Johnson Creek Legacy Pesticide Study:
Source Investigation of Legacy Pesticides in the Upper Johnson Creek Watershed

Technical Report
6.30.05

prepared by
Johnson Creek Watershed Council

In consultation with:
Johnson Creek Watershed Interjurisdictional Committee

DEQ Contract No.: 141-03

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1.0 Introduction

Johnson Creek is 303(d) listed for various water quality parameters including the legacy pesticides DDT[1] and dieldrin. Additional listing of a legacy pesticide (chlordane) is proposed. The Department of Environmental Quality (DEQ) with the assistance of the U.S. Geological Survey (USGS) and members of the Interjurisdictional Committee for Johnson Creek[2] (IJC) have prepared Total Maximum Daily Loads (TMDL) for DDT, dieldrin, bacteria and temperature. The study summarized in this report focuses on DDT and dieldrin.

The occurrence of DDT and dieldrin in water and streambed sediment from Johnson Creek was first identified by the USGS in a study in 1989-90, and has been detected in several subsequent studies. Samples of streambed sediments taken from Johnson Creek in 1992 had the highest concentration of DDT and dieldrin of any samples taken in the Willamette Basin. Studies done in 1994 and 2002 revealed continued detections of both DDT and dieldrin in the water, and in most samples, concentrations exceeded acceptable health standards. In these studies, the highest concentrations of legacy pesticides were generally detected at the most upstream sampling points in the basin.

Prior research and sediment & water column monitoring conducted by USGS, DEQ and the City of Portland's Bureau of Environmental Services (BES) has focused on the urbanized portions of the Johnson Creek watershed. The last major monitoring effort designed to collect data for the preparation of bacteria and toxics TMDLs occurred in Fall/Winter 2001/2002. Analyses of the data indicated that additional significant sources of legacy pesticide appear to be present in the upper watershed above Creek Mile 18.2 (Palmblad Road). Zoning maps indicate that this portion of the watershed is dominated by non-urban land uses. In order to provide better information for a land use based TMDL load allocation, the project studied the contribution to the instream pesticide load from various types of non-urban land uses in the upper watershed.

The purpose of this study was to gain a greater understanding of where the legacy pesticides in the creek originate. Since previous studies focused on the area of Johnson Creek west of Highway 26 (Lower Johnson Creek), the present study focused primarily on the stream east of Highway 26 (Upper Johnson Creek). Past studies found that pesticide concentrations decrease as the stream flows towards the Willamette. Consequently, the main objectives of this study were to: 1) identify areas where higher DDT and Dieldrin concentrations occur; and 2) compare the concentrations in the upper creek to concentrations in the lower creek. To meet these objectives, water samples were collected at 16 locations. These locations include 2 stormwater outfalls that drain urban areas, 3 tributaries that drain urban areas, 3 tributaries that drain rural areas, and 8 sites on the mainstem of Johnson Creek. A variety of stream flow and seasonal weather conditions were targeted in the five sampling events between October 2003 and June 2004.

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[1] DDT: dichlorodiphenyltrichloroethane. DDT and dieldrin are considered legacy pesticides since they are no longer applied yet they persist in the environment.

[2] Members of the IJC include the Cities of Milwaukee, Gresham and Portland, Clackamas & Multnomah Counties and the Johnson Creek Watershed Council.

2.0 Tasks

The tasks of this study were to:

1. Investigate land use based sources of legacy pesticides in the upper Johnson Creek watershed.
2. Disseminate information about monitoring results and source investigation to stakeholders and the interested public.
3. Identify potential actions that may reduce instream loads of legacy pesticides in the Johnson Creek watershed.

The goals of the tasks were met by collecting and analyzing water samples at representative sites in the watershed. A GIS analysis attempted to correlate the pesticide concentrations at different monitoring locations with the associated catchment, land use, topography, soil types and soil erodibility. The lack of detailed GIS land use data for this area resulted in correlations not being possible in respect to identifying specific land uses (i.e. type of agricultural use) in the geographic areas that drain to monitoring sites. However the results showed substantially lower pesticide concentrations in residential streams and stormwater outfalls than in agricultural areas. After analysis of the data, the results were distributed to watershed residents and stakeholders in a 'fact sheet' type format. Included in the 'fact sheet' was an overview of erosion control measures listed by activity type. The fact sheet encourages everyone who lives and/or works in the watershed to employ best management practices that will reduce the amount of legacy pesticides entering the creek.

3.0 Selection of Sampling Sites

The City of Portland Bureau of Environmental Services (BES) conducted the initial site reconnaissance to locate sampling locations using the following objectives:

- Easy accessibility under a variety of weather conditions
- Located on or accessible from public property (such as a public road bridge)
- Drain predominantly agricultural land uses, including small acreage farms and nurseries

After the initial reconnaissance that identified about 15 potential monitoring locations mainly on the Upper Johnson Creek main stem, the IJC's Technical Advisory Committee (TAC) for this study decided to add some locations downstream of Palmblad Rd. The purpose of these additions was threefold:

- Connect this study with the TMDL monitoring study conducted by USGS in 2002
- Investigate a tributary in an established residential area
- Investigate a tributary in a residential area under development where erosion is of potential concern

To address the first bulleted item, the following were selected: two city outfalls, one in Portland and one in Gresham, and a monitoring location in a residential tributary. At each of these three sites, five grab samples were collected in March 2002 during the TMDL monitoring study. To address the second and third bulleted items, staff at the City of Gresham were able to identify additional suitable tributaries.

The City of Portland's BES' Investigation and Monitoring Services (IMS) Division conducted a final investigation of the identified sites to ensure that these locations indeed meet the stated objectives and decided on the monitoring locations listed in Table 3-1 and shown in Figure 3-1.

Even though the budget was originally set up for up to 15 sampling locations, the TAC decided to, initially at least, expand the number of sampling locations to 16. After three sampling events, monitoring sites JCP3 and JCP6 were dropped from the list due to budget constraints and an evaluation that the initial data from these cites was not obviously different from adjacent sampling sites, and an evaluation that indicated that the initial data from these sites was not obviously different from adjacent sampling sites.

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Table 3-1. Monitoring Locations

Address	Site ID	Water Body	Land Use	TMDL Study
SE 252nd Ave. (Palmblad)	JCP1	Johnson Creek	Agricultural	YES
SE 267th Ave.	JCP2	Johnson Creek	Agricultural	
SE 282nd Ave.	JCP3	Johnson Creek	Agricultural	
SE Short Rd.	JCP4	Johnson Creek	Agricultural	
SE 307th Ave.	JCP5	Johnson Creek	Agricultural	
SE Pleasant Home Rd.	JCP6	Johnson Creek	Agricultural	
SE 327th Ave.	JCP7	Johnson Creek	Agricultural	
SE Cottrell Rd.	JCP8	Johnson Creek	Agricultural	
Approx. 7300 SE 162nd Ave	CC [1]	Clatsop Creek	Residential	YES
Approx 7500 SE 162nd Ave	CC2 [1]	Clatsop Creek	Residential	
SE Heiney Rd.	HCP1	Heiney Creek	Established Residential	
SE Cleveland Ave.	NCP1	Nechakokee Creek	Developing Residential	
SE 240th Place	SCP1	Sunshine Creek	Agricultural	
SE Hideway Ct.	SCP2	Sunshine Creek	Agricultural	
SE Bluff Rd.	UTP1	Unnamed Tributary	Agricultural	
SE 45th Ave & SE Umatilla St.	S45U	Stormwater Outfall	Mixed	YES
S Main Ave & Powell Blvd	SGCP	Stormwater Outfall	Commercial	YES

[1] Monitoring location had to be move slightly from CC to CC2 because property owner refused access after first sampling event.

4.0 Sampling Methods

The City of Portland IMS used standard surface water and stormwater monitoring protocols to collect samples at 14 stream and 2 stormwater outfall locations. Field parameters were measured using a multi-meter that simultaneously measures pH, temperature, and conductivity. Turbidity was measured with a dedicated turbidity meter.

5.0 Analytical Methods

Total suspended solids (TSS) and turbidity were analyzed at the City of Portland Water Pollution Control Lab (WPCL). The pesticide analyses were performed by the Texas A&M University

GERG lab, which specializes in low-level pesticide analyses. The method reporting limit (MRL) for the pesticides was variable due to difference in the matrix and other equipment-related factors but typically was in the range of 0.1 to 0.3 ng/L. Many of the pesticides listed were part of the suite of analytes but were not reviewed in any detail as part of this study. All concentrations of all DDX species (i.e. DDT and breakdown products of DDT) were summed to result in a total DDT concentration for further study.

Table 5-1. Analytes

Analyte Name	Units	Method	Volume/ Container
Pesticides			
2,4'-DDD	ng/L	EPA 8081M	1 L / amber glass
2,4'-DDE	ng/L	EPA 8081M	
2,4'-DDT	ng/L	EPA 8081M	
4,4'-DDD (p,p'-TDE)	ng/L	EPA 8081M	
4,4'-DDE (p,p'-DDX)	ng/L	EPA 8081M	
4,4'-DDT	ng/L	EPA 8081M	
Aldrin	ng/L	EPA 8081M	
BHC, alpha	ng/L	EPA 8081M	
BHC, beta	ng/L	EPA 8081M	
BHC, delta	ng/L	EPA 8081M	
BHC, gamma (lindane)	ng/L	EPA 8081M	
Chlordane, alpha	ng/L	EPA 8081M	
Chlordane, gamma	ng/L	EPA 8081M	
Chlorpyrifos	ng/L	EPA 8081M	
Dieldrin	ng/L	EPA 8081M	
Endosulfan I	ng/L	EPA 8081M	
Endosulfan II	ng/L	EPA 8081M	
Endrin	ng/L	EPA 8081M	
Endrin aldehyde	ng/L	EPA 8081M	
Endrin ketone	ng/L	EPA 8081M	
Heptachlor	ng/L	EPA 8081M	
Heptachlor epoxide	ng/L	EPA 8081M	
Methoxychlor	ng/L	EPA 8081M	
Toxaphene	ng/L	EPA 8081M	
Conventional			
Solids - total suspended	mg/L	SM 2540 D	1 L / plastic
Field			
Conductivity - specific	µmhos/cm	SM 2510 B	
Turbidity	NTU	SM 2130 B	
pH	S.U.	SM 4500-H B	
Temperature	°C	SM 2550 B	

6.0 Discussion of Results

A complete list of the data collected is located in Appendix A. Table 6-0 provides a summary of the sampling events, sites sampled, and sampling conditions. The City of Gresham stormwater outfall SGCP could only be sampled during storm events due to the lack of dry weather flow. The City of Portland outfall, on the other hand, had appreciable dry weather flow and thus, it was sampled during each of the five sampling events. The dry weather flow is most likely due to a combination of groundwater inflow into and capture of springs by the piped system.

Table 6-0. Summary of Monitoring Events

Event #	1	2	3	4	5
Sample Date	10/21/2003	12/12/2003	2/26/2004	4/13/2004	6/7/2004
Sample ID	**Sites Sampled**				
JCP1	X	X	X	X	X
JCP2	X	X	X	X	X
JCP3	X	X	X		
JCP4	X	X	X	X	X
JCP5	X	X	X	X	X
JCP6	X	X	X		
JCP7	X	X	X	X	X
JCP8	X	X	X	X	X
CC [1]	X				
CC2 [1]		X	X	X	X
HCP1	X	X	X	X	X
NCP1	X	X	X	X	X
SCP1	X	X	X	X	X
SCP2	X	X	X	X	X
UTP1	X	X	X	X	X
S45U	X	X	X	X	X
SGCP [2]		X	X		X

1 Monitoring location had to be move slightly from CC to CC2 because property owner refused access after first sampling event.

2 Monitoring location SGCP (City of Gresham stormwater outfall) was not sampled during dry weather due to lack of flow

6.1 Precipitation and Stream Flow

The selection of sampling events was based on the objectives to collect samples during two dry and three wet events at approximately two-to-three month intervals. On sample collection dates, sampling at all 16 locations typically occurred during a 4 to 6 hour period.

Rainfall was measured at the three City of Portland HYDRA Rainfall Network stations which are located closest to the monitoring locations in the middle and upper Johnson Creek watershed. The rainfall amounts provided in Table 6-1 constitute an unweighted average of these stations. Typically, the difference between these three stations during the time periods of interest was small. Flow and temperature were measured at the USGS flow gage 14211400 at Regner Rd. in Gresham, which is located slightly downstream of the most downstream sampling location in the

Johnson Creek main stem. At the same location, a turbidity meter was installed in January 2004 and provided the median daily turbidity values listed in Table 6-1.

In general, precipitation during the preceding 24 hours, stream flow, and turbidity correlate fairly well. The flow during event #5 is lower than expected based on precipitation. This could be due to the showery nature of this storm event that may not have generated rainfall evenly throughout the watershed. The average daily flow indicates a flashy stream that responds quickly to rainfall and shows extreme differences between dry and wet events.

Table 6-1. Precipitation and Stream Flow during Sampling Events

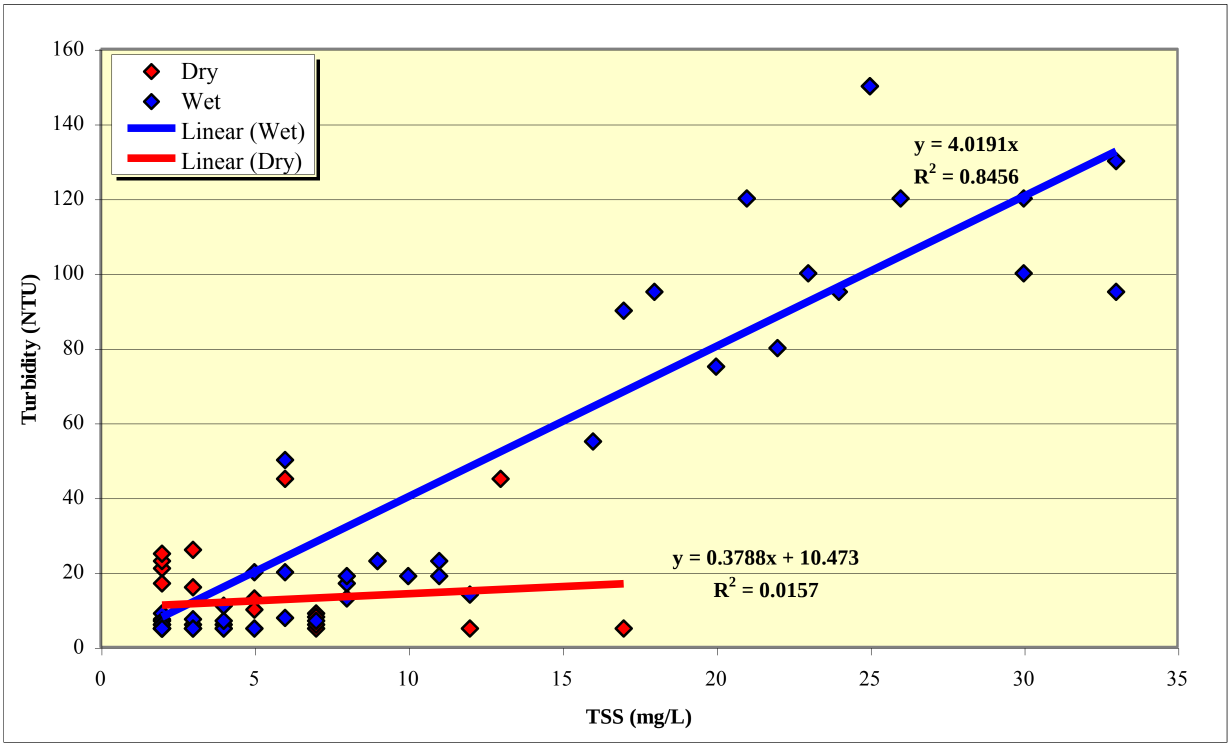
Event #	1	2	3	4	5
Sample Date	10/21/2003	12/12/2003	2/26/2004	4/13/2004	6/7/2004
Rainfall during Sampling Collection (inch)	0.00	0.00	0.09	0.00	0.01
Rainfall During Preceding 24 hours (inch)	0.00	0.27	0.31	0.00	0.20
Mean T (°C)	16.2	8.3	7.6	13.2	14.4
Median Daily Turbidity @ Regner Rd. (FTU)	N/A	N/A	74.1	5.5	28.6
Mean Daily Flow @ Regner Rd. gage (cf)	2.6	64	83	4.3	7.4
Event Type	dry	wet	wet	dry	wet

6.2 Total Suspended Solids (TSS) and Turbidity

Grab samples collected at all monitoring locations were analyzed for TSS at the WPCL and for turbidity in the field. Figure 6-2 shows the correlation between TSS and turbidity for dry and wet sampling events.

During storm events, a strong and highly significant relationship exists, whereas no such relationship can be observed during non-storm events. However, considering TSS concentrations up to 15 mg/L for dry and wet events, the two data sets appear comparable. It seems that a strong positive relationship is only present at TSS concentrations above 15 mg/L. Below that level, the turbidity values are typically below 25 NTU and independent of the TSS concentration and precipitation. No definitive explanation for this behavior can be provided based on the available data. However, it could be speculated that colloidal material present instream during dry periods and small storm events make up the majority of turbidity, while at larger storm event the amount of TSS-size particles as well as turbidity instream increase to a point where a good correlation exists. Future research may need to be directed to explore this behavior.

Figure 6-2. Correlation between Turbidity and Total Suspended Solids



6.3 Pesticide Concentrations

Even though a long list of mostly legacy pesticides was analyzed (Appendix A – Data Summary), this report focuses only on DDT and dieldrin. Other pesticides were at times observed, but not as frequently and at all monitoring locations as DDT and dieldrin. The six DDX species presented in the data summary were combined and called 'total DDT' for the purpose of this discussion. All these DDX species are by-products or degradation products of DDT.

Pesticide concentrations at a given surface water monitoring location varied substantially with stream flow and thus with amount of rainfall preceding the sampling event. In general, stormwater outfall and residential sampling locations showed less variation but that may be related to lower observed pesticide concentrations. Concentrations of Total DDT and dieldrin among the monitoring locations varied substantially (Figure 6-3(a) and 6-3(b). The chronic water quality criteria for DDT and dieldrin are 1.0 ng/L and 1.9 ng/L, respectively.

The monitoring locations in Figures 6-3(a) & 6-3(b) are grouped by land use type to allow for an easier comparison among sampling locations within a given land use (see Table 3-1 and Appendix B). Average Total DDT concentrations (Figure 6-3(a)) show a substantial difference between dry and wet events with the exception of some monitoring locations on tributaries, especially SPC2. Total DDT concentrations in the upper Johnson Creek main stem are much higher than in the other monitoring locations and, after an initial increase in the uppermost locations, appear to decrease in the downstream direction.

Dieldrin (Figure 6-3(b)) shows a similar behavior, but the difference between dry and wet events is much less pronounced. Concentrations in some of the tributaries, including Heiney and Sunshine Creeks, are comparable to main stem concentrations.

Two (urban stormwater outfalls) to eight (Upper Main Stem) monitoring locations were combined to show average Total DDT and dieldrin concentrations by land use type (Figure 6-3(c)). The exceedances in the urban stormwater outfalls and urban tributaries are small as compared to the rural tributaries and the upper main stem. Average dieldrin concentrations behave in a similar manner, with the exception of the urban stormwater outfalls. At the outfalls, the dieldrin concentration that was observed is well below the ambient water quality criterion.

The data indicates that the highest legacy pesticide concentrations are present in the upper Johnson Creek watershed. This area generally has very little area of impervious surface and this area often has agricultural activities that are likely to cause regular soil disturbances. These soil disturbances are the likely sources of pesticide-laden sediment that move into the surface waters in the Johnson Creek watershed. Why the dieldrin concentrations remain high during dry periods and low stream flow (which should not cause channel erosion) is unclear. Similar findings were made by the USGS in their report on legacy pesticides in Johnson Creek (SIR 2004-5061).

Figure 6-3(a). Average Total DDT Concentration for Dry and Wet Sampling Events

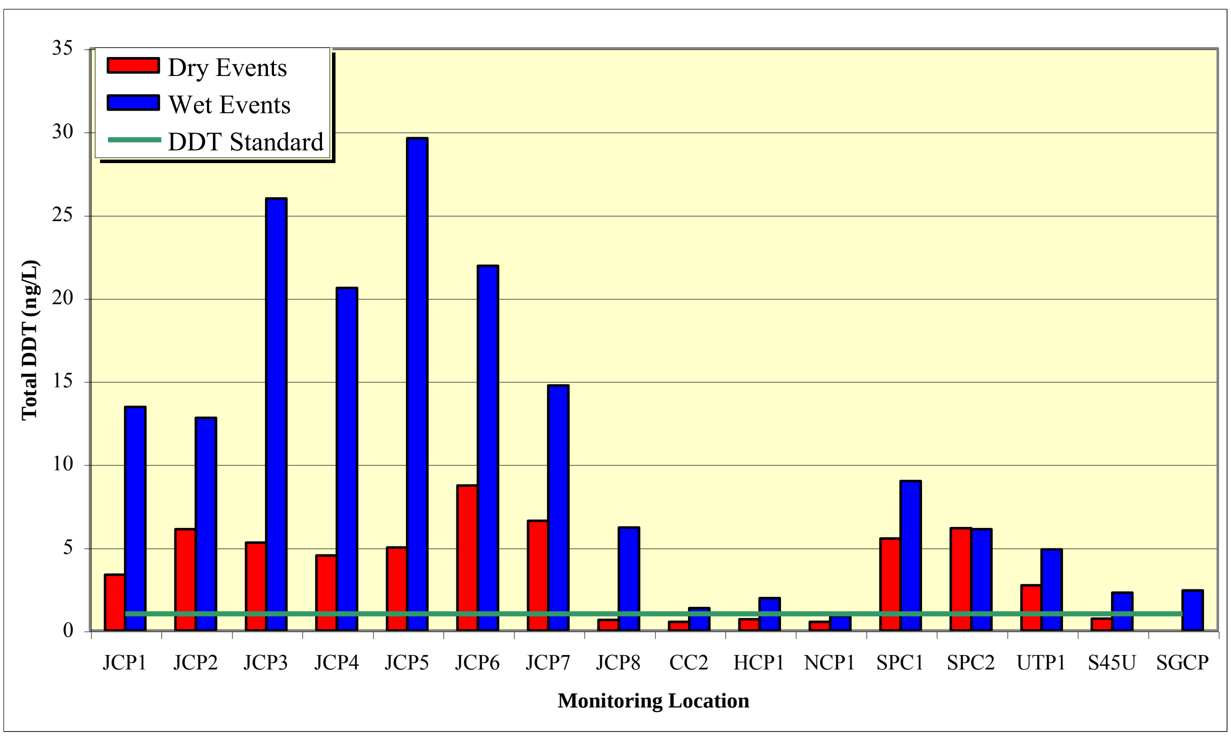


Figure 6-3(b). Average Dieldrin Concentration for Dry and Wet Sampling Events

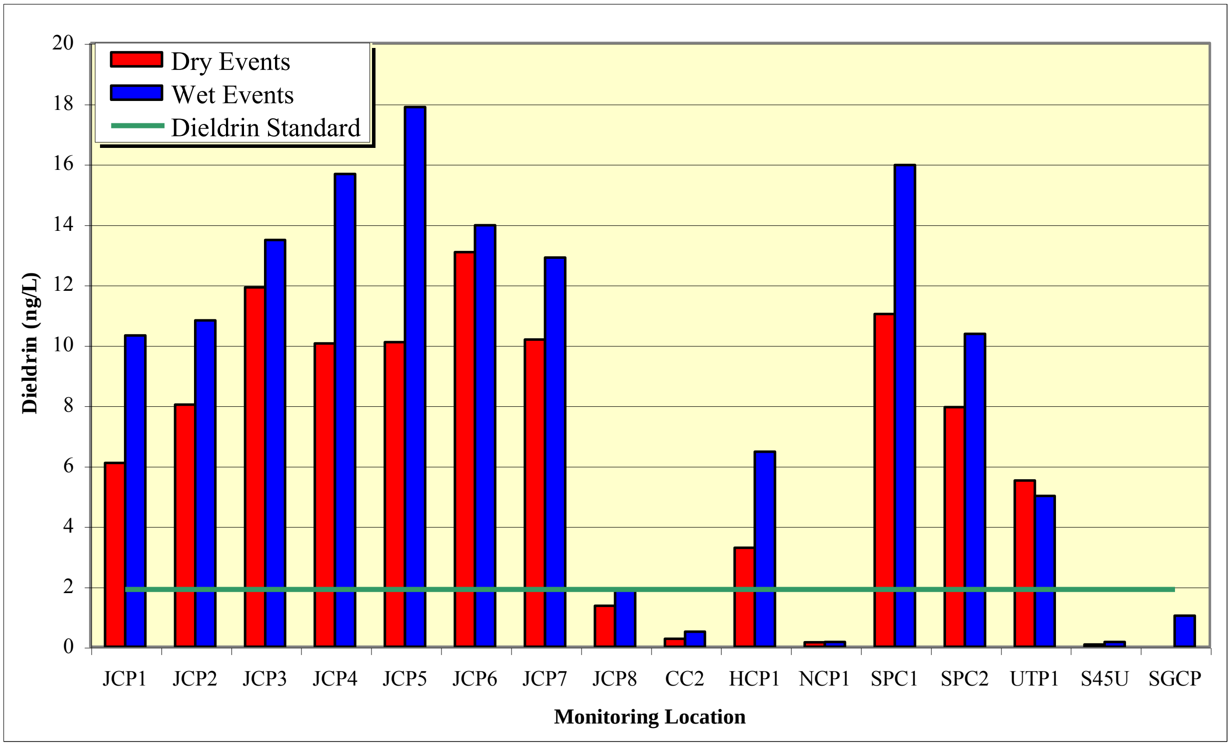
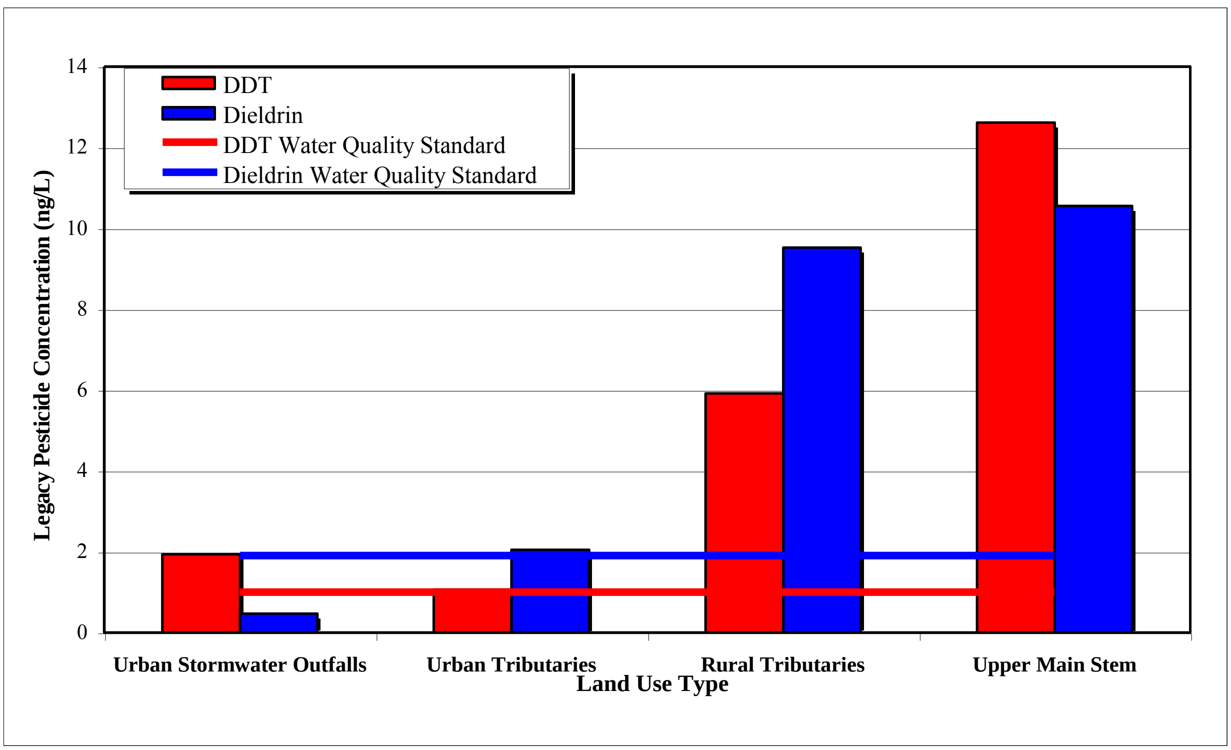


Figure 6-3(c). Average DDT and Dieldrin Concentration by Land Use Type



6.4 Pesticides and TSS / Turbidity

Figure 6-4(a) shows a fairly tight correlation, even at low concentrations, between total DDT and TSS during storm events but no significant relationship exists during dry periods. The correlation between dieldrin and TSS is weak and driven by a few data points at the upper end of the data range observed (Figure 6-4(b)). In most cases, the dieldrin concentration is between 5 and 15 ng/L and appears completely independent of the TSS concentration.

The reasons for the difference between total DDT and dieldrin are not entirely clear. It could be speculated that, while total DDT correlates well with total suspended solids (TSS), there is a possibility that dieldrin is more likely associated with colloidal particles and, thus, the correlation is weak even during storm events. Figure 6-4(c) shows the correlation between dieldrin and turbidity for storm events and for dry periods. The correlation is fairly good for dry periods but much weaker for storm events. Again, this could be an indication that dieldrin is associated with colloidal particles which, as discussed earlier, could be a main contributor to turbidity.
This may not explain, though, why fairly high dieldrin concentrations can be observed even during dry periods when no particles appear to be present. Dieldrin also has a higher solubility in water than DDT but is still very hydrophobic, i.e. it has a high K_{OW} (octanol-water partition coefficient). Whether this higher solubility can explain the observed data is unclear.

Figure 6-4(a). Correlation between Total DDT and Total Suspended Solids (TSS)

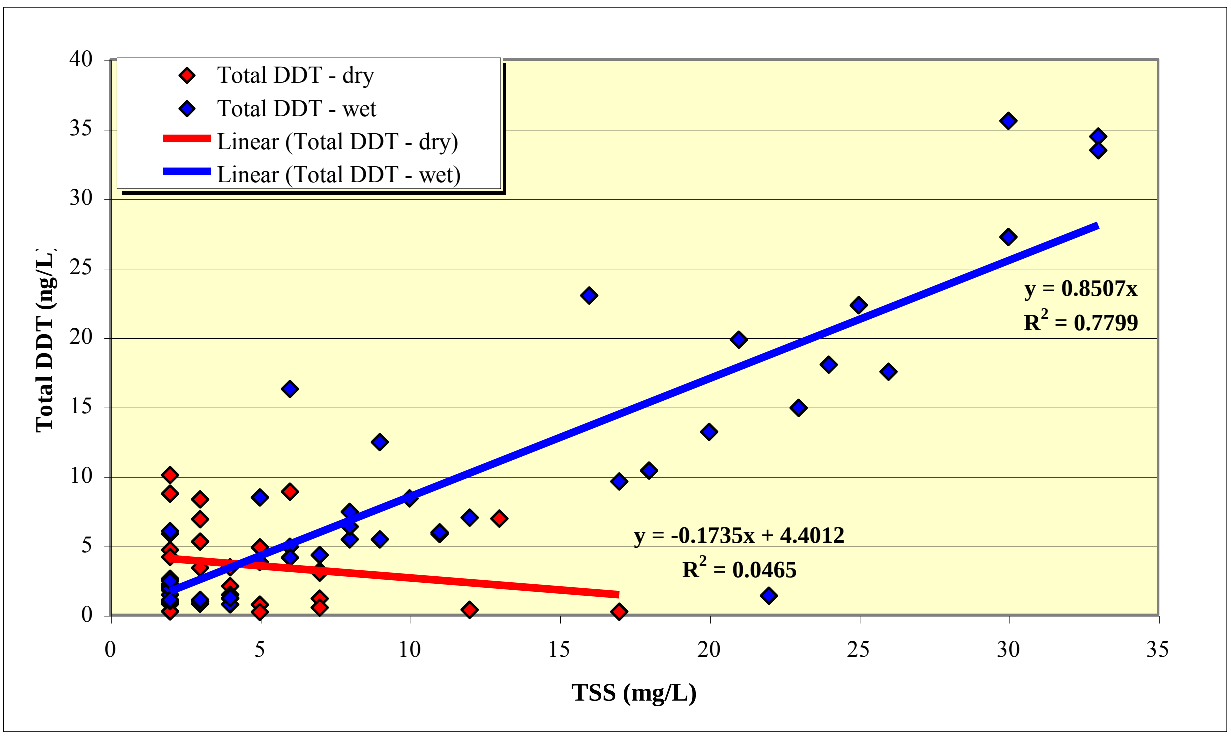


Figure 6-4(b). Correlation between Dieldrin and Total Suspended Solids

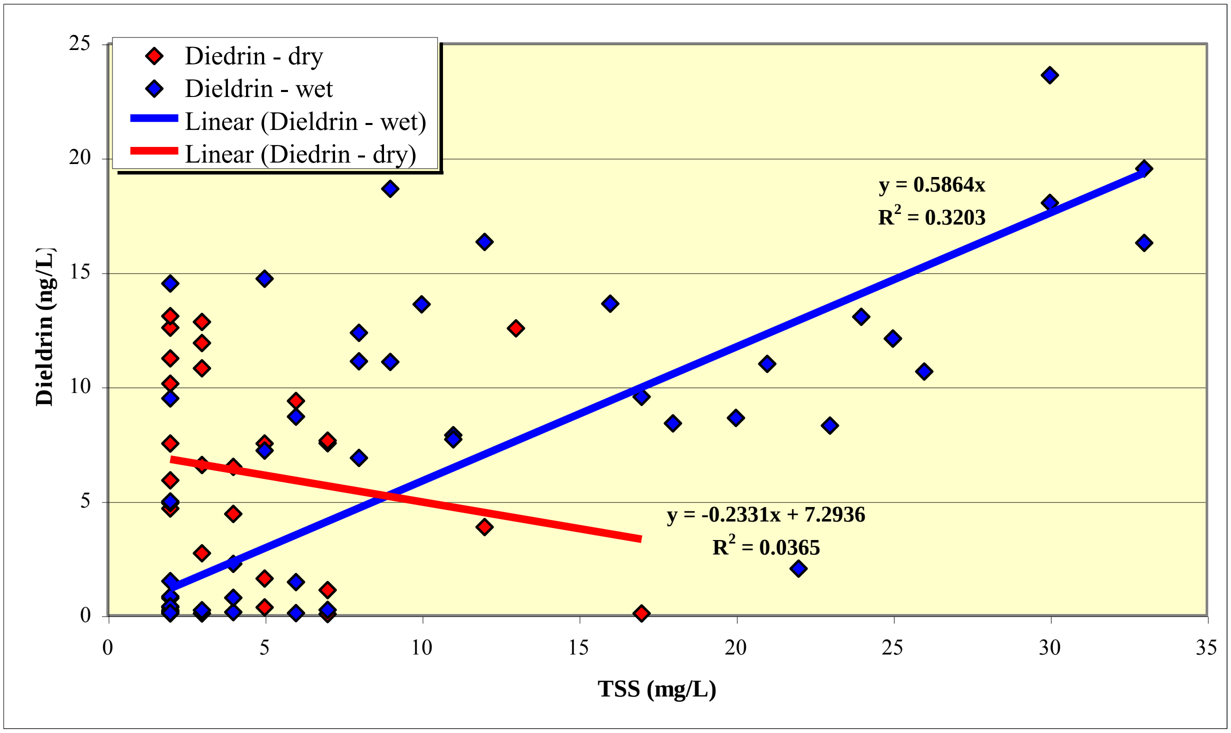
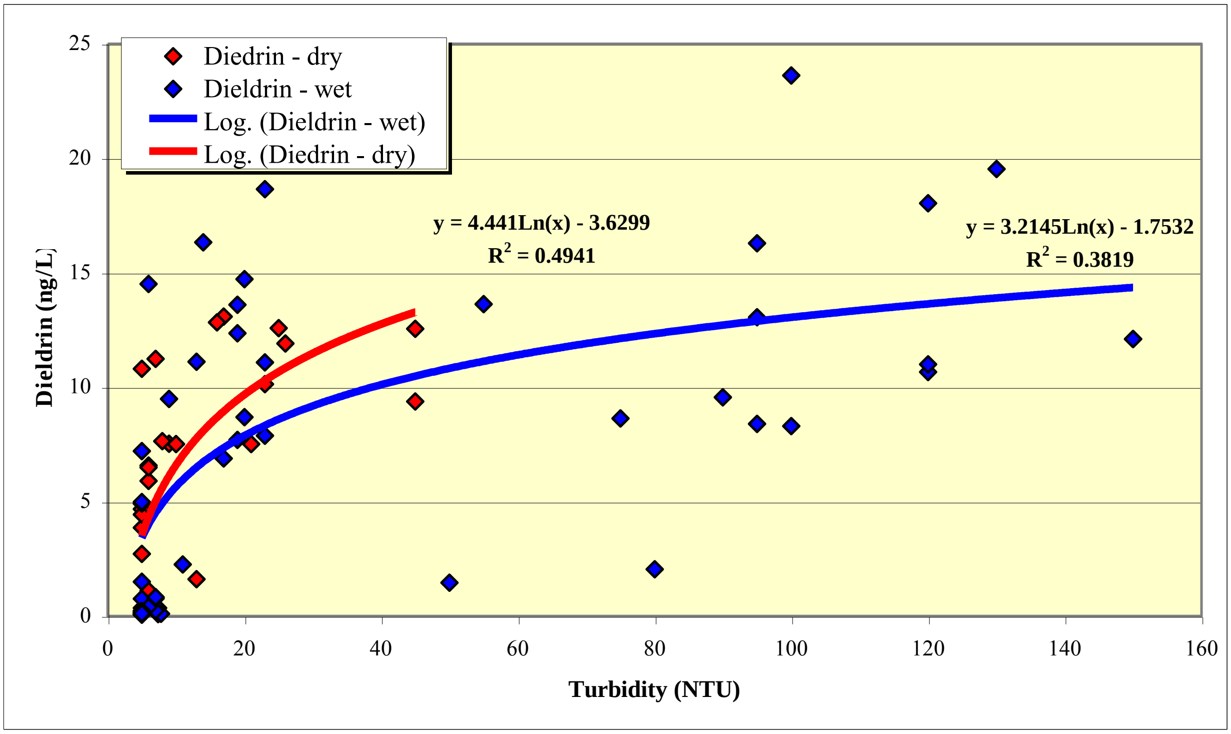


Figure 6-4(c). Correlation between Dieldrin and Turbidity



6.5 GIS Analysis Summary

In order to correlate land uses to in-stream legacy pesticide levels, a GIS analysis was performed to map the boundaries of the sub-catchments that drain to the monitoring location and to determine the area covered by each land use type within this sub-catchment (see appendix B). Table 6-1 summaries the result of this analysis for monitoring locations in the main stem of upper Johnson Creek. The percentage of agricultural land use was determined and compared to the legacy pesticide concentrations detected at the listed monitoring locations. No correlation is evident.

For example, even though the sub-catchment draining to JCP8 and JCP7 have comparable percentage of agricultural land use, the legacy pesticide concentrations are vastly different. This seems to indicate that not the land use by itself but specific practices within the land use are responsible for the observed data. In order to identify these practices, a very detailed on the ground survey would be required that was beyond the scope of this study.

Table 6-1. GIS Land Use by Sub-Catchment

Basin	JCP1	JCP2	JCP3	JCP4	JCP5	JCP6	JCP7	JCP8	Total
Land Use	Area (acres)								
Barren	406	22	21	28	38	5	14	10	544
Low Structure Agriculture	1363	65	89	255	48	26	189	166	2201
High Structure Agriculture	598	102	19	60	337	38	492	140	1786
Deciduous Closed	989	48	31	56	23	12	13	3	1175
Mixed Closed	625	31	44	32	3	25	14	15	789
Conifer Closed	36	2	6	8	0.5	0.9	0.6	0.2	54
Deciduous Open	277	12	8	10	7	2	11	21	348
Mixed Open	160	15	12	16	2	6	15	10	236
Conifer Open	7	0.3	0.8	0.2	0	0.3	0.3	0.2	9
Deciduous Scattered	111	8	2	12	6	2	5	1	147
Mixed Scattered	56	3	3	7	2	0.9	4	0.8	77
Conifer Scattered	5	0.6	0.2	0.2	0.2	0.2	0.6	0	7
Closed Shrub	119	10	6	11	6	3	0.6	2	158
Open Shrub	60	2	3	5	4	0.5	0.5	0.6	76
Scattered Shrub	83	5	3	11	6	1	1	2	112
Meadow/ Grass	231	10	6	10	32	2	4	0.9	296
Total	5126	336	254	521	515	125	765	373	8014.1
% Agricultural	**38%**	**50%**	**43%**	**60%**	**75%**	**51%**	**89%**	**82%**	**50%**
% Low Structure Agriculture	27%	19%	35%	49%	9%	21%	25%	45%	27%
% High Structure Agriculture	12%	30%	7%	12%	65%	30%	64%	38%	22%

7. 0 Summary of Major Findings

The results of the data analyses are as follows:

- Many samples collected in both urban and rural locations exceeded acceptable water quality and health standards.
- Pesticide concentrations are higher during storm events.
- During storm events, there is a strong relationship between total suspended solids (TSS) in the water and concentrations of DDT. Dieldrin concentrations appear more closely linked to turbidity than TSS.
- The concentrations are substantially lower in residential streams and stormwater outfalls than in the agricultural areas.
- The concentrations seem to be declining as the water moves downstream in the main stem of Johnson Creek.
- Within the agricultural area, no correlation between legacy pesticide concentrations and specific agricultural activity could be established.

8.0 Actions to Reduce Sediment and Pesticide Load in Johnson Creek

Upon completion of the data analysis, a fact sheet was created by project partners to disseminate the findings to residents of the study area (see appendix C). The four-page handout includes the results of the study, along with a list of basic erosion control measures to minimize sediment from entering the creek. Since the land use analysis was unable to identify a specific activity contributing to the increased concentrations of legacy pesticides in the Creek, the actions were listed by several land use-based activity types to target all potential sources in the study area. The fact sheet was distributed to residents in the study area of the watershed, stakeholders, and all project partners. The best management practices that were included in the fact sheet are:

<u>Residential Activities:</u>

- Many city stormwater drains lead directly to Johnson Creek. To the extent practicable, keep soil from running off your land and into a storm drain.
- When gardening or landscaping, keep soil on-site by covering exposed piles with tarps or mulch.
- If you have a private roadway, direct the drainage into upland areas at many points or allow runoff to flow into a vegetated buffer strip to filter out pollutants before it leaves your property.
- Add clean gravel to the surface of an unpaved driveway.
- When hiking or mountain biking stay on the trail. In certain instances, feet and tires can both cause soil erosion.

<u>Agricultural Activities:</u>

- Maintain vegetated buffers along streams to filter out sediment in runoff from fields and farm roads.
- Avoid irrigation induced erosion.
- If livestock are confined to one area, maintain a vegetated buffer around the area.
- Avoid grazing to the point of creating bare patches in your pastures, especially near streams and ditches that drain into streams.

- Consider avoiding the use of ditches that directly discharge to a creek. As an alternative, allow runoff to flow into a vegetated buffer strip to filter the pollutants before it leaves the farm.

Construction Activities: *If you are planning to engage in soil-disturbing construction activity, please contact your City or County before you begin to determine the best ways to control erosion and to determine if a permit is needed.*

- Cover exposed areas and piles of soil with tarps or mulch to minimize storm-driven and wind-borne erosion of soil.
- Avoid the placement or movement of soils onto paved areas.
- Install appropriate measures to trap sediments and filter runoff before it leaves the site.
- Quickly re-seed or replant after soil-disturbing activity is complete.

It was also noted that for more information on erosion control measures or pesticide use readers should refer to their local jurisdictional office, or SWCD (Soil and Water Conservation District), in which the contact information was included on the back of the fact sheet.

Appendix A

Data Summary

	Weather	**D**	**W**	**W**	**D**	**W**	**D**	**W**	**W**	**D**	**W**	**D**	**W**	**W**	**D**	**W**
	Event #	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
	Address	SE 252nd					SE 267th					SE 282nd				
	Sample ID	**JCP1**					**JCP2**					**JCP3**				
	Land Use															
	Type	**main stem**					**main stem**					**main stem**				
Parameters	**Units**														**N/S**	**N/S**
Pesticides																
2,4' DDE	ng/L	0.13	0.26	0.73	0.18	1.15	0.98	0.28	0.16	0.14	1.36	0.12	0.27	0.80		
4,4' DDE	ng/L	0.96	3.84	5.75	0.63	1.34	4.99	3.95	4.79	0.63	1.33	0.96	4.36	6.71		
2,4' DDD	ng/L	0.24	0.26	0.71	0.19	0.16	0.15	0.29	0.90	0.13	0.04	0.21	0.29	3.54		
4,4' DDD	ng/L	0.88	1.42	1.95	0.33	0.00	0.30	1.41	0.98	0.39	0.69	0.41	1.58	1.85		
2,4' DDT	ng/L	1.31	1.13	2.28	0.17	0.00	0.44	1.63	1.83	0.22	0.40	2.29	1.89	2.97		
4,4' DDT	ng/L	1.17	6.28	11.56	0.51	1.47	3.21	7.34	9.35	0.60	1.62	1.29	9.12	18.57		
TOTAL DDT	ng/L	4.68	13.19	22.99	2.02	4.12	10.08	14.90	18.01	2.10	5.44	5.28	17.51	34.44		
Aldrin	ng/L	2.64	4.85	0.22	0.19	<0.12	2.99	6.09	0.37	0.18	<0.11	2.99	2.62	0.83		
Alpha HCH	ng/L			13.08	0.55	0.17			23.24	0.43	0.24			27.55		
Chlordane, alpha	ng/L	0.44	0.44	1.02	0.22	0.37	0.42	0.48	0.83	0.28	0.48	0.59	0.54	1.52		
Chlordane, gamma	ng/L	<0.09	0.33	1.27	0.09	0.17	0.79	0.39	1.04	0.14	0.33	0.22	0.45	1.37		
Dieldrin	ng/L	7.52	8.63	13.63	4.67	8.69	10.13	8.29	13.05	5.91	11.08	11.90	10.66	16.28		
Heptachlor Epoxide	ng/L	0.25	0.38	0.56	0.22	0.79	0.27	0.28	0.31	0.20	0.98	0.34	0.29	0.39		
Chlorpyrifos	ng/L	1.59	1.38	5.14	1.12	2.80	0.83	0.43	0.33	2.30	2.30	0.53	0.58	0.61		
Common Parameters																
Turbidity	NTU	21	75	55	<5	20	23	100	95	6	23	26	120	95		
Conductivity	µmhos/cm	108	89	102	91	102	90	81	97	76	94	84	78	67		
TSS	mg/L	2	20	16	2	6	2	23	24	<2	9	3	26	33		
Temperature	°C	16.6	8.6	8.2	12.1	14.3	17.6	8.9	8.4	12.7	15.3	16.6	9	8.3		
pH (field)	S.U.	6.6	5.9	6.9	7.4	6.7	6.6	5.9	6.8	7.5	6.4	6.6	6.0	6.7		

Notes

N/S = Not sampled

	Weather	D	W	W	D	W	D	W	W	D	W	D	W	W	D	W
	Event #	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
	Address	SE Short					SE 307th					SE Pleasant Home				
	Sample ID	**JCP4**					**JCP5**					**JCP6**				
	Land Use															
	Type	**main stem**					**main stem**					**main stem**				
Parameters	**Units**														**N/S**	**N/S**
Pesticides																
2,4' DDE	ng/L	0.29	0.30	0.78	0.17	1.24	0.14	0.32	0.73	0.18	1.86	0.12	0.26	0.41		
4,4' DDE	ng/L	1.26	4.86	8.92	1.01	1.48	1.78	5.49	13.25	0.90	1.73	1.25	2.71	7.25		
2,4' DDD	ng/L	0.30	0.37	2.04	0.22	0.26	0.42	0.37	2.33	0.20	0.33	0.27	0.15	0.56		
4,4' DDD	ng/L	0.50	2.12	2.74	0.58	0.88	1.26	2.05	3.51	0.55	1.00	1.05	0.98	2.02		
2,4' DDT	ng/L	2.06	2.24	3.81	0.28	0.49	0.89	2.49	6.58	0.30	0.83	3.58	1.19	3.95		
4,4' DDT	ng/L	1.46	9.93	17.29	0.89	2.01	2.44	11.59	31.72	0.92	2.63	2.45	5.11	19.27		
TOTAL DDT	ng/L	5.86	19.82	35.58	3.15	6.36	6.94	22.31	58.12	3.04	8.39	8.73	10.39	33.46		
Aldrin	ng/L	2.32	2.94	0.37	0.12	<0.11	0.19	3.37	0.90	0.08	<0.12	0.18	3.84	1.29		
Alpha HCH	ng/L			36.75	0.47	0.37			53.05	0.48	0.44			105.33		
Chlordane, alpha	ng/L	0.63	0.57	1.30	0.39	0.62	0.71	0.6	1.94	0.34	0.64	0.72	0.38	1.33		
Chlordane, gamma	ng/L	0.20	0.51	1.34	0.23	0.41	0.29	0.5	1.71	0.16	0.52	0.40	0.26	1.07		
Dieldrin	ng/L	12.58	11	23.61	7.52	12.36	12.55	12.1	27.93	7.64	13.60	13.07	8.39	19.53		
Heptachlor Epoxide	ng/L	3.50	0.28	0.45	0.23	0.89	0.29	0.33	0.46	0.24	1.25	0.40	0.38	0.26		
Chlorpyrifos	ng/L	0.90	0.94	0.45	6.49	3.29	1.14	0.35	0.23	10.53	4.55	0.53	0.37	0.12		
Common Parameters																
Turbidity	NTU	25	120	100	9	19	45	150	190	8	19	17	95	130		
Conductivity	µmhos/cm	85	78	68	80	96	85	80	69	76	89	122	78	67		
TSS	mg/L	2	21	30	7	8	13	25	60	7	10	2	18	33		
Temperature	°C	17	9.1	8.4	13.3	16.1	16.9	9.3	8.4	12.6	17	17.6	9.5	8.8		
pH (field)	S.U.	6.5	5.9	6.6	7.4	6.4	6.4	5.8	7.0	6.9	6.6	6.7	5.9	6.8		

	Weather	D	W	W	D	W	D	W	W	D	W	D	W	W	D	W
	Event #	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
	Address	SE 327th					SE Cottrell					SE 162nd				
	Sample ID	**JCP7**					**JCP8**					**CC**	**CC2**			
	Land Use											**residential**				
	Type	**main stem**					**main stem**					**tributary**				
Parameters	**Units**															
Pesticides																
2,4' DDE	ng/L	0.18	0.29	0.27	0.24	0.72	0.16	0.19		0.24	0.81	<0.29	0.14	0.07	0.13	1.56
4,4' DDE	ng/L	1.36	2.54	5.99	1.27	1.62	0.19	0.29	0.72	0.19	0.25	0.06	0.07	0.03	0.07	0.14
2,4' DDD	ng/L	0.39	0.14	0.58	0.37	0.30	0.12	0.02		0.10	0.05	<0.12	0.30	0.09		
4,4' DDD	ng/L	1.18	0.83	1.83	0.92	1.05	0.12	0.00				0.17	0.00	0.84		
2,4' DDT	ng/L	3.15	1.05	3.11	0.60	0.76	0.09	15.43				0.10	0.07	0.12		0.09
4,4' DDT	ng/L	2.07	4.75	15.43	1.48	2.95	0.06	0.00	0.67		0.12	<0.10	0.43	0.01		0.11
TOTAL DDT	ng/L	8.33	9.60	27.21	4.87	7.41	0.74	15.92	1.39	0.53	1.23	0.84	1.00	1.17	0.20	1.90
Aldrin	ng/L	0.08	3.25	1.32	0.55	<0.11	0.36	5.24	0.13	0.08	<0.12	0.16	1.86		0.13	<0.11
Alpha HCH	ng/L			100.70	0.44	0.29			1.06	0.38	0.13			1.40	0.42	0.18
Chlordane, alpha	ng/L	0.66	0.36	1.12	0.48	0.63	0.26	<0.11		0.10	0.14	0.22	<0.11	0.04	0.08	0.12
Chlordane, gamma	ng/L	0.35	0.24	0.87	0.32	0.56	0.11	<0.09	0.17	0.12	0.32	0.02	<0.09	0.10	0.08	0.20
Dieldrin	ng/L	12.83	9.55	18.03	7.51	11.11	1.61	1.46	2.04	1.10	2.25	0.17	0.35	0.76	0.35	0.39
Heptachlor Epoxide	ng/L	0.42	0.31	0.27	0.47	0.52	0.18	0.18		0.02	0.42	0.09	<0.11		0.12	0.45
Chlorpyrifos	ng/L	0.41	0.24	0.60	63.05	5.80	0.68	1.04	0.24	0.20	0.36	0.78	0.30	0.21	0.00	0.63
Common Parameters																
Turbidity	NTU	16	90	120	10	13	13	50	80	6	11	<5	7.4	7	<5	6
Conductivity	µmhos/cm	114	81	71	103	99	66	59	55	59	89	173	93	72	86	90
TSS	mg/L	3	17	30	5	8	5	6	22	7	4	<2	<2	4	5	<2
Temperature	°C	17.8	9.6	8.5	12.8	16.7	18.3	9.6	8.4	14.3	17.7	16.3	8.8	8.5	10.3	14.6
pH (field)	S.U.	6.9	5.7	6.8	7.1	6.6	6.5	5.6	6.7	6.9	6.4	6.8	6.1	6.9	6.7	6.5

Parameters	Units	HCP1 D 1	HCP1 W 2	HCP1 W 3	HCP1 D 4	HCP1 W 5	NCP1 D 1	NCP1 W 2	NCP1 W 3	NCP1 D 4	NCP1 W 5	SCP1 D 1	SCP1 W 2	SCP1 W 3	SCP1 D 4	SCP1 W 5
	Weather Event #	**D 1**	**W 2**	**W 3**	**D 4**	**W 5**	**D 1**	**W 2**	**W 3**	**D 4**	**W 5**	**D 1**	**W 2**	**W 3**	**D 4**	**W 5**
	Address	SE Heiney					SE Cleveland					SE 240th				
	Sample ID	**HCP1**					**NCP1**					**SCP1**				
	Land Use	**residential**					**residential**									
	Type	**tributary**					**tributary**					**tributary**				
Pesticides																
2,4' DDE	ng/L	<0.29	0.42	0.07	0.08	1.69	<0.29	0.12	0.12	0.16	1.01	0.80	0.52	0.40	1.27	1.29
4,4' DDE	ng/L	0.10	0.93	0.65	0.13	0.23	0.03	0.10	0.59	0.04	0.08	1.79	3.35	4.29	3.06	2.95
2,4' DDD	ng/L	<0.12	0.15	0.11	0.00	0.08	<0.12	0.45		0.00		0.12	0.17		0.16	
4,4' DDD	ng/L	0.25	0.00	0.21	0.11	0.33	0.11	0.06		0.03		0.32	1.00	0.90	0.00	
2,4' DDT	ng/L	0.10	0.02	0.08	0.07	0.06	<0.13	0.00		0.04		0.23	0.63	0.85	0.61	0.34
4,4' DDT	ng/L	<0.10	0.25	0.33		0.20	<0.10	0.06	0.04			0.91	2.78	6.00	1.79	1.47
TOTAL DDT	ng/L	0.96	1.77	1.46	0.38	2.60	0.78	0.79	0.75	0.26	1.08	4.17	8.45	12.44	6.89	6.04
Aldrin	ng/L	0.20	1.82		0.14	<0.11	0.19	2.53	0.09	0.11	<0.11	0.93	1.05	0.14	0.23	0.86
Alpha HCH	ng/L			0.97	0.39	0.07			0.91	0.30	0.13			6.93	0.40	0.25
Chlordane, alpha	ng/L	0.21	<0.11	0.08	0.11	0.11	0.20	<0.11		0.05	0.07	0.05	0.24	0.25	0.31	0.50
Chlordane, gamma	ng/L	0.04	<0.09	0.20	0.00	<0.09	0.10	<0.09	0.19	0.06	0.04	0.19	0.16	0.52	0.43	0.22
Dieldrin	ng/L	2.71	4.91	9.49	3.86	4.98	0.22	<0.09		0.08	0.23	11.24	14.72	18.65	10.80	14.51
Heptachlor Epoxide	ng/L	0.15	0.24	0.21	0.19	1.15	0.08	0.12		0.12	0.54	0.31	0.32	0.18	0.20	0.68
Chlorpyrifos	ng/L	0.41	1.09	0.35	0.05	1.33	0.35	0.41	0.07	0.13	0.18	15.54	3.89	38.08	9.68	11.20
Common Parameters																
Turbidity	NTU	<5	<5	9	<5	<5	<5	7.4	11	<5	<5	7	20	23	<5	6
Conductivity	µmhos/cm	146	117	101	143	112	134	96	73	93	95	168	126	86	213	183
TSS	mg/L	3	<2	2	12	<2	<2	3	4	<2	3	<2	5	9	3	<2
Temperature	°C	15.7	9.5	8.3	10.9	14.4	15.4	8.9	9.1	10.7	13.7	17.3	10.2	9.1	12.4	14.1
pH (field)	S.U.	6.8	6.6	6.8	6.8	6.9	6.0	6.1	6.8	6.7	7.0	7.0	6.3	6.6	7.0	6.9

D 1	W 2	W 3	D 4	W 5	D 1	W 2	W 3	D 4	W 5	D 1	W 2	W 3	D 4	W 5	D 1	W 2	W 3	D 4	W 5
SE Hideway Ct					SE Bluff Rd					SE 45th @ SE Umatilla St.					S Main @ Powell Blvd				
SCP2					**UTP1**					**S45U**					**SGCP**				
tributary					**tributary**					**mixed outfall**					**commercial outfall**				
															N/S			**N/S**	
1.98	0.34	0.44	0.49	1.37	0.20	0.05	0.71	0.28	1.07	<0.29	0.13	0.08	0.02	0.66		0.43	0.30		1.35
3.45	2.39	2.30	1.18	3.03	1.49	2.25	2.11	0.83	1.28	0.14	0.13	0.09		0.17		0.3	0.06		0.09
0.34	0.16		0.32	0.29	0.20	0.13		0.22	0.18	<0.12	0.59	0.16	0.09			<0.13	0.43		
0.83	0.81	0.29	0.90	0.71	0.48	0.42	0.24	0.36	0.56	0.25	0.00	1.93	0.03			<0.07	0.00		0.73
0.28	0.41	0.22	0.21	0.37	0.66	0.41	0.42	0.09	0.17	0.27	0.10	0.48	0.09	0.18		<0.14	0.00		0.10
1.98	1.33	2.56	0.35	1.23	0.36	1.65	2.47	0.29	0.55	<0.10	0.21	1.57		0.08		1.46	1.46		0.17
8.86	5.45	5.82	3.44	7.00	3.39	4.90	5.95	2.07	3.80	1.18	1.45	4.30	0.23	1.09		2.53	2.24		2.43
0.48	1.77	0.16	0.28	1.66	0.39	<0.11	0.20	0.35	0.52	0.17	1.65		0.10	<0.11		1.56			<0.10
		2.94	0.20	0.16			1.36	0.16	0.14			0.75	0.35	0.12			0.42		0.27
0.52	0.2	0.15	0.22	0.71	0.53	0.35	0.42	0.28	2.26	0.24	0.15	0.31	0.08	0.14		0.18			0.37
0.42	0.16	0.55	0.22	0.24	0.20	0.24	0.49	0.35	0.51	0.20	0.13	0.49	0.07	0.11		0.11	0.15		0.26
9.37	6.88	7.88	6.49	16.33	6.57	<0.1	7.69	4.43	7.20	0.06	0.14	0.23	<0.09	0.11		0.76	0.83		1.50
0.22	0.15	0.14	0.19	0.58	0.22	<0.11	0.21	0.18	0.62	0.11	<0.11	0.06	0.01	0.45		<0.11			0.67
11.93	3.68	13.60	3.49	10.15	1.40	<0.36	0.13	0.59	1.19	0.22	0.45	0.32	0.09	<0.35		0.92	0.51		1.48
45	17	23	6	14	6	7.8	19	<5	<5	<5	<5	7	<5	<5		<5	7		<5
186	99	74	125	169	166	92	66	114	129	247	239	219	240	242		45	70		73
6	8	11	4	12	3	6	11	4	5	7	4	7	17	<2		<2	<2		2
16.9	9.4	8.6	13.9	16.2	19	9.5	8.8	15.7	16.3	15.2	12.7	11.5	14.9	14.5		10.9	9.3		15.5
6.4	5.9	6.5	7.0	6.6	6.6	5.3	5.9	7.0	6.6	6.5	6.6	6.6	7.0	6.6		6.4	7.0		7.0

Appendix B

Study Area Map

Appendix C

Johnson Creek
Legacy Pesticide Study 2003-2004
Fact Sheet