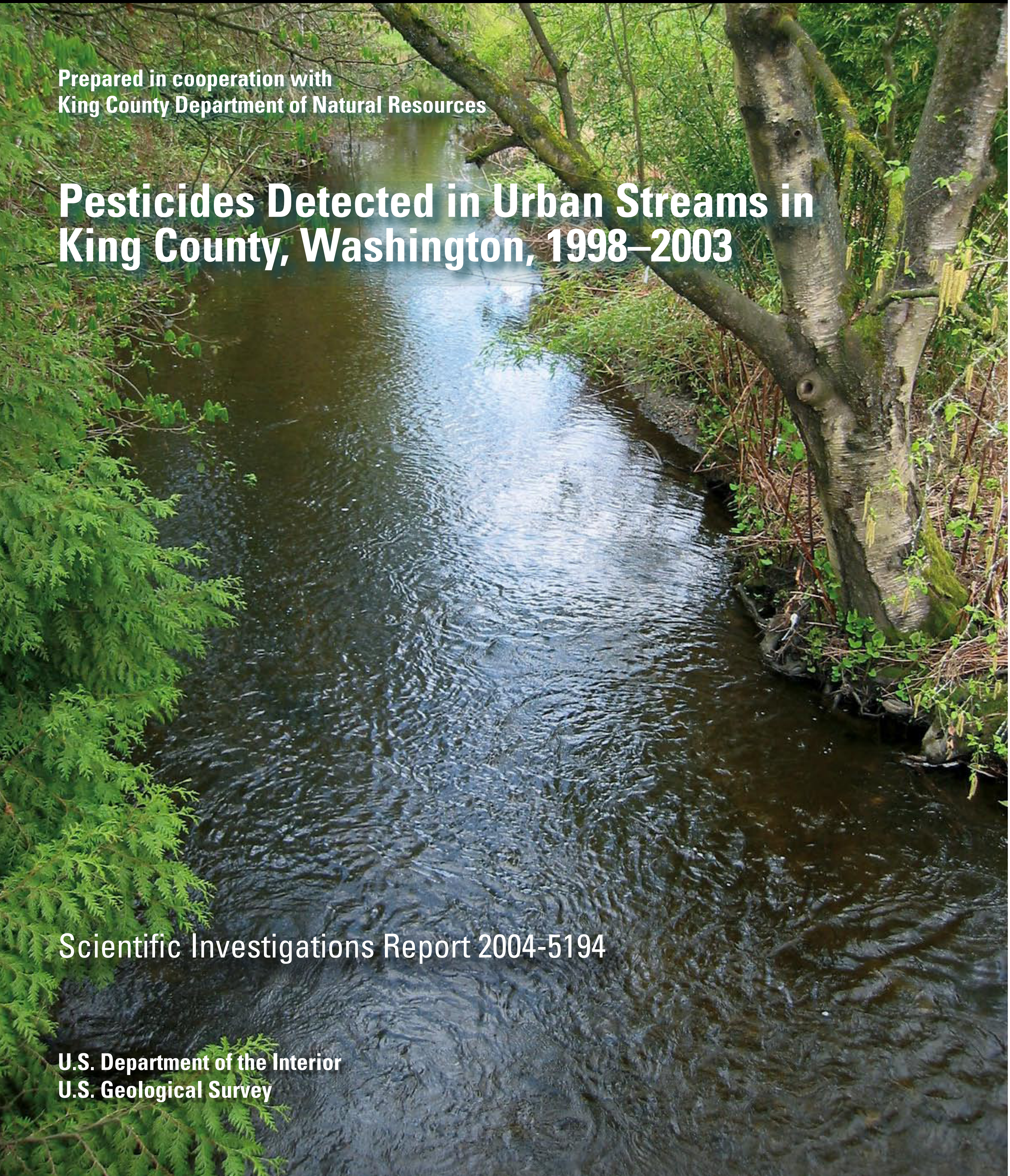

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Pesticides Detected in Urban Streams in King County, Washington, 1998–2003

Scientific Investigations Report 2004-5194

U.S. Department of the Interior
U.S. Geological Survey

Cover: View of Swamp Creek downstream (south) from the 175th Street bridge near Bothell Way.
(Photograph taken by Sara Coughlin, King County Department of Natural Resources, 2002.)

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By Lonna M. Frans

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U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of the Interior
Gale A. Norton, Secretary

U.S. Geological Survey
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Conversion Factors and Datum

Inch/Pound to SI

Multiply	By	To obtain
	Length	
mile (mi	1.609	kilometer

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L or micrograms per liter (µg/L.

Datum

Horizontal coordinate information is referenced to the North American Datum of 1927 (NAD 27.

Pesticides Detected in Urban Streams in King County, Washington, 1998–2003

By Lonna M. Frans

Abstract

The U.S. Geological Survey and the King County Department of Natural Resources collected water samples from 14 sites on urban streams in King County during storms and during base flow between 1998 and 2003. The samples were analyzed for the presence of 155 pesticides and pesticide transformation products.

Thirty-nine of the compounds were detected at least once during the study: 20 herbicides, 9 insecticides, 2 fungicides, 6 pesticide transformation products, and 2 other types of compounds. The most widespread compound was 4-nitrophenol, which was detected at all 14 sampling sites. The most frequently detected compound was pentachlorophenol, a fungicide, which occurred in more than 80 percent of the samples. The most frequently detected herbicides were prometon, trichlopyr, 2,4-D, and MCPP, and the most frequently detected insecticides were diazinon and carbaryl. All of the most frequently detected herbicides and insecticides were sold for homeowner use over the timeframe of this study.

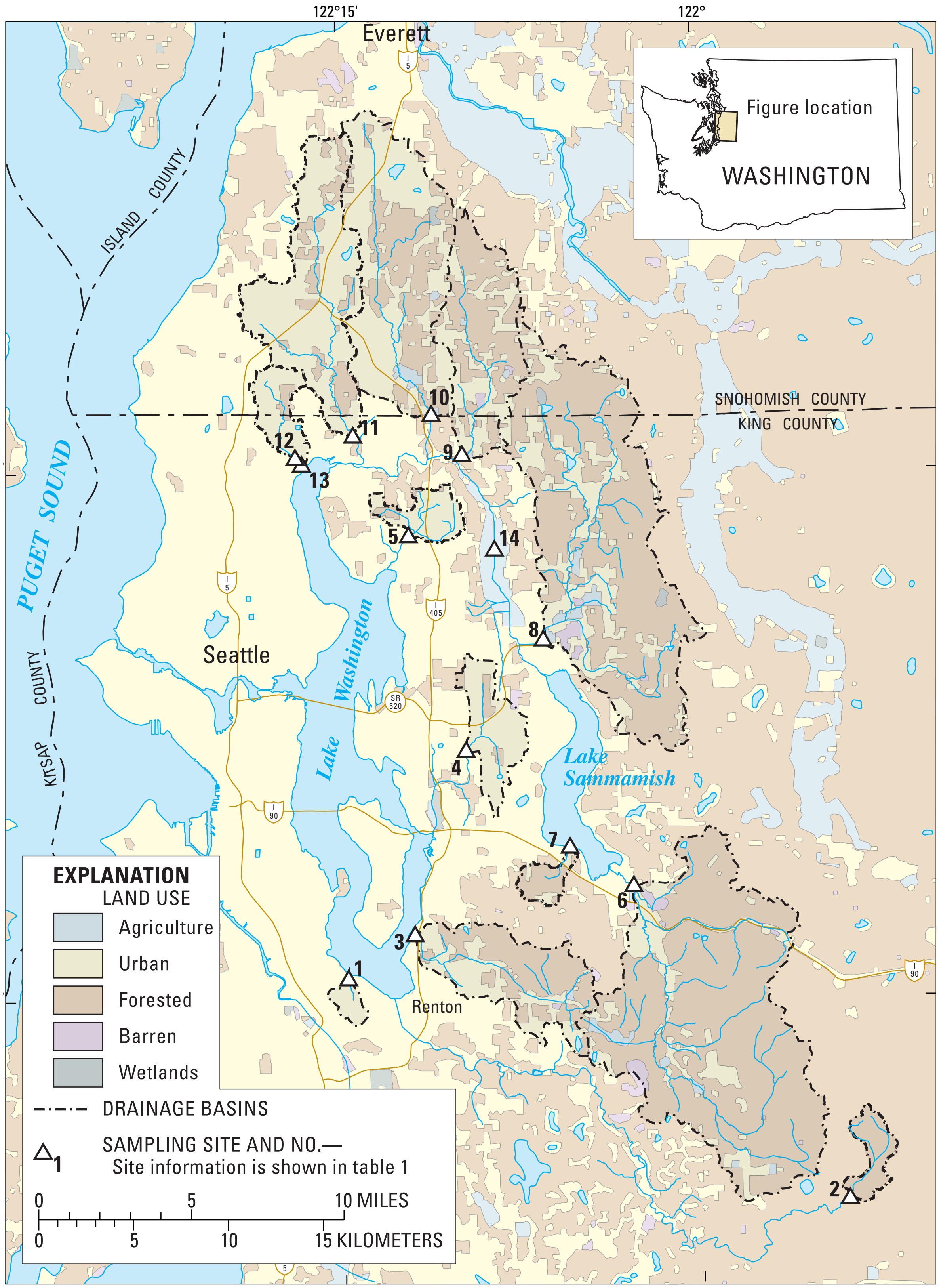
More compounds were detected during storms than during base flow, and were detected more frequently and typically at high concentrations during storms. Seven compounds were detected only during storms. Most of the compounds that were detected during storms occurred more frequently during spring storms than during autumn storms.

Introduction

A wide variety of pesticides are applied each year to urban and suburban residential areas in King County, Washington. In order to assess the occurrence and distribution of these pesticides and their transformation products, the U.S. Geological Survey (USGS) and the King County Department of Natural Resources collected water samples at 14 sites on streams in the Lake Washington drainage basin in King County between 1998 and 2003 (fig. 1 and table 1). The water samples were analyzed for 155 pesticides and pesticide transformation products (hereafter referred to as pesticides) at three laboratories using three different methods.

Twelve of the sampling sites were small streams that drain generally urban areas, and one site (site 14) was a small stream running out of an urban area with potential agricultural runoff sources. The last site (site 2, Rock Creek) was in a non-urban forested area and was used as a reference site.

The purpose of this report is to describe the types and concentrations of pesticides detected at each sampling site, the effects of storms and base flow on the distribution and concentration of pesticides at the sites, and the potential sources of the pesticides present.



Base from U.S. Geological Survey digital data, 1:100,000, 1983
Universal Transverse Mercator projection, Zone 10 Datum NAD27

Figure 1. Location of sites sampled for pesticides and pesticide transformation products on urban streams in King County, Washington, 1998–2003.

Table 1. Sites sampled for pesticides and pesticide transformation products in King County, Washington, 1998-2003.

Site No. (see fig. 1 for location)	USGS station No.	Site name
1	12113499	Taylor Creek
2	12117695	Rock Creek
3	12119600	May Creek
4	12119990	Kelsey Creek
5	12120480	Juanita Creek
6	12121600	Issaquah Creek
7	12121750	Lewis Creek
8	12124500	Bear Creek
9	12125500	Little Bear Creek
10	12126200	North Creek
11	12127000	Swamp Creek
12	12127290	Lyon Creek at 178th
13	12127300	Lyon Creek at Lake Forest Park
14	474243122083001	Unnamed Creek @ 124th

Methods

Water samples for the pesticide analysis were collected at the sampling sites and processed at three laboratories between 1998 and 2003.

Sample Collection and Processing

Samples were collected by either manual sampling or an automated sampler (autosampler). Manual samples were collected using a US DH-81 sampler, as described by Wilde and others (1999a), except at the irrigation return, where the sample bottle was dipped directly into the flow. The samplers can hold either a 1- or 3-liter Teflon® sample bottle, and all parts of the sampler coming into contact with sample water were made of Teflon®. Samples were collected using the equal-width-increment (EWI) method, in which a transect was established across the width of the creek. Water was collected at about 10 equally spaced intervals along the transect by lowering and raising the sampler vertically through the water column. The collected water from each interval then was composited into a glass carboy. Autosamplers were installed to sample runoff during the storms from 2000 to 2003 and were triggered during a rainstorm when the level of the creek rose. When the autosampler was triggered, the water sample was collected from a single point in the midpoint of the stream through a Teflon® tube into a glass carboy (Isco, Inc., 1992). Water in the streams was well mixed at the sampling point.

Except for the autosampler, all equipment used to collect and process samples was cleaned with a 0.2-percent nonphosphate detergent, rinsed with deionized water, rinsed with pesticide-grade methanol, air-dried, wrapped in aluminum foil, and stored in a dust-free environment prior to sample collection (Wilde and others, 1999b). All of the autosampler parts that contacted the sample were washed in detergent, soaked in sulfuric acid for 24 hours, rinsed with deionized water, and stored in plastic bags. All bottles used to collect stream water were rinsed thoroughly with the stream water before sample collection and processing.

The samples in the glass carboys were split using a Teflon® cone splitter into individual samples for analysis at the USGS National Water Quality Laboratory (NWQL) in Lakewood, Colorado, the USGS Organic Geochemistry Research Laboratory (OGRL) in Lawrence, Kansas (2002 and 2003 samples only), and the Washington State Department of Ecology Manchester Environmental Laboratory in Manchester, Washington, (Wilde and others, 1999c). Samples were processed within 24 hours of collection. The equipment and procedures used to collect and process samples are described by Wilde and others (1999a, 1999c). Samples collected for analysis by the USGS laboratories were filtered through a 0.7-micrometer pore-size, baked glass-fiber filter into baked amber-glass bottles and shipped on ice within 24 hours of filtration. Samples for analysis by the Manchester Environmental Laboratory were collected from the cone splitter in clear glass bottles, but were not filtered. They were stored on ice and transported to the laboratory within 24 hours of processing.

Laboratory Procedures

The samples were analyzed for 155 pesticides and pesticide transformation products (hereafter referred to as pesticides) by the three laboratories. At the NWQL, known quantities of surrogate compounds were added to each water sample and then passed through a solid-phase extraction (SPE) cartridge to extract pesticide compounds. The SPE cartridge was packed with porous silica coated with a carbon-18 organic phase. Pesticides retained on the SPE cartridges were eluted with a hexane-isopropanol mixture, which was analyzed for 52 pesticides using gas chromatography/mass spectrometry (GC/MS) with selected ion monitoring (Zaugg and others, 1995, and Madsen and others, 2003) (table 2). Fipronil and its transformation products were added to the analyte list in autumn 2002, so those compounds were analyzed for only in the final sample at Little Bear Creek, North Creek, and the irrigation return, as well as all samples from May, Kelsey, and Taylor Creeks.

At the OGRL, the samples were derivatized (converted to another chemical compound for identification) with 9-fluorenyl-methylchloroformate, passed through an SPE cartridge, and analyzed for three pesticides (table 2) using high-performance liquid chromatography/mass spectrometry (HPLC/MS) (Lee and others, 2002).

Table 2. Analytes and laboratory reporting levels for pesticides analyzed at the U.S. Geological Survey National Water Quality Laboratory or the U.S. Geological Survey Organic Geochemistry Research Laboratory.

[Trade or common name(**s**): Any use of trade, product, or firm names in this publication is for descriptive purposes only and does not imply endorsement by the U.S. Geological Survey. Type of pesticide: H, herbicide; I, insecticide; T, transformation product. –, no trade or common name or registry number; µg/L, microgram per liter]

Pesticide target analyte	Trade or common name(s)	Type of pesticide	Chemical Abstracts Service registry No.	Laboratory reporting level (µg/L)
National Water Quality Laboratory				
Acetochlor	Acenit, Sacenid	H	34256-82-1	0.006
Alachlor	Lasso	H	15972-60-8	.005
Atrazine	AAtrex	H	1912-24-9	.007
Azinphos-methyl[1]	Guthion	I	86-50-0	.050
Benfluralin	Balan, Benefin	H	1861-40-1	.010
Butylate	Sutan +, Genate Plus	H	2008-41-5	.004
Carbaryl[1]	Sevin, Savit	I	63-25-2	.041
Carbofuran[1]	Furadan	I	1563-66-2	.020
Chlorpyrifos	Lorsban	I	2921-88-2	.005
Cyanazine	Bladex	H	21725-46-2	.018
DCPA	Dacthal	H	1861-32-1	.003
4,4'-DDE	–	T	72-55-9	.003
Desethylatrazine[1]	–	T	6190-65-4	.006
Desulfinylfipronil[2]	–	T	–	.012
Desulfinylfipronil-amide[2]	–	T	–	.029
Diazinon	Several	I	333-41-5	.005
Dieldrin	Panoram D-31	I	60-57-1	.009
2,6-Diethylanaline	–	T	579-66-8	.006
Disulfoton	Di-Syston	I	298-04-4	.021
EPTC	Eptam, Eradicane	H	759-94-4	.004
Ethalfluralin	Sonalan, Curbit EC	H	55283-68-6	.009
Ethoprophos	Mocap	I	13194-48-4	.005
Fipronil[2]	Regent	I	120068-37-3	.016
Fipronil sulfide[2]	–	T	120067-83-6	.013
Fipronil sulfone[2]	–	T	120068-36-2	.024
Fonofos	Dyfonate	I	944-22-9	.003
alpha-HCH	–	I	319-84-6	.005
gamma-HCH	Lindane	I	58-89-9	.004
Linuron	Lorox, Linex	H	330-55-2	0.035
Malathion	Several	I	121-75-5	.027
Methyl parathion	Penncap-M	I	298-00-0	.015
Metolachlor	Dual, Pennant	H	51218-45-2	.013
Metribuzin	Lexone, Sencor	H	21087-64-9	.006
Molinate	Ordram	H	2212-67-1	.003
Napropamide	Devrinol	H	15299-99-7	.007
Parathion	Several	I	56-38-2	.010
Pebulate	Tillam	H	1114-71-2	.004
Pendimethalin	Prowl, Stomp	H	40487-42-1	.022
cis-Permethrin	Ambush, Pounce	I	54774-45-7	.006
Phorate	Thimet, Rampart	I	298-02-2	.011
Prometon	Pramitol	H	1610-18-0	.005
Propyzamide	Kerb	H	23950-58-5	.004
Propachlor	Ramrod	H	1918-16-7	.025
Propanil	Stampede	H	709-98-8	.011
Propargite	Comite, Omite	I	2312-35-8	.023
Simazine	Aquazine, Princep	H	122-34-9	.005
Tebuthiuron	Spike	H	34014-18-1	.016
Terbacil[1]	Sinbar	H	5902-51-2	.034
Terbufos	Counter	I	13071-79-9	.017
Thiobencarb	Bolero	H	28249-77-6	.010
Triallate	Far-Go	H	2303-17-5	.002
Trifluralin	Treflan, Trilin	H	1582-09-8	.009
Organic Geochemistry Research Laboratory				
Aminomethyl-phosphonic acid	–	T	1066-51-9	0.1
Glufosinate	Finale, Liberty	H	77182-82-2	.1
Glyphosate	Roundup	H	1071-83-6	.1

[1]Concentrations for these pesticides are qualitatively identified and reported with a J code (estimated value). J codes are used to signify estimated values for all detections that are less than the method detection limit, greater than the highest calibration standard, or otherwise less reliable than average because of sample-specific or compound-specific considerations. All J-coded data are considered to be reliable detections, but with greater than average uncertainty in quantification.

[2]These compounds were added to the method in autumn 2002.

At the Manchester Environmental Laboratory, pesticides present in the whole-water samples were extracted using methylene chloride and analyzed for 141 targeted pesticides (table 3) using U.S. Environmental Protection Agency Method 8085, which uses capillary-column GC analysis with an atomic emission detector (AED) and ion-trap GC/MS confirmation (Norman Olson, Manchester Environmental Laboratory, written commun., 1999). This method also permitted detection of several non-target compounds on certain occasions. During 2001, a portion of the water from Bear and Issaquah Creeks was filtered at the laboratory to provide a comparison of filtered and unfiltered analyses. Some pesticides were analyzed by both NWQL and Manchester Environmental Laboratory.

Table 3. Analytes and quantitation limits for pesticides analyzed at the Washington State Department of Ecology Manchester Environmental Laboratory.

[**Trade or common name(s):** Any use of trade, product, or firm names in this publication is for descriptive purposes only and does not imply endorsement by the U.S. Geological Survey. **Quantitation limit:** Limits are approximate and often are different for each sample; these values are representative of a typical sample. **Type of Pesticide:** F, fungicide; H, herbicide; I, insecticide; T, transformation product; O, other. µg/L, microgram per liter; –, none available]

Pesticide target analyte	Trade or common name(s)	Type of pesticide	Chemical Abstracts Service registry No.	Quantitation limit (µg/L)
Acifluorfen-sodium	Blazer	H	62476-59-9	0.17
Alachlor	Lasso	H	15972-60-8	.26
Aldrin	–	I	309-00-2	.035
Ametryn	Evik, Gesapax	H	834-12-8	.071
Atraton	–	H	1610-17-9	.21
Atrazine	AAtrex	H	1912-24-9	.071
Azinphos-methyl	Guthion	I	86-50-0	.12
Azinphos ethyl	Gusathion A	I	2642-71-9	.12
Benfluralin	Balan, Benefin	H	1861-40-1	.11
Bentazon	Basagran	H	25057-89-0	.063
Bromacil	Hyvar, Woprovar	H	314-40-9	.28
Bromoxynil	Bromanil, Emblem	H	1689-84-5	.042
Butachlor	Butanox, Machete	H	23184-66-9	.25
2-Butoxy-ethanol phosphate[1]	–	O	78-51-3	–
Butylate	Sutan +, Genate Plus	H	2008-41-5	.14
Caffeine[1]	–	O	58-08-2	–
Captafol	Difolatan, Foltaf	F	2425-06-1	.21
Captan	Orthocide	F	133-06-2	.14
Carbophenothion	Trithion	I	786-19-6	.80
Carboxin	Vitavax	F	5234-68-4	.78
cis-Chlordane	Terminator	I	5103-71-9	.035
trans-Chlordane	Terminator	I	5103-74-2	.035
alpha-Chlordene	–	I	56534-02-2	.043
gamma-Chlordene	–	I	56641-38-4	.035
Chlorothalonil	Daconil, Bravo	F	1897-45-6	.17
Chlorpropham	Taterpex, Sprout Nip	H	101-21-3	.28
Chlorpyrifos	Lorsban	I	2921-88-2	.055
Coumaphos	Agridip	I	56-72-4	.090
Cyanazine	Bladex	H	21725-46-2	.11
Cycloate	Sabet	H	1134-23-2	.14
2,4-D	Weed-B-Gon, Weedone	H	94-75-7	.042
2,4-DB	Venceweed, Butoxone	H	94-82-6	.050
DCPA	Dacthal	H	1861-32-1	.033
2,4’-DDD	TDE	I	53-19-0	.035
2,4’-DDE	–	T	3424-82-6	.035
4,4’-DDD	TDE	I	72-54-8	.035
4,4’-DDE	–	T	72-55-9	.035
DDMU	–	T	1022-22-6	.035
2,4’-DDT	DDT	I	789-02-6	.035
4,4’-DDT	DDT	I	50-29-3	.035
Demeton-O	–	I	298-03-3	.055
Demeton-S	–	I	126-75-0	.060
Di-allate	–	H	2303-16-4	.27
Diazinon	Several	I	333-41-5	.06
Dicamba	Banvel	H	1918-00-9	.042
Dichlobenil	Barrier, Casoron	H	1194-65-6	.16
2,6-Dichloro-benzamide[1]	–	T	2008-58-4	–
3,5-Dichlorobenzoic Acid	–	H	51-36-5	.042
Dichlorprop	2,4-DP, Seritox 50	H	120-36-5	.046
Dichlorvos	DDVP	I	62-73-7	.060
Dicofol	Kelthane	I	115-32-2	.17
Diclofop-methyl	Hoelon	H	51338-27-3	.063
Dieldrin	Panoram D-31	I	60-57-1	0.035
Dimethoate	Trounce, Roxion	I	60-51-5	.060
Dinoseb	DNBP	H	88-85-7	.063
Dioxathion	–	I	78-34-2	.12
Diphenamid	–	H	957-51-7	.21
Disulfoton	Di-Syston	I	298-04-4	.045
Diuron	Karmex, Direx	H	330-54-1	.48
Endosulfan I	Several	I	959-98-8	.035
Endosulfan II	Several	I	33213-65-9	.035
Endosulfan sulfate	–	T	1031-07-8	.035
Endrin	Hexadrin	I	72-20-8	.035
Endrin aldehyde	–	T	7421-93-4	.035
Endrin ketone	–	T	53494-70-5	.035
EPN	–	I	2104-64-5	.075
EPTC	Eptam, Eradicane	H	759-94-4	.14
Ethalfluralin	Sonalan, Curbit EC	H	55283-68-6	.11
Ethion	Ethiosul	I	563-12-2	.055
Ethofumesate[1]	Nortron, Tramat	H	26225-79-6	–
Ethoprophos	Mocap	I	13194-48-4	.060
Fenamiphos	Nemacur	I	22224-92-6	.12
Fenarimol	Rubigan	F	60168-88-9	.21
Fenitrothion	Fenitox, Rothion	I	122-14-5	.055
Fensulfothion	–	I	115-90-2	.075
Fenthion	Baytex	I	55-38-9	.055
Fluridone	Sonar	H	59756-60-4	.13
Fonofos	–	I	944-22-9	.045
alpha-HCH	–	T	319-84-6	.035
beta-HCH	–	I	319-85-7	.035
delta-HCH	–	I	319-86-8	.035
gamma-HCH	Lindane	I	58-89-9	.035
Heptachlor	Fennotox	I	76-44-8	.035
Heptachlor Epoxide	–	T	1024-57-3	.035
Hexazinone	Velpar	H	51235-04-2	.11
Ioxynil	Certrol H	H	1689-83-4	.042
Malathion	several	I	121-75-5	.060
MCPA	Metaxon, Kilsem	H	94-74-6	.083
MCPP	Mecoprop	H	93-65-2	.083
Merphos (1 & 2)	Folex	H	150-50-5	.12
Metalaxyl	Apron	F	57837-19-1	.48
Methoxychlor	Marlate	I	72-43-5	.035
Methyl chlorpyrifos	Reldan	I	5598-13-0	.050
Methyl paraoxon	–	T	950-35-6	.15
Methyl parathion	Penncap-M	I	298-00-0	.055
Metolachlor	Dual, Pennant	H	51218-45-2	.28
Metribuzin	Lexone, Sencor	H	21087-64-9	.071
Mevinphos	Phosdrin	I	7786-34-7	.075
MGK264	–	I	113-48-4	.50
Mirex	–	I	2385-85-5	.035
Molinate	Ordram	H	2212-67-1	.14
Napropamide	Devrinol	H	15299-99-7	.21
4-Nitrophenol	–	T	100-02-7	.073
cis-Nonachlor	–	I	5103-73-1	.035
trans-Nonachlor	–	I	39765-80-5	.035
Norflurazon	Evital, Solicam	H	27314-13-2	.14
Oxadiazon[1]	Ronstar, Order	H	19666-30-9	–
Oxychlordane	–	T	27304-13-8	.035
Oxyfluorfen	Goal	H	42874-03-3	.28
Parathion	several	I	56-38-2	.06
Pebulate	Tillam	H	1114-71-2	.14
Pendimethalin	Prowl, Stomp	H	40487-42-1	.11
Pentachlorophenol	PCP, Penta	F	87-86-5	.021

Table 3. Analytes and quantitation limits for pesticides analyzed at the Washington State Department of Ecology Manchester Environmental Laboratory.—Continued

[**Trade or common name(s):** Any use of trade, product, or firm names in this publication is for descriptive purposes only and does not imply endorsement by the U.S. Geological Survey. **Quantitation limit:** Limits are approximate and often are different for each sample; these values are representative of a typical sample. **Type of Pesticide:** F, fungicide; H, herbicide; I, insecticide; T, transformation product; O, other. µg/L, microgram per liter; –, none available]

Pesticide target analyte	Trade or common name(s)	Type of pesticide	Chemical Abstracts Service registry No.	Quantitation limit (µg/L)
Phorate	Thimet, Rampart	I	298-02-2	0.055
Phosmet	Imidan	I	732-11-6	.080
Phosphamidon	Dixon	I	13171-21-6	.18
Picloram	Tordon	H	1918-02-1	.042
Profluralin	–	H	26399-36-0	.17
Prometon	Pramitol	H	1610-18-0	.071
Prometryn	Caparol, Gesagard	H	7287-19-6	.071
Propyzamide	Kerb	H	23950-58-5	.28
Propachlor	Ramrod	H	1918-16-7	.17
Propazine	Prozinex	H	139-40-2	.071
Propetamphos	Safrotin	I	31218-83-4	.15
Ronnel	Fenclorphos	I	299-84-3	.055
Simazine	Gesatop, Princep	H	122-34-9	.072
Sulfotep	Bladafum	I	3689-24-5	.045
Sulprofos	Bolstar	I	35400-43-2	.055
2,4,5-T	–	H	93-76-5	.033
2,4,5-TB	–	H	93-80-1	.038
2,4,5-TP	Silvex	H	93-72-1	.033
Tebuthiuron	Spike	H	34014-18-1	.11
Temephos	Abate	I	3383-96-8	0.70
Terbacil	Sinbar	H	5902-51-2	.21
Terbutryn	Ternit	H	886-50-0	.071
2,3,4,5-Tetrachlorophenol	Dowicide 6	F	4901-51-3	.023
2,3,4,6-Tetrachlorophenol	Dowicide 6	F	58-90-2	.023
Tetrachlorvinphos	Gardona	I	961-11-5	.15
Triadimefon	Bayleton	F	43121-43-3	.18
Triallate	Far-Go	H	2303-17-5	.18
Tribufos	DEF	H	78-48-8	.11
2,4,5-Trichlorophenol	Dowicide 2	F	95-95-4	.025
2,4,6-Trichlorophenol	Dowicide 2S	F	88-06-2	.025
Triclopyr	Garlon, Grazon	H	55335-06-3	.035
Trifluralin	Treflan, Trilin	H	1582-09-8	.11
Vernolate	–	H	1929-77-7	.14

[1]Non-target analyte.

Results of Quality–Control Assessment

During the study, one equipment blank, five field blanks, and one replicate were analyzed in conjunction with environmental samples to assess bias and analytical variability. Field and equipment blanks were prepared with organic-grade water obtained from the NWQL. The blanks and replicate were subjected to all the same sample handling and processing as the environmental samples.

Pesticides were not detected in the field or equipment blanks. Concentration differences in the set of replicate samples ranged from 0.88 to 4.0 percent, as measured by relative percentage of difference, for samples analyzed by the NWQL and between 0.0 and 47.8 percent for samples analyzed by the Manchester Laboratory (table 4). The percentage of differences seem high for certain compounds, but the concentrations are very low, so even small differences in detectable concentrations can lead to large percentage of differences. Modifications were not made to the data set on the basis of these results.

Quality-control procedures for the NWQL and Manchester Environmental Laboratory included the use of laboratory reagent blanks, spikes, surrogates, internal standards, and calibration as described by Huntamer and others (1992) and by Pritt and Raese (1995).

Table 4. Concentrations and precision data for replicate samples with detections.

[**Relative percentage of difference:** Calculated as the difference between the two concentrations divided by the mean. J, estimated. µg/L, microgram per liter]

Pesticide	Concentration in replicates (µg/L)	Relative percentage of difference
U.S. Geological Survey National Water Quality Laboratory analyses		
Simazine	1.03	2.9
	1.00	
Prometon	.114	.88
	.113	
Diazinon	.194	4.0
	.202	
Carbaryl	.121J	2.5
	.118J	
Washington Department of Ecology Manchester Environmental Laboratory analyses		
2,4-D	0.34	5.7
	.36	
4-Nitrophenol	.1J	42.4
	.065J	
2,6-Dichlorobenzamide	.086J	47.8
	.14J	
Diazinon	.16	37.0
	.11	
Dicamba	.027J	29.8
	.02J	
Dichlobenil	.24	28.6
	.18	
Dichlorprop	.032J	.0
	.032J	
MCPP	.57	5.4
	.54	
Pentachlorophenol	.1	.0
	.1	
Simazine	.25	38.1
	.17	
Trichlopyr	.18	.0
	.18	

Pesticide Detections

Thirty-nine pesticides and pesticide transformation products were detected in water samples from the urban streams (table 5) (table 6, at back of report). Of the 39 analytes detected, 20 were herbicides, 9 were insecticides, 2 were fungicides, 6 were pesticide transformation products (4-nitrophenol is a transformation product of methyl parathion, 2,6-dichlorobenzamide is a transformation product of diclobenil, aminomethylphosphonic acid is a transformation product of glyphosate, desethylatrazine is a transformation product of atrazine, 4,4'-DDE is a transformation product of 4,4'-DDT, and desulfinylfipronil amide is a transformation product of fipronil), and 2 were other types of compounds (caffeine and 2-butoxy-ethanol phosphate). However, not all compounds that were detected (table 5) were analyzed for in all samples because of changes in the analytical target lists (the addition of glyphosate, fipronil, and their transformation products) or because some of the detected compounds were non-target analytes. Therefore, for the remainder of this report, only those compounds that were analyzed for at all sites are presented in comparisons of detections between sites and the rates of compound detections. Additionally, the filtered and unfiltered results are combined, so a particular compound was counted as only one detection if it was detected in both the filtered and unfiltered samples.

The most widespread compound was 4-nitrophenol, which was detected at all sampling sites (table 5), but was detected in less than one-half the samples collected (fig. 2). The fungicide pentachlorophenol was the most frequently detected compound, and was detected in more than 80 percent of the samples and at all sites except at the forested Rock Creek reference site (site 2). The herbicides prometon, trichlopyr, 2,4-D, and MCPP were present in more than 70 percent of the samples collected and also were the most widespread herbicides, as they were detected at all sites except Rock Creek. Diazinon and carbaryl were the most widespread insecticides and were detected in 12 and 10 of the streams, respectively. They also were the most frequently detected insecticides, present in more than 60 and 30 percent of samples, respectively.

The largest number of compounds at detectable concentrations, 25, was in samples from Juanita Creek (site 5), followed by 22 in samples from the Unnamed Creek (site 14) and 21 in samples from Lyon Creek at 178th (site 12). Only two compounds were detected at the Rock Creek reference site (fig. 3). One or two fungicides and transformation products were detected at all streams except Rock Creek, where fungicides were not detected. Two to three insecticides were detected at most sites; however, five or more insecticides were detected in Juanita Creek, Lyon Creek at 178th, and the Unnamed Creek. Insecticides were not detected in Taylor (site 1) and Rock Creeks. Of the classes of compounds analyzed, the detections of herbicides varied the most among sites, ranging from one at Rock Creek to 15 at Juanita Creek. Between 6 and 12 herbicides were detected at most sites. Herbicides typically make up more than 60 percent of the compounds detected in each stream (fig. 4).

Table 5. Pesticides and pesticide transformation products detected in water samples collected at sites on urban streams in King County, Washington, 1998–2003.

[**Sample site:** na, not analyzed; ×, detected; –, not detected]

Pesticide	Sample site													
	Unnamed Creek (site 14)	Juanita Creek (site 5)	Little Bear Creek (site 9)	Lyon Creek at 178th (site 12)	Lyon Creek at Lake Forest Park (site 13)	North Creek (site 10)	Lewis Creek (site 7)	Kelsey Creek (site 4)	Bear Creek (site 8)	Issaquah Creek (site 6)	Swamp Creek (site 11)	May Creek (site 3)	Taylor Creek (site 1)	Rock Creek (site 2)
4-Nitrophenol	×	×	×	×	×	×	×	×	×	×	×	×	×	×
2,4-D	×	×	×	×	×	×	×	×	×	×	×	×	×	–
MCPP	×	×	×	×	×	×	×	×	×	×	×	×	×	–
Pentachlorophenol	×	×	×	×	×	×	×	×	×	×	×	×	×	–
Prometon	×	×	×	×	×	×	×	×	×	×	×	×	×	–
Trichlopyr	×	×	×	×	×	×	×	×	×	×	×	×	×	–
Diazinon	×	×	×	×	×	×	×	×	×	×	×	×	–	–
Dicamba	×	×	×	×	×	×	×	×	–	–	–	×	×	×
Dichlobenil	×	×	×	×	×	×	×	×	×	×	×	–	–	–
Atrazine	×	×	×	×	×	×	×	–	×	×	×	–	–	–
Carbaryl	×	×	×	×	×	×	–	×	×	×	–	×	–	–
MCPA	×	×	×	×	×	–	×	×	–	×	×	–	×	–
Simazine	×	×	×	×	×	×	×	–	×	–	×	–	–	–
Malathion	×	×	×	×	–	×	×	–	×	–	×	–	–	–
2,6-Dichlorobenzamide	×	×	×	×	na	×	×	na	×	na	na	na	na	na
Diuron	×	×	×	×	–	–	–	–	×	×	–	–	–	–
Glyphosate	×	na	×	na	na	×	na	×	na	na	na	×	×	na
Chlorpyrifos	×	×	–	×	×	–	×	–	–	–	–	–	–	–
Metolachlor	×	×	–	–	–	–	–	×	–	–	–	×	×	–
Trifluralin	×	×	–	–	×	–	–	×	–	×	–	–	–	–
Desethylatrazine	–	–	×	–	×	–	×	–	×	–	–	–	–	–
Dichlorprop	×	×	×	×	–	–	–	–	–	–	–	–	–	–
Tebuthiuron	×	–	×	–	×	×	–	–	–	–	–	–	–	–
Aminomethylphosphonic acid	×	–	×	na	na	–	na	×	na	na	na	na	na	na
Bromacil	–	×	×	–	×	–	–	–	–	–	–	–	–	–
Caffeine	×	na	×	na	na	×	na	na	na	na	na	na	na	na
4,4’-DDD	–	×	–	×	–	–	–	–	–	–	–	–	–	–
4,4’-DDE	–	×	–	×	–	–	–	–	–	–	–	–	–	–
4,4’-DDT	–	×	–	×	–	–	–	–	–	–	–	–	–	–
EPTC	–	×	–	–	–	–	×	–	–	–	–	–	–	–
Napropamide	–	–	×	×	–	–	–	–	–	–	–	–	–	–
2-butoxy-ethanol phosphate	na	na	na	na	na	na	na	na	na	×	na	na	na	na
Carbofuran	na	na	na	na	na	na	na	–	–	–	–	–	–	–
Desulfinylfipronil amide	na	na	na	na	na	na	na	×	na	na	na	–	–	na
Ethofumesate	×	na	na	na	na	na	na	na	na	na	na	na	na	na
Fipronil	na	na	na	na	na	na	na	×	na	na	na	na	na	na
gamma-HCH	–	×	–	–	–	–	–	–	–	–	–	–	–	–
Metalaxyl	×	–	–	–	–	–	–	–	–	–	–	–	–	–
Oxadiazon	×	na	na	na	na	na	na	na	na	na	na	na	na	na

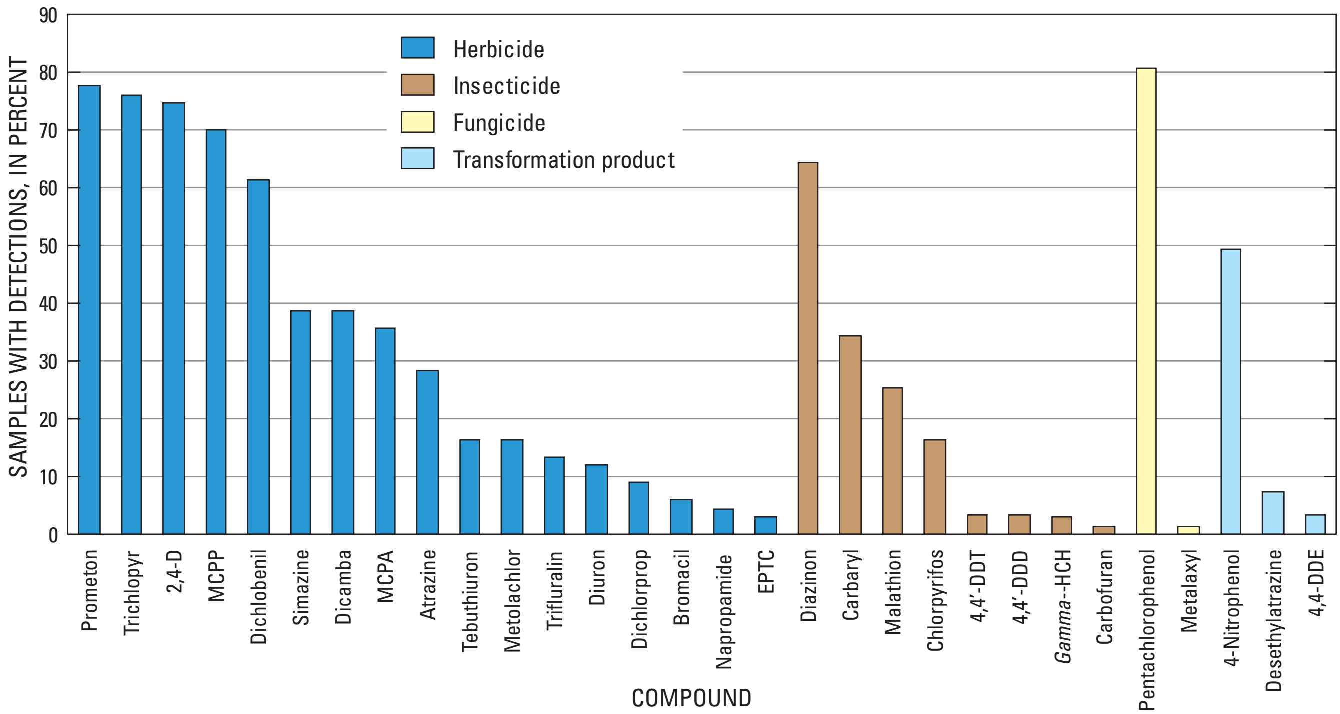


Figure 2. Percentage of samples with detections of pesticides in urban streams in King County, Washington, 1998–2003.

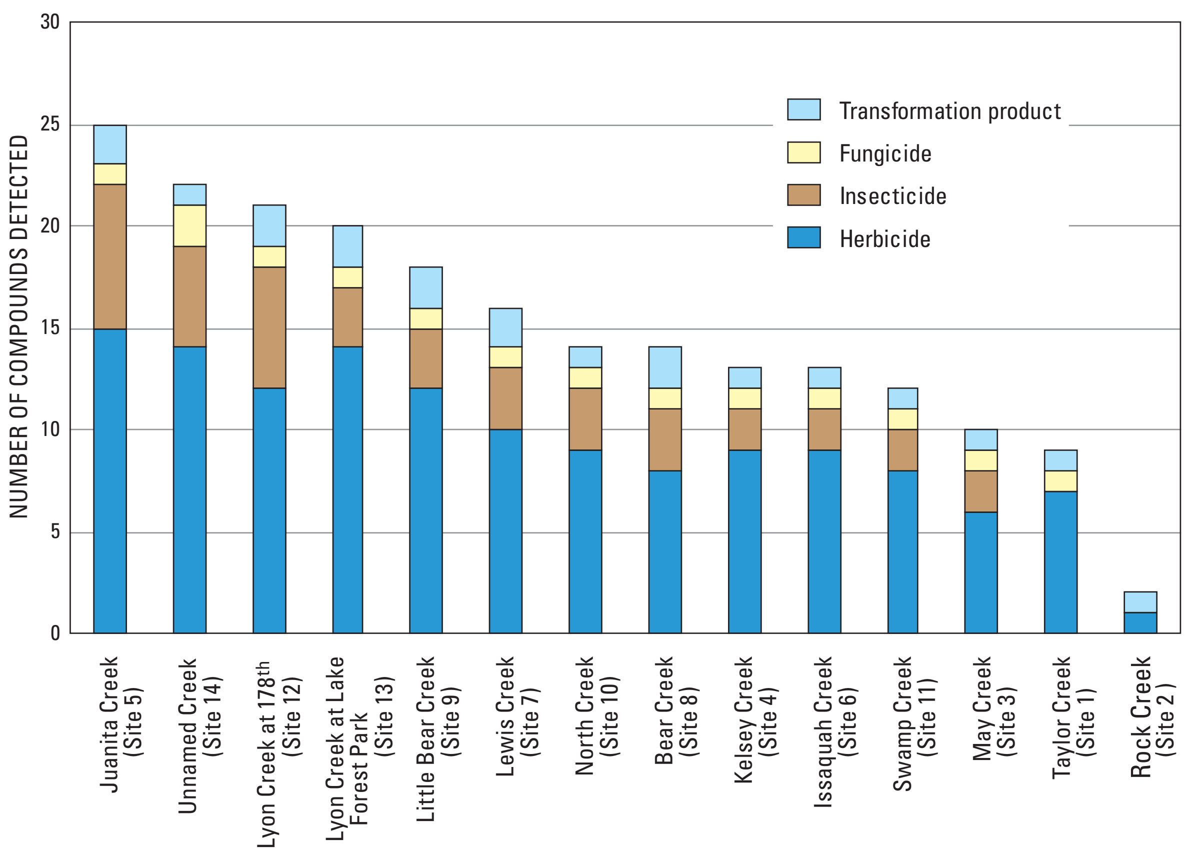


Figure 3. Number of compounds detected for each class of pesticides at sampling sites on urban streams in King County, Washington, 1998–2003.

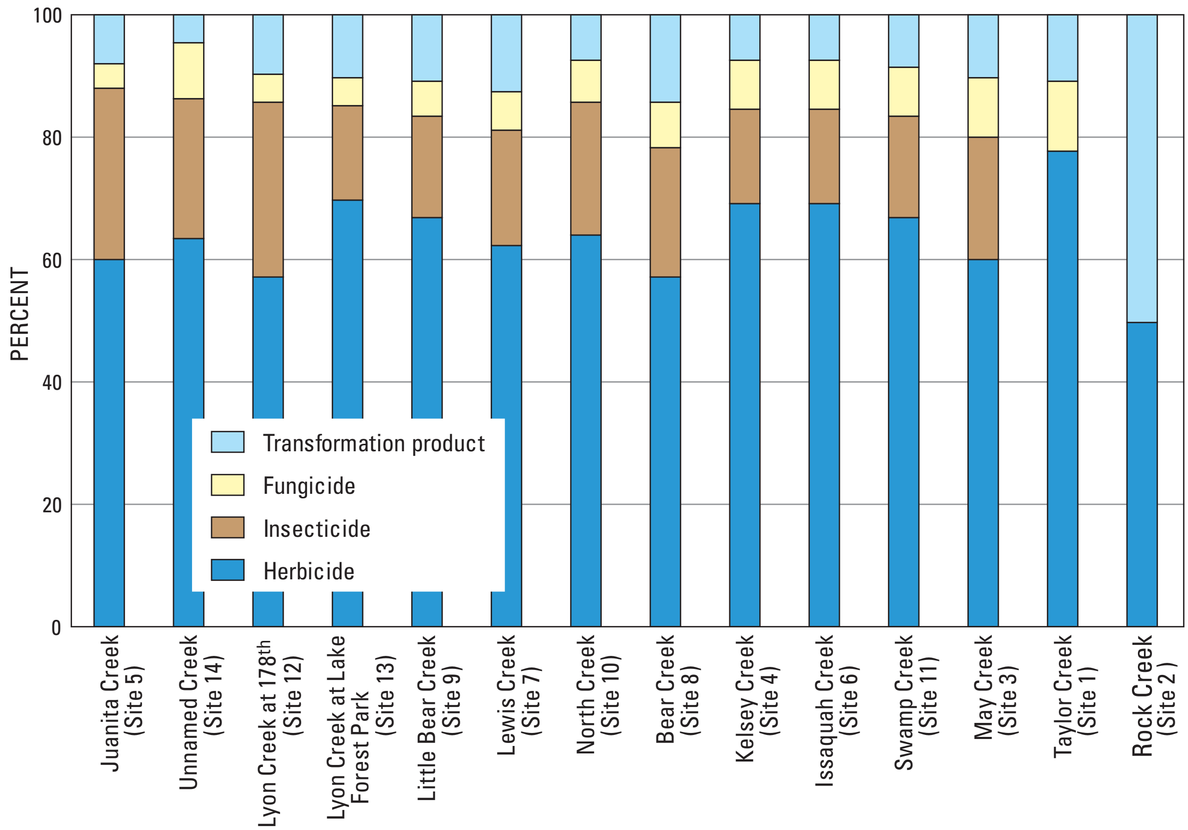


Figure 4. Percentage of each class of pesticides detected at sampling sites on urban streams in King County, Washington, 1998–2003.

Effect of Storms on Pesticide Detections

More compounds were detected during storms than during base flow, and they were detected more frequently and typically at high concentrations (fig. 5). Seven of the compounds were detected only during storms and two were detected only during base flow. All other compounds were detected under both conditions. For most compounds, the percentage of samples with detections also was higher during storms than during base flow. This is likely due to the increased flushing of the pesticides into the streams during storm events.

Eighteen of 28 compounds that were detected during storms occurred more frequently during spring storms than during autumn storms (fig. 6), and six of the compounds were not detected during autumn storms at all. This pattern of detection likely reflects the timing of pesticide application, because most pesticides are applied more often in the spring as homeowners begin working in their yards.

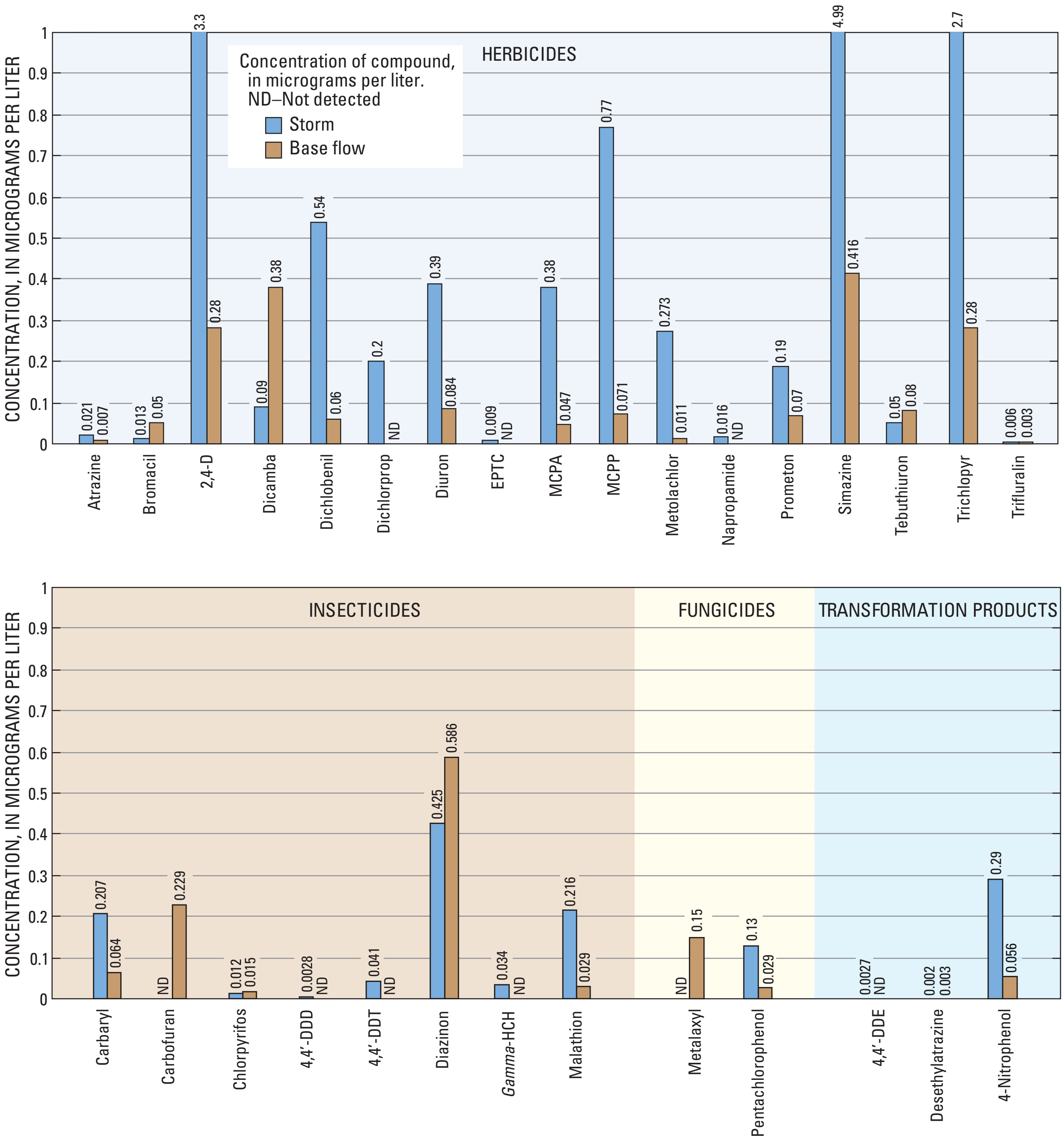


Figure 5. Maximum concentrations of pesticides and pesticide transformation products detected during storms and during base flow at sampling sites on urban streams in King County, Washington, 1998–2003.

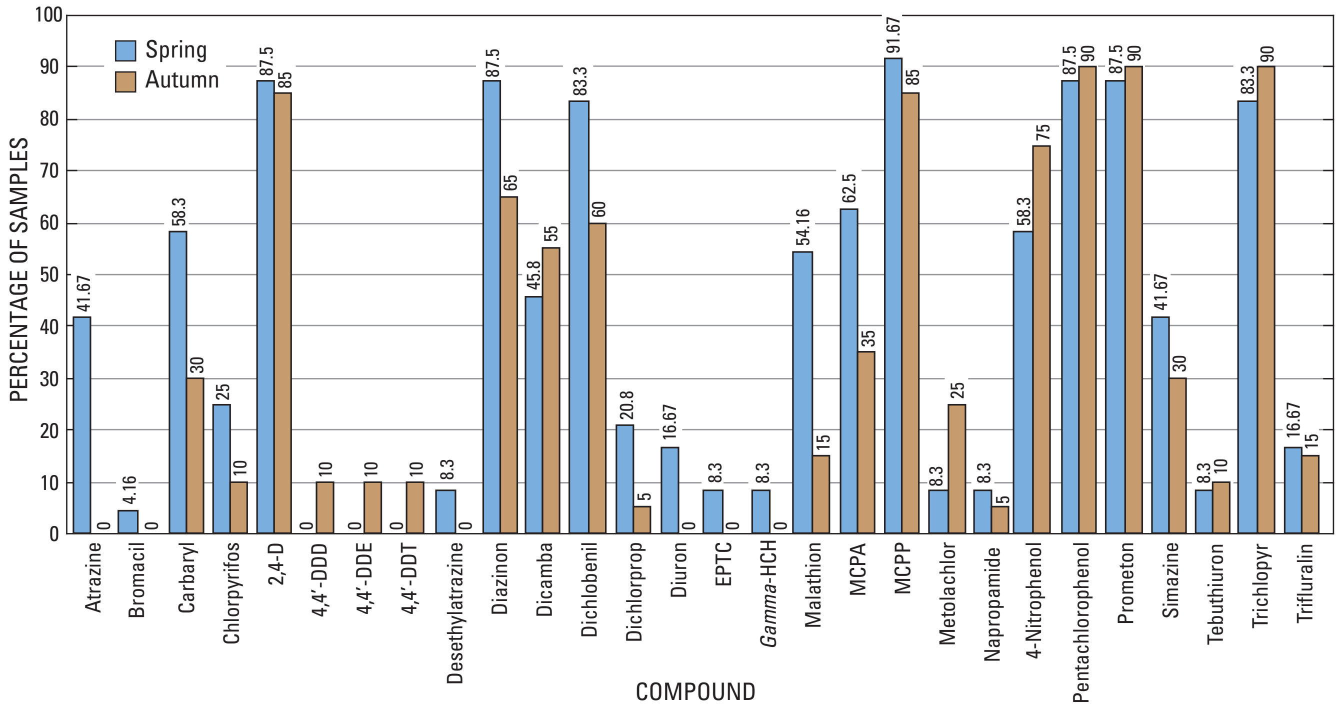


Figure 6. Percentage of samples with pesticide detections in urban streams in King County, Washington, during spring and autumn storms, 1998–2003.

Potential Pesticide Sources

Residential use of pesticides is a possible major source for the most frequently detected compounds in the urban streams. Homeowners typically use pesticides for lawn and shrub care and for insect control around their property. For example, dichlobenil is a commonly used herbicide for weed control around woody shrubs and trees, and the popular insecticide diazinon is used to control ants, aphids, beetles, and other insects. Six of the seven most frequently detected pesticides (2,4-D, diazinon, dichlobenil, MCPP, prometon, and triclopyr) are currently sold for residential use or, in the case of diazinon, were just recently banned (Voss and Embrey, 2000, and Phillip Dickey, Washington Toxics Coalition, written commun., 2004). The other most frequently detected pesticide, pentachlorophenol, likely does not originate from residential application. Pentachlorophenol is a common wood preservative that is used in pressure treatment of wood for uses such as utility poles and railroad ties. Several other pesticides that were detected (carbaryl, dicamba, glyphosate, malathion, MCPA, EPTC) also are sold in King County home and garden stores, and thus are available for residential use (Voss and Embrey, 2000, and Phillip Dickey, Washington Toxics Coalition, written commun., 2004). Although their sale is now banned for homeowner use, chlorpyrifos, which was detected at five sites, was available for retail sale until 2001 and diazinon was available until 2003. Carbaryl sales increased substantially in 2002 as a replacement insecticide for chlorpyrifos and diazinon (Phillip Dickey, Washington Toxics Coalition, written commun., 2004). As a result of the phase out of chlorpyrifos and diazinon, their rates of detection likely will decrease in the future as homeowners use up any remaining stock that they have.

It is difficult to distinguish which of the pesticides detected in Unnamed Creek samples (site 14) are the result of urban application and which are the result of agricultural application because the irrigation-return water contains both urban and agricultural sources of water. The turf farm withdraws water from the Sammamish River for irrigation use and returns the water through a small stream that runs out of an urban area and then feeds into a ditch. However, of the four compounds detected only in the Unnamed Creek sample (ethofumesate, oxadiazon, carbofuran, and metalaxyl), none of them has recorded retail sales in King County and they are most often associated with agricultural applications.

Summary

The U.S. Geological Survey and the King County Department of Natural Resources assessed the occurrence and distribution in urban streams in King County, Washington, of pesticides applied in urban and suburban residential areas. Water samples collected between 1998 and 2003 from 13 sites on urban streams and 1 reference site on a stream in a forested area were analyzed for the presence of 155 pesticides and pesticide transformation products during storms and during base flow.

Samples were collected by either manual sampling or an automated sampler and were analyzed at the U.S. Geological Survey's National Water Quality Laboratory and Organic Geochemistry Research Laboratory and the Washington State Department of Ecology Manchester Environmental Laboratory.

Of the 155 compounds analyzed for, 39 were detected at least once during the study. Twenty of the compounds were herbicides, nine were insecticides, two were fungicides, six were transformation products, and two were other types of compounds. Only 4-nitrophenol was detected at all 14 sampling sites. Pentachlorophenol, a fungicide, was the most frequently detected compound, occurring in more than 80 percent of the samples. The most frequently detected herbicides were prometon, trichlopyr, 2,4-D, and MCPP, and the most frequently detected insecticides were diazinon and carbaryl. All of the most frequently detected herbicides and insecticides were sold for homeowner use over the timeframe of this study.

More compounds were detected during storms than during base flow, and seven compounds were detected only during storm events. Compounds also were detected more frequently and typically at high concentrations during storms. Most of the compounds that were detected during storms occurred more frequently during spring storms than during autumn storms.

Residential use of pesticides by homeowners is a possible major source for the most frequently detected compounds in the urban streams. Four compounds that were detected only in samples from the site on an irrigation return are most often associated with agricultural applications rather than residential use.

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Table 6. Concentrations of pesticides and pesticide transformation products detected in stream water samples during storms and during baseflow at sites on streams in King County, Washington, 1998–2003.

[Locations of sites are shown in figure 1. All concentrations are in micrograms per liter. Concentrations: J, estimated value; M, identified, but value is too low to quantify; N, there is evidence that the analyte is present. <, less than; –, not analyzed]

Bear Creek (site 8)

Stream condition	Date	Collection method	2,4-D,		2,6-Dichlorobenzamide, unfiltered	4-Nitrophenol		Atrazine, filtered	Carbaryl, filtered
			filtered	unfiltered		filtered	unfiltered		
Storm	05-14-01	Auto sampler	0.083J	0.076J	0.036J	0.054J	0.0045NJ	0.003J	0.081J
Storm	10-08-01	Auto sampler	<.24	.031J	–	<.18	.14J	<.007	<.041
Base flow	06-18-01	DH-81	.14J	.15J	–	.051J	.016J	.004J	<.041
Base flow	09-17-01	DH-81	<.21	.045J	–	.046J	<.31	<.007	<.041

Stream condition	Date	Collection method	Desethylatrazine, filtered	Diazinon		Dichlobenil, filtered	Diuron, filtered	Malathion, filtered	MCPP	
				filtered	unfiltered				filtered	unfitered
Storm	05-14-01	Auto sampler	0.002J	0.008	0.012J	<0.057	0.011J	<0.027	0.055J	0.065J
Storm	10-08-01	Auto sampler	<.006	.005J	.014J	.021J	<.20	.007J	<.49	<.51
Base flow	06-18-01	DH-81	.002J	<.005	<.018	.0079J	.037NJ	<.027	.028J	.023J
Base flow	09-17-01	DH-81	<.006	<.005	<.016	<.052	<.16	<.027	<.42	<.36

Stream condition	Date	Collection method	Pentachlorophenol		Prometon		Simazine		Trichlopyr	
			filtered	unfiltered	filtered	unfiltered	filtered	unfiltered	filtered	unfiltered
Storm	05-14-01	Auto sampler	0.009J	0.013J	0.01J	0.001J	<0.011	<0.031	<0.13J	0.12J
Storm	10-08-01	Auto sampler	.1J	.015J	.004J	<.14	<.011	<.14	.02J	.015J
Base flow	06-18-01	DH-81	.0038J	.0043J	.01J	<.022	.074	.065J	.0061J	.0086J
Base flow	09-17-01	DH-81	<.10	<.09	.004J	<.02	.005J	<.02	<.18	<.15

Issaquah Creek (site 6)

Stream condition	Date	Collection method	2,4-D		2-Butoxyethanol phosphate	4-Nitrophenol		Atrazine, filtered	Carbaryl, filtered	Diazinon	
			filtered	unfiltered		filtered	unfiltered			filtered	unfiltered
Storm	05-14-01	Auto sampler	0.077J	0.082J	–	0.029NJ	0.024NJ	0.002J	0.018J	<0.005	<0.022
Storm	10-08-01	Auto sampler	.4	.41	0.21NJ	.18J	<.46	<.007	<.041	.011	.025J
Baseflow	06-18-01	DH-81	<.16	<.16	–	.029J	.056J	<.007	<.041	<.005	<.017
Baseflow	09-17-01	DH-81	<.17	<.19	–	.038J	.032J	<.007	<.041	<.005	<.016

Stream condition	Date	Collection method	Dichlobenil		Diuron		MCPA		MCPP	
			filtered	unfiltered	filtered	unfiltered	filtered	unfiltered	filtered	unfiltered
Storm	05-14-01	Auto sampler	<0.053	<0.054	0.24NJ	0.11NJ	<0.50	<0.45	0.076J	0.057J
Storm	10-08-01	Auto sampler	.08	.21	<.19	<.19	.05J	.073J	.33J	.39J
Baseflow	06-18-01	DH-81	<.042	<.039	<.13	<.13	<.32	<.32	<.32	<.32
Baseflow	09-17-01	DH-81	<.042	<.042	<.13	<.12	<.35	<.38	<.35	<.38

Stream condition	Date	Collection method	Pentachlorophenol		Prometon		Trichlopyr		Trifluralin, filtered
			filtered	unfiltered	filtered	unfiltered	filtered	unfiltered	
Storm	05-14-01	Auto sampler	0.023J	0.04J	0.01J	0.0071J	0.037J	0.04J	<0.009
Storm	10-08-01	Auto sampler	.06J	.078J	.01J	<.031	.06J	.063J	.004J
Baseflow	06-18-01	DH-81	.0048J	.0045J	<.01	<.021	.0045J	.0055J	<.009
Baseflow	09-17-01	DH-81	<.087	<.095	<.01	<.019	<.15	<.16	<.009

Table 6. Concentrations of pesticides and pesticide transformation products detected in stream water samples during storms and during baseflow at sites on streams in King County, Washington, 1998–2003.—Continued

[Locations of sites are shown in figure 1. All concentrations are in micrograms per liter. Concentrations: J, estimated value; M, identified, but value is too low to quantify; N, there is evidence that the analyte is present. <, less than; –, not analyzed]

Juanita Creek (site 5)

Stream condition	Date	Time	Collection method	2,4-D, unfiltered	2,6-Dichloro-benzamide, unfiltered	4,4′-DDD, unfiltered	4,4′-DDE, unfiltered	4,4′-DDT, unfiltered	4-Nitrophenol, unfiltered	Atrazine, filtered	Bromacil, unfiltered	Carbaryl, filtered
Storm	04-23-98	1340	DH-81	1.0	0.005NJ	–	–	–	0.29	<0.001	<0.079	<0.003
Storm	04-23-98	1930	DH-81	.63	.008NJ	–	–	–	.25	.004	<.082	.022J
Storm	04-23-98	2110	DH-81	.59	<.081	–	–	–	.22	<.001	<.081	.017J
Storm	06-24-99	0750	DH-81	.52	.1J	<0.011	<0.011	<0.011	.086J	<.001	<.079	.023J
Storm	10-08-99	0930	DH-81	.64	.016J	<.011	<.011	<.011	<.14	<.001	<.082	.026J
Storm	11-16-99	1030	DH-81	.03J	–	.0028J	.0027J	.084J	.098NJ	<.001	<.081	<.003
Baseflow	08-17-99	1040	DH-81	.11	.1J	<.011	<.011	.002J	<.14	.005	.009J	<.003

Stream condition	Date	Time	Chlorpyrifos, unfiltered	Diazinon		Dicamba, unfiltered	Dichlobenil, unfiltered	Dichlorprop, unfiltered	Diuron, unfiltered	EPTC, filtered	Lindane, filtered	Malathion, filtered
				filtered	unfiltered							
Storm	04-23-98	1340	–	0.242	–	0.09	0.081J	<0.046	<0.16J	<0.002	<0.004	0.087
Storm	04-23-98	1930	–	.276	–	.034J	.54	<.045	<.12J	<.010	.034	.073
Storm	04-23-98	2110	–	.309	–	.041	.18	<.045	<.12J	.009	.03	.071
Storm	06-24-99	0750	0.004NJ	.182	0.14	.025J	.31	.021J	.39NJ	<.002	<.004	<.010
Storm	10-08-99	0930	.002NJ	.179	.12	.028J	.062	<.086	<.12	<.002	<.004	.01
Storm	11-16-99	1030	<.016	.013	.015J	<.083	.039	.013NJ	<.12	<.002	<.004	<.005
Baseflow	08-17-99	1040	<.016	.014	.021J	<.079	.014J	<.087	<.12J	<.002	<.004	<.005

Stream condition	Date	Time	Malathion, unfiltered	MCPA, unfiltered	MCPP, unfiltered	Metolachlor, filtered	Pentachlorophenol, unfiltered	Prometon		Simazine, filtered	Trichlopyr, unfiltered	Trifluralin, filtered
								filtered	unfiltered			
Storm	04-23-98	1340	–	0.38	0.74	<0.002	0.04NJ	0.05	<0.02	<0.005	0.037NJ	0.002J
Storm	04-23-98	1930	–	.12	.39	<.002	.076	.09	<.02	.014	.17	.003J
Storm	04-23-98	2110	–	.14	.44	.004	.077	.08	<.02	.026	.1	.003J
Storm	06-24-99	0750	0.004NJ	.025NJ	.69	.142	.11	.08	.017J	<.005	.29	.006
Storm	10-08-99	0930	<.016	.092J	.37	<.002	.11	.09	<.02	.007	.26	<.002
Storm	11-16-99	1030	<.016	<.17	.075J	<.002	.04J	.03	<.02	.056	.04J	<.002
Baseflow	08-17-99	1040	<.016	<.16	.028J	<.002	.013J	.07	.057J	.004J	.12	<.002

Kelsey Creek (site 4)

Stream condition	Date	Collection method	2,4-D, unfiltered	4-Nitrophenol, unfiltered	Aminomethyl-phosphonic acid, filtered	Carbaryl, filtered	Desulfinyl-fipronil amide, filtered	Diazinon, filtered	Dicamba, unfiltered	Dichlobenil, unfiltered
Storm	10-16-03	Auto sampler	0.19	0.047NJ	<0.1	<0.041	<0.009	<0.005	0.014NJ	0.12
Storm	11-18-03	Auto sampler	.13J	.1NJ	<.1	.009J	.004J	.024	.012NJ	<.31J
Baseflow	07-08-03	DH-81	.021NJ	<.28	.1	<.041	<.009	<.005	.011NJ	<.065
Baseflow	08-05-03	DH-81	.15J	<.27	.1	<.041	<.009	<.005	.01J	<.063

Stream condition	Date	Collection method	Fipronil, filtered	Glyphosate, filtered	MCPA, unfiltered	MCPP, unfiltered	Pentachloro-phenol, unfiltered	Prometon, filtered	Trichlopyr, unfiltered	Trifluralin, filtered
Storm	10-16-03	Auto sampler	0.004J	0.5	0.061J	0.1J	0.042J	0.02	0.12	0.005J
Storm	11-18-03	Auto sampler	<.016	.7	.035J	.039J	.075J	.008	.091J	.006J
Baseflow	07-08-03	DH-81	<.007	.4	<.33	<.33	.02J	<.01	.031J	<.009
Baseflow	08-05-03	DH-81	<.007	<.1	<.31	.071J	.021J	<.01	.033J	<.009

Table 6. Concentrations of pesticides and pesticide transformation products detected in stream water samples during storms and during baseflow at sites on streams in King County, Washington, 1998–2003.—Continued

[Locations of sites are shown in figure 1. All concentrations are in micrograms per liter. Concentrations: J, estimated value; M, identified, but value is too low to quantify; N, there is evidence that the analyte is present. <, less than; –, not analyzed]

Lewis Creek (site 7)

Stream condition	Date	Time	Collection method	2,4-D, unfiltered	2,6-Dichloro-benzamide, unfiltered	4-Nitrophenol, unfiltered	Atrazine, filtered	Chlorpyrifos, unfiltered
Storm	04-23-98	1340	DH-81	0.027J	0.004NJ	0.069	<0.001	–
Storm	04-23-98	1550	DH-81	<.041	.016J	.021J	.002J	–
Storm	04-23-98	2020	DH-81	.12	.039J	.048J	.002J	–
Storm	06-24-99	1110	DH-81	.54	.091J	.058NJ	<.001	0.004NJ

Stream condition	Date	Time	Desethylatrazine, filtered	Diazinon		Dicamba, unfiltered	EPTC, filtered	Malathion, unfiltered
				filtered	unfiltered			
Storm	04-23-98	1340	<0.002	0.238	–	<0.04	0.005	–
Storm	04-23-98	1550	<.002	.105	–	<.041	<.002	–
Storm	04-23-98	2020	.002J	.094	–	<.04	<.002	–
Storm	06-24-99	1110	<.002	.073	0.049J	.032J	<.002	0.002NJ

Stream condition	Date	Time	MCPA, unfiltered	MCPP, unfiltered	Pentachloro-phenol, unfiltered	Prometon, filtered	Simazine, filtered	Trichlopyr, unfiltered
Storm	04-23-98	1340	0.018NJ	0.061NJ	0.016J	<0.02	<0.005	<0.034
Storm	04-23-98	1550	.041J	.11	<.02	.01J	.002J	<.034
Storm	04-23-98	2020	.013NJ	.13	.021NJ	.01J	<.005	.022NJ
Storm	06-24-99	1110	.079J	.77	.024NJ	.01J	<.005	.18

Little Bear Creek (site 9)

Stream condition	Date	Time	Collection method	2,4-D, unfiltered	2,6-Dichloro-benzamide, unfiltered	4-Nitrophenol, unfiltered	Aminomethyl-phosphonic acid, filtered	Atrazine, filtered	Bromacil, unfiltered	Caffeine, unfiltered	Carbaryl, filtered	Desethyl-atrazine, filtered
Storm	05-03-00	1100	Auto sampler	0.23	–	<0.14	–	0.005	<0.081	–	0.018J	<0.002
Storm	05-03-00	1340	DH-81	.18	–	<.15	–	<.005	<.083	–	<.020	<.002
Storm	10-09-00	1315	Auto sampler	.52	–	.25	–	<.007	<.095	–	<.041	<.006
Storm	06-28-02	2145	Auto sampler	3.3	–	<.33	0.4	<.008	<.086	0.37J	.032J	<.006
Storm	11-12-02	1230	Auto sampler	.37	–	.23J	.1	<.007	<.069	–	.007J	<.006
Baseflow	06-27-00	1130	DH-81	<.100	–	<.18	–	<.001	<.089	–	<.003	.003J
Baseflow	07-10-02	1115	DH-81	.12J	–	<.27	<.1	.002J	<.083	–	<.041	<.006
Baseflow	08-21-02	1130	DH-81	.041J	0.01J	<.29	.1	<.007	.018J	–	<.041	<.006

Stream condition	Date	Time	Diazinon		Dicamba, unfiltered	Dichlobenil, unfiltered	Dichlorprop, unfiltered	Diuron, unfiltered	Glyphosate, filtered	Malathion, filtered
			filtered	unfiltered						
Storm	05-03-00	1100	0.008	0.01J	<0.078	0.029J	<0.086	<0.24	–	<0.005
Storm	05-03-00	1340	.007	.0066J	<.083	.011J	<.092	<.25	–	<.005
Storm	10-09-00	1315	<.005	.0098J	.012J	.034J	<.12	<.21	–	<.027
Storm	06-28-02	2145	.004J	<.017J	.041NJ	.019J	.2J	<.13	2.0	.016J
Storm	11-12-02	1230	.005	<.014	.032NJ	.095	<.17	<.10	.3	<.027
Baseflow	06-27-00	1130	<.002	.0057J	<.1	.06	<.11	<.13	–	<.005
Baseflow	07-10-02	1115	.004J	.047J	<.16	<.042	<.17	<.13	<.1	<.027
Baseflow	08-21-02	1130	<.005	<.017	.0034NJ	<.043	<.18	.084NJ	.1	<.027

Stream condition	Date	Time	MCPA, unfiltered	MCPP, unfiltered	Napropamide, filtered	Pentachloro-phenol, unfiltered	Prometon, filtered	Simazine, filtered	Tebuthiuron, filtered	Trichlopyr, unfiltered
Storm	05-03-00	1100	0.02NJ	0.17	<0.003	0.092	0.01J	<0.010	0.01	0.18
Storm	05-03-00	1340	<.17	.057J	<.003	.027J	.01J	<.005	.02	.15
Storm	10-09-00	1315	<.23	.20J	<.007	.052J	.02	<.011	<.02	.74
Storm	06-28-02	2145	<.38	.29J	<.007	.072J	.01J	.011	<.02	2.7
Storm	11-12-02	1230	<.32	.029J	.015	.058J	.01J	<.005	.03	.39
Baseflow	06-27-00	1130	<.20	<.20	<.003	<.050	M	.005	.01J	<.084
Baseflow	07-10-02	1115	.016J	.025J	<.007	.0063NJ	.01J	<.005	.01J	0.048J
Baseflow	08-21-02	1130	.047J	.039J	<.007	.012J	<.01	<.005	<.02	0.031J

Table 6. Concentrations of pesticides and pesticide transformation products detected in stream water samples during storms and during baseflow at sites on streams in King County, Washington, 1998–2003.—Continued

[Locations of sites are shown in figure 1. All concentrations are in micrograms per liter. Concentrations: J, estimated value; M, identified, but value is too low to quantify; N, there is evidence that the analyte is present. <, less than; –, not analyzed]

Lyon Creek at 178th (site 12)
(Replicate sample was collected on 06/24/99; see table 4)

Stream condition	Date	Time	Collection method	2,4-D, unfiltered	2,6-Dichloro-benzamide, unfiltered	4,4′-DDD, unfiltered	4,4′-DDE, unfiltered	4,4′-DDT, unfiltered	4-Nitrophenol, unfiltered	Atrazine, filtered	Carbaryl, filtered
Storm	05-14-98	0540	DH-81	0.29	0.031J	–	–	–	0.047NJ	0.019	0.012J
Storm	05-14-98	0640	DH-81	.14	.031J	–	–	–	.036J	.021	.011J
Storm	06-24-99	0800	DH-81	.34	.086J	<0.011	<0.011	<0.011	.1J	<.001	.121J
Storm	10-08-99	0940	DH-81	.69	.023J	<.012	<.012	<.012	<.14	<.001	<.020
Storm	11-16-99	1730	DH-81	.034J	–	.0021J	.0021J	.041J	.12NJ	<.001	<.003
Baseflow	08-17-99	1240	DH-81	.015J	.051J	<.011	<.011	.002J	<.15	.004	<.003

Stream condition	Date	Time	Chlorpyrifos, unfiltered	Diazinon		Dicamba, unfiltered	Dichlobenil, unfiltered	Dichlorprop, unfiltered	Diuron, unfiltered	Malathion, filtered
				filtered	unfiltered					
Storm	05-14-98	0540	–	0.305	–	0.036J	0.061	<0.043	<0.12	0.033
Storm	05-14-98	0640	–	.425	–	.02J	.063	.0081J	<.12	.037
Storm	06-24-99	0800	0.003NJ	.194	0.16	.027J	.24	.032J	.007NJ	<.030
Storm	10-08-99	0940	<.017	.073	.045	.016J	.31	<.086	<.13	.017
Storm	11-16-99	1730	<.016	.014	.014J	<.081	.065	<.089	<.12	<.005
Baseflow	08-17-99	1240	<.016	<.002	<.016	<.085	.033	<.093	<.12J	<.005

Stream condition	Date	Time	Malathion, unfiltered	MCPA, unfiltered	MCPP, unfiltered	Napro-pamide, filtered	Pentachloro-phenol, unfiltered	Prometon, filtered	Simazine		Trichlopyr, unfiltered
									filtered	unfiltered	
Storm	05-14-98	0540	–	0.025NJ	0.15	0.016	0.036	0.03	4.73	3.3	0.13
Storm	05-14-98	0640	–	.026J	.13	.014	.042	.04	4.99	3.3	.091
Storm	06-24-99	0800	0.004NJ	<.18	.57	<.003	.1	.11	1.03	.25	.18
Storm	10-08-99	0940	<.017	<.16	.52	<.030	.066	.02	.223	<.021J	.29
Storm	11-16-99	1730	<.016	<.16	.18	<.003	.098	.02	<.005	<.020J	.058J
Baseflow	08-17-99	1240	<.016	<.17	<.17	<.003	.013J	.01J	.416	.28	.041J

Lyon Creek at Lake Forest Park (site 13)

Stream condition	Date	Time	Collection method	2,4-D, unfiltered	4-Nitrophenol, unfiltered	Atrazine		Bromacil, unfiltered	Carbaryl, filtered	Chlorpyrifos, unfiltered
						filtered	unfiltered			
Storm	05-03-00	0930	Auto sampler	0.2	<0.15	0.017	0.0099J	<0.081	0.207J	0.003NJ
Storm	05-03-00	1345	DH-81	.29	<.16	.008	.014NJ	.013NJ	.164J	.003NJ
Storm	10-09-00	1230	Auto sampler	.2	.29	<.007	<.071J	<.11	<.060	<.022
Baseflow	06-27-00	1115	DH-81	<.11	<.19	<.001	.004NJ	.05J	<.003	<.018

Stream condition	Date	Time	Desethylatrazine, filtered	Diazinon		Dicamba, unfiltered	Dichlobenil, unfiltered	MCPA, unfiltered	MCPP, unfiltered
				filtered	unfiltered				
Storm	05-03-00	0930	<0.002	0.059	0.054	<0.083	0.11	0.056J	0.084J
Storm	05-03-00	1345	<.002	.099	.13	<.089	.1	.036NJ	.18
Storm	10-09-00	1230	<.006	.044	.031J	.026J	.071	<.22	.39
Baseflow	06-27-00	1115	.003J	.005	.0072J	<.11	.013J	<.21	<.21

Stream condition	Date	Time	Pentachlorophnol, unfiltered	Prometon, filtered	Simazine		Tebuthiuron, filtered	Trichlopyr, unfiltered	Trifluralin, filtered
					filtered	unfiltered			
Storm	05-03-00	0930	0.026J	0.03	0.033	0.015J	<0.01	0.1	<0.002
Storm	05-03-00	1345	.034J	.04	.045	.046	<.01	.061J	<.002
Storm	10-09-00	1230	.12	.02	.1	<.028	<.02	.1	<.009
Baseflow	06-27-00	1115	<.054	.01J	.008	<.022	.01J	<.090	.003J

Table 6. Concentrations of pesticides and pesticide transformation products detected in stream water samples during storms and during baseflow at sites on streams in King County, Washington, 1998–2003.—Continued

[Locations of sites are shown in figure 1. All concentrations are in micrograms per liter. Concentrations: J, estimated value; M, identified, but value is too low to quantify; N, there is evidence that the analyte is present. <, less than; –, not analyzed]

May Creek (site 3)

Stream condition	Date	Collection method	2,4-D, unfiltered	4-Nitrophenol, unfiltered	Carbaryl, filtered	Diazinon, filtered	Dicamba, unfiltered	Glyphosate, filtered
Storm	10-16-03	Auto sampler	0.056J	0.047NJ	0.027J	0.007	<0.16	0.2
Storm	11-18-03	Auto sampler	.073J	.064NJ	<.041	<.005	.0075NJ	.2
Baseflow	07-08-03	DH-81	<.16	<.28	<.041	<.005	<.16	<.1
Baseflow	08-05-03	DH-81	<.16	<.29	<.041	<.005	<.16	<.1

Stream condition	Date	Collection method	MCPP, unfiltered	Metolachlor, filtered	Pentachlorophenol, unfiltered	Prometon, filtered	Trichlopyr, unfiltered
Storm	10-16-03	Auto sampler	0.047J	0.273	0.066J	0.01J	0.062J
Storm	11-18-03	Auto sampler	.05 J	.095	.037J	.01	.031J
Baseflow	07-08-03	DH-81	<.32	.011J	<.08	<.01	<.13
Baseflow	08-05-03	DH-81	<.33	<.013	<.082	<.01	<.14

North Creek (site 10)

Stream condition	Date	Collection method	2,4-D, unfiltered	2,6-Dichloro-benzamide, unfiltered	4-Nitrophenol, unfiltered	Atrazine, filtered	Caffeine, unfiltered	Carbaryl, filtered
Storm	06-28-02	Auto sampler	0.47	–	<0.32	<0.007	0.23J	0.017J
Storm	11-12-02	Auto sampler	<.044	–	.13J	<.007	–	.011J
Baseflow	07-10-02	DH-81	.053J	–	<.30	.002J	–	.010J
Baseflow	08-21-02	DH-81	<.17	0.019J	<.30	<.007	–	<.041

Stream condition	Date	Collection method	Diazinon		Dicamba, unfiltered	Dichlobenil, unfiltered	Glyphosate, filtered	Malathion, filtered	MCPP, unfiltered
			filtered	unfiltered					
Storm	06-28-02	Auto sampler	0.007	<0.020J	0.035NJ	0.021J	0.1	0.010J	0.24J
Storm	11-12-02	Auto sampler	.011	<.014	<.19	.024	<.1	<.027	.091J
Baseflow	07-10-02	DH-81	.009	.076J	<.17	.003J	<.1	<.027	.037J
Baseflow	08-21-02	DH-81	<.005	.14J	<.17	<.045	<.1	<.027	.014NJ

Stream condition	Date	Collection method	Pentachlorophenol, unfiltered	Prometon		Simazine, filtered	Tebuthiuron, filtered	Trichlopyr, unfiltered
				filtered	unfiltered			
Storm	06-28-02	Auto sampler	0.11	0.04	<0.025	0.007	<0.02	0.11J
Storm	11-12-02	Auto sampler	.058J	.02	<.018	.008	<.02	.11J
Baseflow	07-10-02	DH-81	.0098J	.02	.04NJ	.052	.02J	.27
Baseflow	08-21-02	DH-81	.014J	<.01	<.022	<.005	<.02	.017NJ

Rock Creek (site 2)

Stream condition	Date	Collection method	4-Nitrophenol, unfiltered	Dicamba, unfiltered
Storm	05-14-98	DH-81	<0.071	<0.041
Storm	06-24-99	DH-81	.037NJ	.011J
Storm	10-08-99	DH-81	<.14	<.081
Storm	11-16-99	DH-81	<.15	<.083
Baseflow	08-17-99	DH-81	<.16	<.089

Swamp Creek (site 11)

Stream condition	Date	Time	Collection method	2,4-D, unfiltered	4-Nitrophenol, unfiltered	Atrazine, unfiltered	Diazinon		Dichlobenil, unfiltered	Malathion	
							filtered	unfiltered		filtered	unfiltered
Storm	05-03-00	1200	Auto sampler	0.058J	<0.14	<0.020	0.025	0.019	0.025J	0.032	0.013J
Storm	05-03-00	1500	DH-81	.055J	<.15	<.020	.03	.021	.018J	.021	.0069J
Storm	10-09-00	1340	Auto sampler	.12	.17J	<.023	.029	.017J	.023J	<.027	<.018
Baseflow	06-27-00	1310	DH-81	<.11	<.19	.007NJ	.004J	.0044J	.021J	<.005	<.019

Stream condition	Date	Time	MCPA, unfiltered	MCPP, unfiltered	Pentachlorophenol, unfiltered	Prometon, filtered	Simazine, filtered	Trichlopyr, unfiltered
Storm	05-03-00	1200	0.026J	0.068J	0.02J	0.02	<0.010	0.12
Storm	05-03-00	1500	.031J	.066J	.014J	.02	<.010	.13
Storm	10-09-00	1340	<.22	.14J	.079	.01J	<.011	.11
Baseflow	06-27-00	1310	<.21	<.21	<.054	.01J	.007	<.09

Table 6. Concentrations of pesticides and pesticide transformation products detected in stream water samples during storms and during baseflow at sites on streams in King County, Washington, 1998–2003.—Continued

[Locations of sites are shown in figure 1. All concentrations are in micrograms per liter. Concentrations: J, estimated value; M, identified, but value is too low to quantify; N, there is evidence that the analyte is present. <, less than; –, not analyzed]

Taylor Creek (site 1)

Stream condition	Date	Collection method	2,4-D, unfiltered	4-Nitrophenol, unfiltered	Dicamba, unfiltered	Glyphosate, filtered	MCPA, unfiltered
Storm	10-16-03	Auto sampler	0.11J	0.035NJ	0.014NJ	0.2	0.027J
Storm	11-18-03	Auto sampler	.049J	<.27	.0078NJ	.1	.023NJ
Baseflow	07-08-03	DH-81	<.18	<.32	<.18	<.1	<.36
Baseflow	08-05-03	DH-81	<.16	<.28	<.16	<.1	<.33

Stream condition	Date	MCPP, unfiltered	Metolachlor, filtered	Pentachlorophenol, unfiltered	Prometon, filtered	Trichlopyr, unfiltered
Storm	10-16-03	0.077J	0.010J	0.029J	0.19	0.061J
Storm	11-18-03	.056J	.007J	.091	.03	.045J
Baseflow	07-08-03	<.36	<.013	.011J	<.01	<.15
Baseflow	08-05-03	<.33	<.013	.0049J	.01J	<.14

Unnamed Site @ 124th (site 14)

Stream condition	Date	Collection method	2,4-D, unfiltered	2,6-Dichloro-benzamide, unfiltered	4-Nitro-phenol, unfiltered	Aminometyl-phosphonic acid, filtered	Atrazine, filtered	Caffeine, unfiltered	Carbaryl, filtered	Carbofuran	
										filtered	unfiltered
Storm	06-28-02	Dip	0.45	–	<0.29	0.5	<0.007	0.31J	0.098J	<0.020	–
Storm	11-12-02	Dip	.041J	–	.23J	.5	<.007	.11J	.047J	<.020	–
Baseflow	09-11-00	Dip	.28	0.21J	<.19	–	<.006	–	<.003	.229	0.089NJ
Baseflow	07-10-02	Dip	.16J	.11J	<.30	.8	.003J	–	.064J	<.020	–
Baseflow	08-21-02	Dip	.12J	.016J	<.27	1.3	.004J	–	.035J	<.020	–

Stream condition	Date	Chlorpyrifos		Diazinon		Dicamba, unfiltered	Dichlobenil, unfiltered	Dichlorprop, unfiltered	Diuron, unfiltered
		filtered	unfiltered	filtered	unfiltered				
Storm	06-28-02	0.012	<0.016J	0.005	0.21J	<0.16	0.079	0.033J	<0.12
Storm	11-12-02	.008	<.014	<.005	<.014	.088J	<.036	<.18	<.11
Baseflow	09-11-00	.005	<.019	.586	.47	.38	.041J	<.12	.052NJ
Baseflow	07-10-02	.015	.0028J	.014	.19J	<.17	<.001	<.19	<.13
Baseflow	08-21-02	.015	.0089J	<.005	<.015	<.15	.0082J	<.17	.075NJ

Stream condition	Date	Ethofumesate, unfiltered	Glyphosate, filtered	Malathion		MCPA, unfiltered	MCPP, unfiltered	Metalaxyl, unfiltered
				filtered	unfiltered			
Storm	06-28-02	–	1.2	0.216	0.12J	<0.33	0.092J	<0.12
Storm	11-12-02	–	.8	<.027	<.014	.079J	.079NJ	<.11
Baseflow	09-11-00	2.4NJ	–	<.005	<.019	<.22	<.22	.15
Baseflow	07-10-02	–	.8	.029	.0045J	<.34	<.34	<.13
Baseflow	08-21-02	–	1.3	<.027	<.015	<.31	.048J	<.11

Stream condition	Date	Metolachlor, filtered	Oxadiazon, unfiltered	Pentachlorophenol, unfiltered	Prometon, filtered	Simazine, filtered	Tebuthiuron, filtered	Trichlopyr, unfiltered	Trifluralin, filtered
Storm	06-28-02	<0.013	–	0.13	0.03	<0.005	<0.02	0.31	<0.009
Storm	11-12-02	<.013	–	.092	.01J	.01	.05	.12J	<.009
Baseflow	09-11-00	.007	–	.029NJ	.01J	<.005	.08J	.28	.003J
Baseflow	07-10-02	.004J	–	.021NJ	.01J	.007	.06	.036J	<.009
Baseflow	08-21-02	.007J	0.066J	.015NJ	.03	.007	.02	.11J	<.009

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