Y. Wei, and J. Lu	2001	Acute Toxicity of 33 Herbicides to the Green Alga Chlorella pyrenoidosa	Bull.Environ.Contam.Toxicol. 66(4):536-541	
	Gammarus fasciatus	Scud	LC50			Mayer, F.L.Jr., and M.R. Ellersieck	1986	Manual of Acute Toxicity: Interpretation and Data Base for 410 Chemicals and 66 Species of Freshwater Animals	Resour.Publ.No.160, U.S.Dep.Interior, Fish Wildl.Serv., Washington, DC :505 p. (USGS Data File)	
	Mun and Gilliom (2001)									
Ethalfluralin										
	Daphnia magna	Water flea	EC50	ITX	IMBL	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
	Pseudokirchneriella subcapitata	Green algae	EC50	POP	ABND	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
	No aquatic invertebrate toxicity data									
	Lepomis macrochirus	Bluegill	LC50	MOR	MORT	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
Clopyralid										
	Daphnia sp.	Water flea	EC50	ITX	IMBL	Pesticide Manual 10th edition ask Gary				
	No aquatic invertebrate toxicity data									
	Chironomus sp.	Midge	LC50	MOR	MORT	Vardia, H.K., and P.S. Rao	1986	Pesticidal Effects on Chironomid Larvae	Rev.Biol.(Lisb.) 13(1-4):113-115	
	No fish toxicity data									
MCPA										
	Daphnia magna	Water flea	EC50*	ITX	IMBL	Crosby, D.G., and R.K. Tucker	1966	Toxicity of Aquatic Herbicides to Daphnia magna	Science 154:289-291	
	Pseudokirchneriella subcapitata	Green algae	EC50	PHY	PSYN	Caux, P.Y., L. Menard, and R.A. Kent	1996	Comparative Study of the Effects of MCPA, Butylate, Atrazine, and Cyanazine on Selenastrum capricornutum	Environ.Pollut. 92(2):219-225	
	Daphnia magna	Water flea	LC50	MOR	MORT	Knapek, R., and S. Lakota	1974	Biological Testing to Determine Toxic Effects of Pesticides in Water. (Einige Biotests zur Untersuchung der Toxischen Wirkung von Pestiziden im Wasser)	Tagungsber.Akad.Landwirtschaftswiss.D.D.R.126:105-109 (GER) (ENG ABS) (1977) (Author Communication Used)	
	Oncorhynchus mykiss	Rainbow trout, donaldson trout	LC50	MOR	MORT	Havlikova, J., Z. Svobodova, and O. Filipova	1981	The Acute Toxicity of Galinex Special a Aminex 500 to Fish	Bul.Vyzk.Ustav Ryb.Hydrobiol.Vodnany 17(4):26-30 (CZE) (ENG ABS)	

Compound	Species	Taxonomic Group	Endpoint	Effect	Effect Measure-ment	Author	Year	Title	Reference Source	Source
MCPP										
	Daphnia magna	Water flea	EC50	ITX	IMBL	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
	Ankistrodesmus falcatus	Green algae	EC50	GRO	GGRO	Tscheu-Schluter, M.	1974	Acute Toxicity of Herbicides for Selected Aquatic Organisms. I. Synthetic Growth-Promoting Herbicides, Phenoxycarboxylic Acids	Acta Hydrochim.Hydrobiol. 2(2):139-159 (GER) (OECDG Data File)	
	Lepomis macrochirus	Bluegill	LC50	MOR	MORT	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
Picloram										
	Daphnia magna	Water flea	EC50	ITX	IMBL	Mayer, F.L.Jr., and M.R. Ellersieck	1986	Manual of Acute Toxicity: Interpretation and Data Base for 410 Chemicals and 66 Species of Freshwater Animals	Resour.Publ.No.160, U.S.Dep.Interior, Fish Wildl.Serv., Washington, DC :505 p. (USGS Data File)	
	Pseudokirchneriella subcapitata	Green algae	EC50	POP	ABND	St.Laurent, D., C. Blaise, P. MacQuarrie, R. Scroggins, and B. Trottier	1992	Comparative Assessment of Herbicide Phytotoxicity to Selenastrum capricornutum Using Microplate and Flask Bioassay Procedures	Environ.Toxicol.Water Qual. 7:35-48	
	Gammarus pseudolimnaeus	Scud	LC50	MOR	MORT	Mayer, F.L.Jr., and M.R. Ellersieck	1986	Manual of Acute Toxicity: Interpretation and Data Base for 410 Chemicals and 66 Species of Freshwater Animals	Resour.Publ.No.160, U.S.Dep.Interior, Fish Wildl.Serv., Washington, DC :505 p. (USGS Data File)	
	Ictalurus punctatus	Channel catfish	LC50	MOR	MORT	Mayer, F.L.Jr., and M.R. Ellersieck	1986	Manual of Acute Toxicity: Interpretation and Data Base for 410 Chemicals and 66 Species of Freshwater Animals	Resour.Publ.No.160, U.S.Dep.Interior, Fish Wildl.Serv., Washington, DC :505 p. (USGS Data File)	
Triallate										
	Daphnia magna	Water flea	EC50	ITX	IMBL	Mayer, F.L.Jr., and M.R. Ellersieck	1986	Manual of Acute Toxicity: Interpretation and Data Base for 410 Chemicals and 66 Species of Freshwater Animals	Resour.Publ.No.160, U.S.Dep.Interior, Fish Wildl.Serv., Washington, DC :505 p. (USGS Data File)	
	Pseudokirchneriella subcapitata	Green algae	EC50	POP	BMAS	Turbak, S.C., S.B. Olson, and G.A. McFeters	1986	Comparison of Algal Assay Systems for Detecting Waterborne Herbicides and Metals	Water Res. 20(1):91-96	
	Chironomus plumosus	Midge	LC50	MOR	MORT	Mayer, F.L.Jr., and M.R. Ellersieck	1986	Manual of Acute Toxicity: Interpretation and Data Base for 410 Chemicals and 66 Species of Freshwater Animals	Resour.Publ.No.160, U.S.Dep.Interior, Fish Wildl.Serv., Washington, DC :505 p. (USGS Data File)	
	Oncorhynchus mykiss	Rainbow trout, donaldson trout	LC50	MOR	MORT	Mayer, F.L.Jr., and M.R. Ellersieck	1986	Manual of Acute Toxicity: Interpretation and Data Base for 410 Chemicals and 66 Species of Freshwater Animals	Resour.Publ.No.160, U.S.Dep.Interior, Fish Wildl.Serv., Washington, DC :505 p. (USGS Data File)	
Trifluralin										
	Cladocera Munn and Gilliom (2001)									
	Navicula pelliculosa	Diatom	EC50	POP	ABND	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	PAN
	Invertebrates Munn and Gilliom (2001)									
	Fish Munn and Gilliom (2001)									
Imazamethabenz										
	Daphnia magna	Water flea	EC50			Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
	Pseudokirchneriella subcapitata	Green algae	EC50			St.Laurent, D., C. Blaise, P. MacQuarrie, R. Scroggins, and B. Trottier	1992	Comparative Assessment of Herbicide Phytotoxicity to Selenastrum capricornutum Using Microplate and Flask Bioassay Procedures	Environ.Toxicol.Water Qual. 7:35-48	
	No aquatic invertebrate toxicity data									
	Oncorhynchus mykiss	Rainbow trout, donaldson trout	LC50			Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
Quinclorac										
	Daphnia magna	Water flea	EC50	ITX	IMBL	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
	Anabaena flosaquae	Blue-green algae	EC50	POP	ABND	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
	Americanysis bahia	Oposum Shrimp	LC50	MOR	MORT	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	PAN
	Lepomis macrochirus	Bluegill	LC50	MOR	MORT	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
Imazathapyr										
	Daphnia magna	Water flea	EC50	ITX	IMBL	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
	Pseudokirchneriella subcapitata	Green algae	EC50	POP	ABND	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
	No aquatic invertebrate toxicity data									
	Ictalurus punctatus	Channel catfish	LC50	MOR	MORT	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
Imazamox										
	Daphnia magna	Water flea	EC50	ITX	IMBL	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
	No algal toxicity data									
	No aquatic invertebrate toxicity data									
	Lepomis macrochirus	Bluegill	LC50	MOR	MORT	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	

Compound	Species	Taxonomic Group	Endpoint	Effect	Effect Measure-ment	Author	Year	Title	Reference Source	Source
Glyphosate										
	Daphnia magna	Water flea	EC50	ITX	IMBL	Mayer, F.L.Jr., and M.R. Ellersieck	1986	Manual of Acute Toxicity: Interpretation and Data Base for 410 Chemicals and 66 Species of Freshwater Animals	Resour.Publ.No.160, U.S.Dep.Interior, Fish Wildl.Serv., Washington, DC :505 p. (USGS Data File)	
	Pseudokirchneriella subcapitata	Green algae	EC50	POP	ABND	St.Laurent, D., C. Blaise, P. MacQuarrie, R. Scroggins, and B. Trottier	1992	Comparative Assessment of Herbicide Phytotoxicity to Selenastrum capricornutum Using Microplate and Flask Bioassay Procedures	Environ.Toxicol.Water Qual. 7:35-48	
	Gammarus pseudolimnaeus	Scud	LC50	MOR	MORT	Mayer, F.L.Jr., and M.R. Ellersieck	1986	Manual of Acute Toxicity: Interpretation and Data Base for 410 Chemicals and 66 Species of Freshwater Animals	Resour.Publ.No.160, U.S.Dep.Interior, Fish Wildl.Serv., Washington, DC :505 p. (USGS Data File)	
	Lepomis macrochirus	Bluegill	LC50	MOR	MORT	Mayer, F.L.Jr., and M.R. Ellersieck	1986	Manual of Acute Toxicity: Interpretation and Data Base for 410 Chemicals and 66 Species of Freshwater Animals	Resour.Publ.No.160, U.S.Dep.Interior, Fish Wildl.Serv., Washington, DC :505 p. (USGS Data File)	
Simazine										
	Daphnia magna	Water flea	EC50	ITX	IMBL	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
	Pseudokirchneriella subcapitata	Green algae	EC50	POP	BMAS	Turbak, S.C., S.B. Olson, and G.A. McFeters	1986	Comparison of Algal Assay Systems for Detecting Waterborne Herbicides and Metals	Water Res. 20(1):91-96	
	Pteronarcys californicus	Stonefly	LC50	MOR	MORT	Mayer, F.L.Jr., and M.R. Ellersieck	1986	Manual of Acute Toxicity: Interpretation and Data Base for 410 Chemicals and 66 Species of Freshwater Animals	Resour.Publ.No.160, U.S.Dep.Interior, Fish Wildl.Serv., Washington, DC :505 p. (USGS Data File)	
	fish used Munn and Gilliom (2001)									
Triclopyr										
	Daphnia pulex	Water flea	EC50	ITX	IMBL	Servizi, J.A., R.W. Gordon, and D.W. Martens	1987	Acute Toxicity of Garlon 4 and Roundup Herbicides to Salmon, Daphnia, and Trout	Bull.Environ.Contam.Toxicol. 39(1):15-22	PAN
	Microcystis aeruginosa and other algae	Green algae	EC50	POP	ABND	Peterson, H.G., C. Boutin, P.A. Martin, K.E. Freemark, N.J. Ruecker, and M.J. Moody	1994	Aquatic Phyto-Toxicity of 23 Pesticides Applied at Expected Environmental Concentrations	Aquat.Toxicol. 28(3/4):275-292 (OECDG Data File)	PAN
	Isonychia sp.	Mayfly	LC50	MOR	MORT	Kreutzweiser, D.P., S.B. Holmes, and D.C. Eichenberg	1994	Influence of Exposure Duration on the Toxicity of Triclopyr Ester to Fish and Aquatic Insects	Arch.Environ.Contam.Toxicol. 26(1):124-129	PAN
	fish used Munn and Gilliom (2001)									
Fluroxypyr										
	Daphnia magna	Water flea	EC50	ITX	IMBL	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
	Pseudokirchneriella subcapitata	Green algae	EC50	POP	ABND	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
	No aquatic invertebrate toxicity data									
	Lepomis macrochirus	Bluegill	LC50	MOR	MORT	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
Quizalofop										
	Daphnia magna	Water flea	EC50			Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
	Navicula pelliculosa	Diatom	EC50			Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
	No aquatic invertebrate toxicity data									
	Lepomis macrochirus	Bluegill	LC50			Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
Bentazon										
	Daphnia magna	Water flea	EC50	ITX	IMBL	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
	Pseudokirchneriella subcapitata	Green algae	EC50	POP	ABND	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
	Americamysis bahia	Oposum shrimp	LC50	MOR	MORT	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	PAN
	Gambusia affinis	Western mosquitofish	LC50	MOR	MORT	Sun, F.	1987	Evaluating Acute Toxicity of Pesticides to Aquatic Organisms: Carp, Mosquito Fish and Daphnids	Plant Prot.Bull.(Chih Wu Pao Hu Hsueh Hui Hui K'an) 29(4):385-396 (CHI) (ENG ABS)	
Ethofumesate										
	Daphnia magna	Water flea	EC50	ITX	IMBL	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
	Pseudokirchneriella subcapitata	Green algae	EC50	POP	ABND	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
	No aquatic invertebrate toxicity data									
	Oncorhynchus mykiss	Rainbow trout,donaldson trout	LC50	MOR	MORT	Mayer, F.L.Jr., and M.R. Ellersieck	1986	Manual of Acute Toxicity: Interpretation and Data Base for 410 Chemicals and 66 Species of Freshwater Animals	Resour.Publ.No.160, U.S.Dep.Interior, Fish Wildl.Serv., Washington, DC :505 p. (USGS Data File)	
Diclofop-methyl										
	Daphnia magna	Water flea	EC50	ITX	IMBL	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
	No algal toxicity data									
	No aquatic invertebrate toxicity data									
	Lepomis macrochirus	Bluegill	LC50	MOR	MORT	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	

Compound	Species	Taxonomic Group	Endpoint	Effect	Effect Measure-ment	Author	Year	Title	Reference Source	Source
Metribuzin										
	Daphnia magna	Water flea	EC50	ITX	IMBL	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
	Navicula pelliculosa	Diatom	EC50	POP	ABND	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
	No aquatic invertebrate toxicity data, used cladoceran LC50									
	fish is Munn and Gilliom (2001)									
desethyl Atrazine										
	no cladoceran toxicity data									
	Chlorella fusca	Green algae	EC50			Kotrikla, A., T. Lekkas, and G. Bletsa	1997	Toxicity of the Herbicide Atrazine, Two of Its Degradation Products and the Herbicide Metolachlor in Photosynthetic Microorganisms	Fresenius Environ.Bull. 6:502-507	
	No aquatic invertebrate toxicity data									
	no fish toxicity data									
Deisopropyl atrazine										
	no cladoceran toxicity data									
	Anabaena variabilis	Blue-green algae	EC50/			Stratton, G.W.	1984	Effects of the Herbicide Atrazine and its Degradation Products, Alone and in Combination, on Phototrophic Microorganisms	Arch.Environ.Contam.Toxicol. 13(1):35-42	
	No aquatic invertebrate toxicity data									
	no fish toxicity data									
AMPA										
	no data									
Alpha BHC										
	Daphnia magna	Water flea	EC50		PROG	Canton, J.H., P.A. Greve, and W. Stooff	1975	A Laboratory Model System for the Study of the Accumulation of Chemicals in the Aquatic Food Chain, Exemplified on alpha-Hexachlorocyclohexane	In: Proc.Int.Symp., Recent Advances in the Assessment of the Health Effects of Environmental Pollution, Commission of the European Communities, Luxembourg :1479-1489	
	Chlorella pyrenoidosa	Green algae	EC50		ABND	Canton, J.H., P.A. Greve, and W. Stooff	1975	A Laboratory Model System for the Study of the Accumulation of Chemicals in the Aquatic Food Chain, Exemplified on alpha-Hexachlorocyclohexane	In: Proc.Int.Symp., Recent Advances in the Assessment of the Health Effects of Environmental Pollution, Commission of the European Communities, Luxembourg :1479-1489	
	Cloeon dipterum	Mayfly	LC50*		MORT	Hashimoto, Y., and Y. Nishiuchi	1981	Establishment of Bioassay Methods for the Evaluation of Acute Toxicity of Pesticides to Aquatic Organisms	J.Pestic.Sci. 6(2):257-264 (JPN) (ENG ABS)	
	Carassius auratus	Goldfish	LC50*		MORT	Hashimoto, Y., and Y. Nishiuchi	1981	Establishment of Bioassay Methods for the Evaluation of Acute Toxicity of Pesticides to Aquatic Organisms	J.Pestic.Sci. 6(2):257-264 (JPN) (ENG ABS)	
Lindane										
	Daphnia magna	Water flea	EC50	~ACC	ELIM	Hartgers, E.M., E.H.W. Heugens, and J.W. Deneer	1999	Effect of Lindane on the Clearance Rate of Daphnia magna	Arch.Environ.Contam.Toxicol. 36(4):399-404	
	Chlamydomonas reinhardtii	Green algae	EC50	POP	GPOP	Schafer, H., H. Hettler, U. Fritsche, G. Pitzen, G. Roderer, and A. Wenzel	1994	Biotests Using Unicellular Algae and Ciliates for Predicting Long-Term Effects of Toxicants	Ecotoxicol.Environ.Saf. 27(1):64-81	
	Limnephilus lunatus	Caddisfly	LC50	MOR	MORT	Schulz, R., and M. Liess	1995	Chronic Effects of Low Insecticide Concentrations on Freshwater Caddisfly Larvae	Hydrobiologia 299(2):103-113	
	Salmo trutta	Brown trout	LC50*	MOR	MORT	Macek, K.J., and W.A. McAllister	1970	Insecticide Susceptibility of Some Common Fish Family Representatives	Trans.Am.Fish.Soc. 99(1):20-27 (Publ in Part As 6797)	
Methoxychlor										
	Daphnia pulex	Water flea	EC50	ITX	IMBL	Mayer, F.L.Jr., and M.R. Ellersieck	1986	Manual of Acute Toxicity: Interpretation and Data Base for 410 Chemicals and 66 Species of Freshwater Animals	Resour.Publ.No.160, U.S.Dep.Interior, Fish Wildl.Serv., Washington, DC :505 p. (USGS Data File)	
	Taeniopteryx nivalis	Stonefly	LC50	MOR	MORT	Bender, M.E., and P.E. Eisele	1971	Long Term Effects of Pesticides on Stream Invertebrates	Office Water Resour.Res., U.S.D.I., OWRR Project No.A-029-Mich:28 p.(U.S.NTIS PB-206692)	
	Oncorhynchus tshawytscha	Chinook salmon	LC50	MOR	MORT	Schoettger, R.A.	1970	Fish-Pesticide Research Laboratory: Progress in Sport Fishery Research	U.S.Dep.Interior, Bur.Sport Fish.Wildl.Res., Publ. 106:2-40 (Publ in Part As 6797)	
Diazinon										
	Daphnia magna	Water flea	EC50			Dortland, R.J.	1980	Toxicological Evaluation of Parathion and Azinphosmethyl in Freshwater Model Ecosystems	Versl.Landbouwkd.Onderz 898:1-112 (Author Communication Used)	PAN
	Pseudokirchneriella subcapitata	Green algae	EC50			Kikuchi, M.	1993	Toxicity Evaluation of Selected Pesticides Used in Golf Links by Algal Growth Inhibition Test	J.Japan Soc.Water Environ.16(10):704-710 (JPN) (ENG ABS)	PAN
	Chironomus tentans	Midge	LC50			Morgan, H.G.	1976	Sublethal Effects of Diazinon on Stream Invertebrates	Ph.D.Thesis, University of Guelph, Guelph, Ontario, Canada:157 p.; Diss.Abstr.Int.B Sci.Eng.38(1):125 (1977)	PAN
	Munn and Gilliom									
Chlorpyrifos										
	Simocephalus vetulus	Water flea	EC50	POP	ABND	Van Wijngaarden, R.P.A., P.J. Van den Brink, S.J.H. Crum, J.H. Oude Voshaar, T.C.M. Brock, and P. Leeuwangh	1996	Effects of the Insecticide Dursban 4E (Active Ingredient Chlorpyrifos) in Outdoor Experimental Ditches: I. Comparison of Short-Term Toxicity Between	Environ.Toxicol.Chem. 15(7):1133-1142	
	Dunaliella tertiolecta	Green algae	EC50*	PHY	PSYN	Samson, G., and R. Popovic	1988	Use of Algal Fluorescence for Determination of Phytotoxicity of Heavy Metals and Pesticides as Environmental Pollutants	Ecotoxicol.Environ.Saf. 16(3):272-278	
	Chironomus thummi	Midge	LC50	MOR	MORT	Hooftman, R.N., K. Van de Guchte, and C.J. Roghair	1993	Development of Ecotoxicological Test Systems to Assess Contaminated Sediments	Project B6/8995, The Netherlands Integrated Program on Soil Research (PCB) :41	
	Cyprinus carpio		LC50	MOR	MORT	Dutt, N., and R.S. Guha	1988	Toxicity of Few Organophosphorus Insecticides to Fingerlings of Bound Water Fishes, Cyprinus carpio (Linn.) and Tilapia mossambica Peters	Indian J.Entomol. 50(4):403-421	

Compound	Species	Taxonomic Group	Endpoint	Effect	Effect Measure-ment	Author	Year	Title	Reference Source	Source
Azinophos methyl										
	Daphnia magna	Water flea	EC50	ITX	IMBL	Dortland, R.J.	1980	Toxicological Evaluation of Parathion and Azinphosmethyl in Freshwater Model Ecosystems	Versl.Landbouwkd.Onderz 898:1-112 (Author Communication Used)	
	no algal toxicity data									
	Gammarus fasciatus	Scud	LC50	MOR	MORT	Mayer, F.L.Jr., and M.R. Ellersieck	1986	Manual of Acute Toxicity: Interpretation and Data Base for 410 Chemicals and 66 Species of Freshwater Animals	Resour.Publ.No.160, U.S.Dep.Interior, Fish Wildl.Serv., Washington, DC :505 p. (USGS Data File)	
	Esox lucius	Northern pike	LC50	MOR	MORT	Mayer, F.L.Jr., and M.R. Ellersieck	1986	Manual of Acute Toxicity: Interpretation and Data Base for 410 Chemicals and 66 Species of Freshwater Animals	Resour.Publ.No.160, U.S.Dep.Interior, Fish Wildl.Serv., Washington, DC :505 p. (USGS Data File)	
Malathion										
	Daphnia magna	Water flea	EC50	ITX	IMBL	Rawash, I.A., I.A. Gaaboub, F.M. El-Gayar, and A.Y. El Shazli	1975	Standard Curves for Nuvacron, Malathion, Sevin, DDT and Kelthane Tested Against the Mosquito Culex pipiens L. and the Microcrustacean Daphnia magna	Toxicology 4(2):133-144 (Author Communication Used)	
	Dunaliella tertiolecta	Green algae	EC50	POP	PSYN	McFeters, G.A., P.J. Bond, S.B. Olson, and Y.T. Tchan	1983	A Comparison of Microbial Bioassays for the Detection of Aquatic Toxicants	Water Res. 17(12):1757-1762	
	Isoperla sp.	Stonefly	LC50	MOR	MORT	Mayer, F.L.Jr., and M.R. Ellersieck	1986	Manual of Acute Toxicity: Interpretation and Data Base for 410 Chemicals and 66 Species of Freshwater Animals	Resour.Publ.No.160, U.S.Dep.Interior, Fish Wildl.Serv., Washington, DC :505 p. (USGS Data File)	
Terbufos										
	Daphnia magna	Water flea	EC50	ITX	IMBL	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
	no algal toxicity data									
	Gammarus pseudolimnaeus	Scud	LC50	MOR	MORT	Howe, G.E., L.L. Marking, T.D. Bills, J.J. Rach, and F.L. Mayer Jr.	1994	Effects of Water Temperature and pH on Toxicity of Terbufos, Trichlorfon, 4-Nitrophenol and 2,4-Dinitrophenol to the Amphipod Gammarus pseudolimnaeus and Rainbow Trout (Oncorhynchus mykiss)	Environ.Toxicol.Chem. 13(1):51-66	
	Lepomis macrochirus	Bluegill	LC50	MOR	MORT	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
Pyridaben										
	Daphnia magna	Water flea	EC50	ITX	IMBL	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
	Cyprinodon variegatus	Sheepshead minnow	LC50	MOR	MORT	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
	Americanysis bahia	Oposum Shrimp	LC50	MOR	MORT	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	PAN
	Oncorhynchus mykiss	Rainbow trout, donaldson trout	LC50	MOR	MORT	Office of Pesticide Programs	2000	Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB))	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	
Dimethoate										
	Daphnia magna	Water flea	EC50	ITX	IMBL	Beusen, J.M., and B. Neven	1989	Toxicity of Dimethoate to Daphnia magna and Freshwater Fish	Bull.Environ.Contam.Toxicol. 42(1):126-133	
	Chlamydomonas noctigama	Green algae	EC50	POP	GPOP	Kallqvist, T., and R. Romstad	1994	Effects of Agricultural Pesticides on Planktonic Algae and Cyanobacteria - Examples of Interspecies Sensitivity Variations	Norw.J.Agric.Sci.Suppl. 13:117-131	
	Cyclops strenuus	Cyclopoid copepod	LC50	MOR	MORT	Aboul-Ela, I.A., and M.T. Khalil	1987	The Acute Toxicity of Three Pesticides on Organisms of Different Trophic Levels as Parameters of Pollution in Lake Wadi El Rayan. El Fayoum, Egypt	Proc.Zool.Soc.A.R.Egypt 13:31-36	
	Salmo trutta	Brown trout	LC50	MOR	MORT	Grande, M., S. Andersen, and D. Berge	1994	Effects of Pesticides on Fish. Experimental and Field Studies	Norw.J.Agric.Sci. Suppl.13:195-209	
Aldicarb										
	Daphnia laevis	Water flea	EC50	ITX	IMBL	Foran, J.A., P.J. Germuska, and J.J. Delfino	1985	Acute Toxicity of Aldicarb, Aldicarb Sulfoxide, and Aldicarb Sulfone to Daphnia laevis	Bull.Environ.Contam.Toxicol. 35(4):546-550 (OECDG Data File	PAN
	Chironomus thummii	Midge	LC50	MOR	MORT	Suorsa, K.E., and S.W. Fisher	1986	Effects of pH on the Environmental Fate of [14C]Aldicarb in an Aquatic Microcosm	Ecotoxicol.Environ.Saf. 11(1):81-90	PAN
	Lepomis macrochirus	Bluegill	LC50	MOR	MORT	Johnson, W.W., and M.T. Finley	1980	Handbook of Acute Toxicity of Chemicals to Fish and Aquatic Invertebrates	Resour.Publ.137, Fish Wildl.Serv., U.S.D.I., Washington, D.C :98 p. (OECDG Data File)	PAN
Methomyl										
	Daphnia magna	Crustaceans	EC50	ITX	IMBL	Mayer, F.L.Jr., and M.R. Ellersieck	1986	Manual of Acute Toxicity: Interpretation and Data Base for 410 Chemicals and 66 Species of Freshwater Animals	Resour.Publ.No.160, U.S.Dep.Interior, Fish Wildl.Serv., Washington, DC :505 p. (USGS Data File)	
	Skeletonema costatum	Algae, Moss, Fungi	EC50	PHY	PSYN	Roberts, M.H.Jr., J.E. Warinner, C.F. Tsai, D. Wright, and L.E. Cronin	1982	Comparison of Estuarine Species Sensitivities to Three Toxicants	Arch.Environ.Contam.Toxicol. 11(6):681-692	
	No aquatic invertebrate data									
	Carassius auratus	Fish	LC50	MOR	MORT	Kaplan, A.M., and H. Sherman	1977	Toxicity Studies with Methyl N-(((Methylamino)Carbonyl)Oxy)-Ethanimidothioate	Toxicol.Appl.Pharmacol. 40(1):1-17 (Author Communication Used)	