Surface Water Monitoring Program for Pesticides in Salmon-Bearing Streams, 2009-2011 Triennial Report

A Cooperative Study by the Washington State Departments of Ecology and Agriculture

DEPARTMENT OF
ECOLOGY
State of Washington

WSDA
100 YEARS

February 2013

Department of Ecology Publication No. 13-03-002
Department of Agriculture Publication No. AGR PUB 102-377

Publication and Contact Information

This report is available on the Department of Ecology website at https://fortress.wa.gov/ecy/publications/SummaryPages/1303002.html and on the Department of Agriculture website at http://agr.wa.gov/FP/Pubs/docs/377-SWM2009-11Report.pdf

Data for this project are available at Ecology's Environmental Information Management (EIM) website www.ecy.wa.gov/eim/index.htm. Search User Study ID, DSAR0004.

The Activity Tracker Code for this study is 03-501

For more information contact:

Publications Coordinator
Environmental Assessment Program
P.O. Box 47600, Olympia, WA 98504-7600
Phone: (360) 407-6764

Washington State Department of Ecology - www.ecy.wa.gov

- Headquarters, Olympia (360) 407-6000
- Northwest Regional Office, Bellevue (425) 649-7000
- Southwest Regional Office, Olympia (360) 407-6300
- Central Regional Office, Yakima (509) 575-2490
- Eastern Regional Office, Spokane (509) 329-3400

Cover photo: Amy Cook, Department of Ecology employee, sampling for pesticides at Mission Creek (photo by Evan Newell).

Surface Water Monitoring Program for Pesticides in Salmon-Bearing Streams, 2009-2011 Triennial Report

A Cooperative Study by the Washington State Departments of Ecology and Agriculture

by

Debby Sargeant, Evan Newell, Paul Anderson, and Amy Cook

Environmental Assessment Program
Washington State Department of Ecology
Olympia, Washington 98504-7710

Water Resource Inventory Areas (WRIAs) and 8-digit Hydrologic Unit Code (HUC) numbers for the study area:

WRIAs

- 3 Lower Skagit/Samish
- 8 Cedar/Sammamish
- 9 Duwamish/Green
- 37 Lower Yakima
- 45 Wenatchee
- 46 Entiat

HUC numbers

- 17110002 Samish
- 17110007 Skagit
- 17110012 Cedar/Sammamish
- 17110013 Duwamish/Green
- 17030003 Yakima
- 17020011 Wenatchee
- 17020010 Entiat

This page is purposely left blank

Table of Contents

.

List of Figures

List of Tables

Abstract

The Washington State Departments of Agriculture and Ecology have been conducting a multi-year monitoring program since 2003 to characterize pesticide concentrations in selected salmon-bearing streams during the typical pesticide-use period in Washington.

The following six basins are being monitored:

- Thornton Creek in the Cedar-Sammamish basin representing urban land use.
- Longfellow Creek in the Green-Duwamish basin representing urban land use.
- Lower Skagit-Samish basin representing western Washington agriculture.
- Lower Yakima basin representing irrigated agriculture.
- Wenatchee and Entiat basins representing tree fruit agriculture.

Of the 74 types of pesticides and pesticide degradates detected, the pesticides that did not meet an assessment criterion or water quality standard include:

- Insecticides: bifenthrin, chlorpyrifos, DDVP, diazinon, endosulfan, ethoprop, malathion, methiocarb, and methomyl.
- Endosulfan degradate: endosulfan sulfate.
- Herbicide: metolachlor.
- Legacy pesticide: DDT and its degradates (DDD and DDE).

Most pesticide concentrations found in this study do not directly affect salmonids. Pesticide concentrations at some of the sites – Big Ditch in the Skagit-Samish basin, the Lower Yakima basin sites, and Brender Creek in the Wenatchee basin – may affect aquatic invertebrate populations which serve as a prey base for salmonids. This may indirectly affect salmon by reducing their food source.

High water temperatures and low dissolved oxygen levels are of concern for the fisheries resource in Indian Slough, Browns Slough, and Big Ditch in the Skagit-Samish basin. Temperature levels for the Lower Yakima sites during some periods are of concern for steelhead fisheries.

Decreasing trends in pesticide concentrations were seen for 16 select pesticides, and increasing trends in concentrations were seen for 10 pesticides. Decreasing trends in insecticides were seen for azinphos-methyl in the Lower Yakima basin, chlorpyrifos in Marion Drain, diazinon in Thornton Creek, and endosulfan in Brender Creek. In Marion Drain there were increasing trends in concentrations for the insecticide ethoprop.

Acknowledgements

The authors of this report thank the following people for their contributions to this study:

- Jim Cowles and Kelly McLain, Washington State Department of Agriculture, for field assistance, document review, and technical assistance.
- George Tuttle and Kirk Cook, Washington State Department of Agriculture, for document review and technical assistance.
- A.V. "Skip" Vecchia, U.S. Geological Survey, for invaluable help and guidance on trend modeling.
- Elizabeth Sanchey and Brandon Ambrose, Yakama Nation Environmental Management Program, for sampling assistance and technical expertise.
- Rick Haley, Skagit County, for sampling assistance and technical expertise.
- Elaine Brouillard, Rosa-Sunnyside Board of Joint Control, for technical assistance.
- Mike Rickel, Cascadia Conservation District, for technical assistance.
- Mike Jurgens for permission to access the Mission Creek site.
- Ray Willard, Washington Dept. of Transportation, for technical assistance.
- Washington State Department of Ecology staff:
    - Michael Friese, Matt Bischof, Casey Deligeannis, Jenna Durkee, Brandee Era-Miller, Joye Redfield-Wilder, Suzanne Saunders, Keith Seiders, Pat Shanley, and Eiko Urmos-Berry for field assistance.
    - Manchester Environmental Laboratory staff, Bob Carrell, Karin Feddersen, Kamilee Ginder, Dickey Huntamer, Stuart Magoon, Dean Momohara, Nancy Rosenbower, John Weakland, Leon Weiks, and Jeff Westerlund, for sample processing, sample analysis, review of results, and technical assistance.
    - Randy Marshall for review and editing of the report.
    - Dale Norton for review and guidance.
    - Joan LeTourneau, Jean Maust, and Diana Olegre for formatting and editing the report.

Executive Summary

The Washington State Departments of Agriculture (WSDA) and Ecology (Ecology) began a multi-year monitoring study to evaluate pesticide concentrations in surface waters in 2003. The study targets pesticide presence in salmon-bearing streams during a typical pesticide-use season (e.g., March through September) in Washington.

As the project progressed, additional sampling areas were added. Currently four types of land-use areas are monitored for this study: urban and three types of agricultural.

This report provides an in-depth analysis of data collected during 2009-2011 in the six basins being monitored and compares the data with previous results where available. This report examines trends and pesticide occurrence/distribution and also determines if water quality concentrations are healthy for aquatic life. Reports from previous years and more information about this project can be found at: www.ecy.wa.gov/programs/eap/toxics/pesticides.htm.

Study Area and Sampling Design

The six basins monitored during 2009-2011 are presented in Figure ES-1. The urban basins include two sites: Thornton Creek, located in the Cedar-Sammamish basin (monitored since 2003) and Longfellow Creek, located in the Green-Duwamish basin (monitored since 2009). The agricultural land use sites include: Five sites in the lower Skagit-Samish basin representing western Washington agriculture (monitored since 2006); four sites in the Lower Yakima basin representing irrigated agriculture (monitored since 2003); and five sites in the Wenatchee-Entiat basins representing tree fruit agriculture (monitored since 2007).

Weekly sampling occurred during the typical pesticide-use season, March through September. Over 170 types of pesticide and pesticide-related compounds were analyzed during each sample event. Additional parameters included total suspended solids, temperature, dissolved oxygen, pH, conductivity, and streamflow measurements. To determine if water quality concentrations were healthy for aquatic life, monitoring data were compared to numeric criteria including: pesticide registrations toxicity criteria, EPA National Recommended Water Quality Criteria (NRWQC), and Washington State water quality standards.

Pesticide Results

During 2009-2011, the majority of pesticide detections met (did not exceed) numeric assessment criteria or water quality standards.

During the three years, 74 pesticide or pesticide-related compounds were detected: 34 herbicides, 21 insecticides, 13 pesticide degradates, 4 fungicides, one wood preservative, and one pesticide synergist. For the urban sites, the Skagit-Samish sites, and the Lower Yakima sites, herbicides were the most commonly detected type of pesticide. For the Wenatchee-Entiat sites, the most commonly detected pesticide types were insecticides and insecticide degradates.

Figure ES-1. State map showing the six urban and agricultural basins monitored during 2009-2011.

Of the 74 types of pesticides and pesticide degradates detected, the pesticides that were above an assessment criterion or water quality standard include:

- Insecticides: bifenthrin, chlorpyrifos, DDVP, diazinon, endosulfan, ethoprop, malathion, methiocarb, and methomyl.
- Endosulfan degradate: endosulfan sulfate.
- Herbicide: metolachlor.
- Legacy pesticide: DDT and its degradates.

Some pesticide detections were above an acute numeric criterion or standard. Most of the pesticide detections that exceeded a numeric criterion were above a chronic criterion, and in most cases, the temporal component of the chronic criteria was not exceeded.

The following is a summary of sites where select pesticides are of concern:

- Longfellow Creek in the Green-Duwamish basin: May 2009 methiocarb detections may be a chronic concern for aquatic invertebrates, a food source for salmon.
- Skagit-Samish basin: July 2011 bifenthrin detections at the upstream Big Ditch site is a chronic concern for fish and aquatic invertebrates, a food source for salmon.

- Lower Yakima basin: These sites had the greatest number of current use pesticide detections that exceeded water quality standards or assessment criteria. The greatest concerns are for an acute and chronic risk to aquatic invertebrates (a food source for salmon) in Spring Creek and Sulphur Creek Wasteway, especially for the insecticide, chlorpyrifos; and a chronic risk to aquatic invertebrates in Marion Drain.
- Wenatchee basin: Endosulfan levels at the Wenatchee basin sites (especially Brender Creek) indicate chronic aquatic health concerns. But endosulfan detections at the Wenatchee sites and endosulfan concentrations in Brender Creek appear to be decreasing over time (Figure ES-2).
    - Consistent detections of total DDT indicate chronic health concerns for aquatic life (e.g., fish and aquatic invertebrates) in Brender Creek. There is a moderately strong relationship between total DDT and total suspended solids; therefore, reductions in total suspended solids would likely lead to lower DDT concentrations.
    - Brender Creek chlorpyrifos concentrations were of acute and chronic concern for aquatic life.

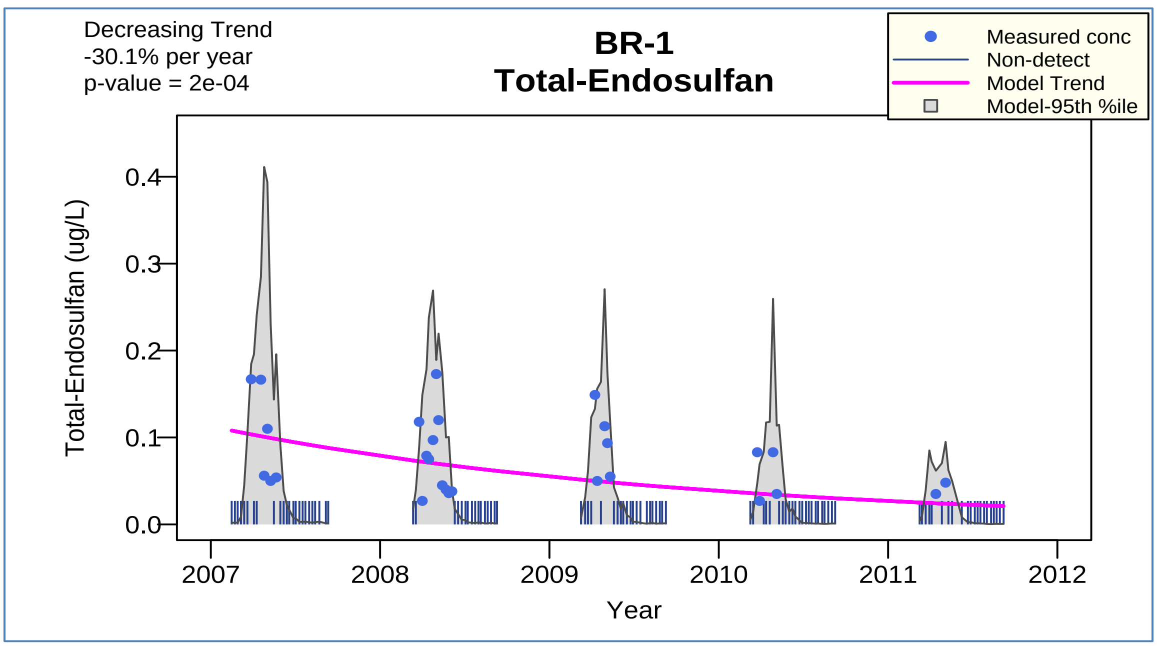


Figure ES-2. Decreasing trends in total endosulfan concentrations at the Brender Creek site, 2007-2011.

To estimate the additive effects of pesticide mixtures, toxic units were calculated. When pesticide mixtures were of concern to aquatic life, it was generally due to a high concentration of a single pesticide in the mixture (68% of the time) that did not meet a water assessment criterion or standard.

Each project area has a characteristic set of pesticides detected at the sites. Pesticides detected are likely related to pesticide use for a specific crop. Each project area was chosen to represent a particular land use (urban, western Washington agriculture, irrigated crop agriculture, and tree-fruit agriculture).

The major factors that influence the number and types of pesticides detected were season and timing of pesticide application for specific crops. Rainfall and flow were significant but less influential.

Trend analysis was conducted at sites having pesticide data that met the trend model requirements. Significant decreasing trends in pesticide concentrations were seen at the following sites:

- Thornton Creek: diazinon, diuron, mecoprop (MCPP), triclopyr.
- Upstream Big Ditch: picloram, tebuthiuron.
- Downstream Big Ditch: bentazon, eptam, metalaxyl, picloram.
- Indian Slough: tebuthiuron.
- Browns Slough: diuron, simazine.
- Downstream Spring Creek: azinphos-methyl, diuron, simazine.
- Marion Drain: atrazine, chlorpyrifos, clopyralid, simazine.
- Sulphur Creek Wasteway: azinphos-methyl, diuron, norflurazon.
- Brender Creek: total endosulfan.

Significant increasing trends in pesticide concentrations were seen at the following sites:

- Downstream Big Ditch: chlorpropham, MCPA.
- Indian Slough: hexazinone, metolachlor.
- Browns Slough: DCPA (dacthal), MCPA, metolachlor.
- Upstream and downstream Spring Creek: dicamba I.
- Marion Drain: dicamba I, ethoprop, pendimethalin, terbacil, trifluralin.
- Sulphur Creek Wasteway: DCPA, dicamba I, MCPA, pendimethalin.

Conventional Parameters

None of the sites consistently met water temperature standards during the 2009-2011 monitoring period. The sites that met the dissolved oxygen water quality standard include: the urban site, Longfellow Creek; Samish River in the Skagit-Samish basin; all of the Lower Yakima sites except upstream Spring Creek; and all of the Wenatchee-Entiat sites.

In the Skagit-Samish basin, high water temperatures and low dissolved oxygen levels are a threat to the fisheries resource in Indian Slough, Browns Slough, and Big Ditch.

During 2009-2011, most sites did not meet the pH standard. The sites that met the standard were upstream Big Ditch, Indian Slough, and the Samish River in the Skagit-Samish basin. The western Washington sites that did not meet the pH standard either fell below or were above the standard, while all the eastern Washington sites were above the pH standard.

Increasing trends in total suspended solids loading were seen at some sites. This increase is attributed in part to increases in flows measured during sample events. Spring Creek in the Lower Yakima basin had an increasing trend in total suspended solids concentrations, loading, and flow at the upstream site, while the downstream site had decreasing trends in total suspended solids concentrations, loading, and flow.

Report Recommendations

Results of this study support the following recommendations and actions:

- WSDA will add five pesticides with increasing trends (dicamba I, hexazinone, metolachlor, terbacil, and trifluralin) to its list of Pesticides of Concern. WSDA uses the Pesticides of Interest Tracking System (POINTS) to identify those pesticides under further review and evaluation for environmental problems. After an initial evaluation, a Pesticide of Interest that shows potential to contaminate surface water or groundwater, or otherwise impact the environment, can be reclassified as a Pesticide of Concern, triggering additional analysis by WSDA.
- While DCPA (dacthal), MCPA, and pendimethalin have already been evaluated by POINTS, due to increasing trends, these pesticides will be included in WSDA's Pesticide of Concern category.
- Ecology will evaluate the need for adding new pesticides to the monitoring program. Usage data for sampling areas should be reviewed to better align with Ecology's list of analytes.
- Ecology will evaluate discontinuing sampling at the high-flow Wenatchee-Entiat sites and replacing these sites with low-flow sites in tree-fruit agricultural areas.
- Ecology will evaluate the need for the extended sampling season for select pesticides in Marion Drain. No pesticides were detected the last two weeks in October, 2009-2011.

Introduction

The Washington State Departments of Agriculture (WSDA) and Ecology (Ecology) began a multi-year monitoring study in 2003 to evaluate pesticide concentrations in surface waters. The study targets pesticide presence in salmon-bearing streams during a typical pesticide-use season (typically March through September) in Washington.

WSDA, the U.S. Environmental Protection Agency (EPA), the National Atmospheric and Oceanic Administration (NOAA) National Marine Fisheries Service, and the U.S. Fish and Wildlife Service (USFWS) use the data collected from this study to refine exposure assessments for pesticides that are registered for use in Washington State. Having regional data to understand the fate and transport of pesticides allows regulators to assess the potential effects of pesticides on endangered salmon species while minimizing the economic impacts to agriculture.

Since 2003 additional sampling areas have been added. Currently four types of land-use areas are monitored for this study: urban and three types of agricultural use. The urban subbasins were chosen due to land-use characteristics such as high density development, history of pesticide detections, pre-spawning mortality of salmon, and habitat use by salmon. The agricultural basins were chosen because they support several salmonid populations, produce a variety of agricultural commodities, and have a high percentage of cultivated land.

This report provides an in-depth analysis of data collected during 2009-2011 in the six basins being monitored. Where possible, the 2009-2011 results are compared to results from previous years of the monitoring program. This report examines trends and pesticide occurrence and distribution, and also determines if water quality concentrations are healthy for aquatic life.

Study Area

This pesticide monitoring project has been ongoing since 2003. As the project has progressed, additional sampling areas have been added.

Basins Monitored During 2009-2011

The six basins monitored during the 2009-2011 triennial period are presented in Figure 1: two urban and four agricultural. The urban basins were chosen due to land-use characteristics, history of pesticide detections, and habitat use by salmon. The agricultural basins were chosen because they support several salmonid populations, produce a variety of agricultural commodities, and have a high percentage of cultivated areas.

Figure 1. State map showing the six urban and agricultural basins monitored during 2009-2011.

Monitoring areas and timeframes are:

- Thornton Creek subbasin is located in the Cedar-Sammamish basin (WRIA[1] 8) and represents an urban land-use area. Two to four sites were sampled on this creek during 2003-2008. One site at the mouth of Thornton Creek was sampled during 2009-2011 (Figure 2).
- Longfellow Creek subbasin is located in the Green-Duwamish basin (WRIA 9) and represents an urban land-use area. One site near the mouth of the basin was sampled during 2009-2011 (Figure 3).
- Four subbasins of the lower Skagit-Samish basin (WRIA 3) were selected to represent western Washington agricultural land-use practices. Five sites, one on the Samish River, two on Big Ditch Slough, one on Browns Slough, and one on Indian Slough, were sampled during 2006-2011 (Figure 4).
- Three subbasins of the Lower Yakima basin (WRIA 37) were selected to represent eastern Washington irrigated crop-land agricultural practices. Four sites, one on Marion Drain, one on Sulphur Creek Wasteway, and two on Spring Creek, were sampled during 2003-2011 (Figure 5).
- Four subbasins of the Wenatchee basin (WRIA 45) and Entiat basin (WRIA 46) were selected to represent central Washington agricultural tree fruit practices. Five sites were sampled during 2007-2011 near the mouth of the following waterways: Peshastin Creek, Mission Creek, Brender Creek, Wenatchee River (WRIA 45), and Entiat River (WRIA 46) (Figure 6).

Site locations and duration of sampling are described in Appendix B.

A full description of the monitoring sites, including land use, salmon fishery, and climate, can be found in previous reports (Sargeant et al., 2010 and Sargeant et al., 2011).

[1] Water Resource Inventory Area

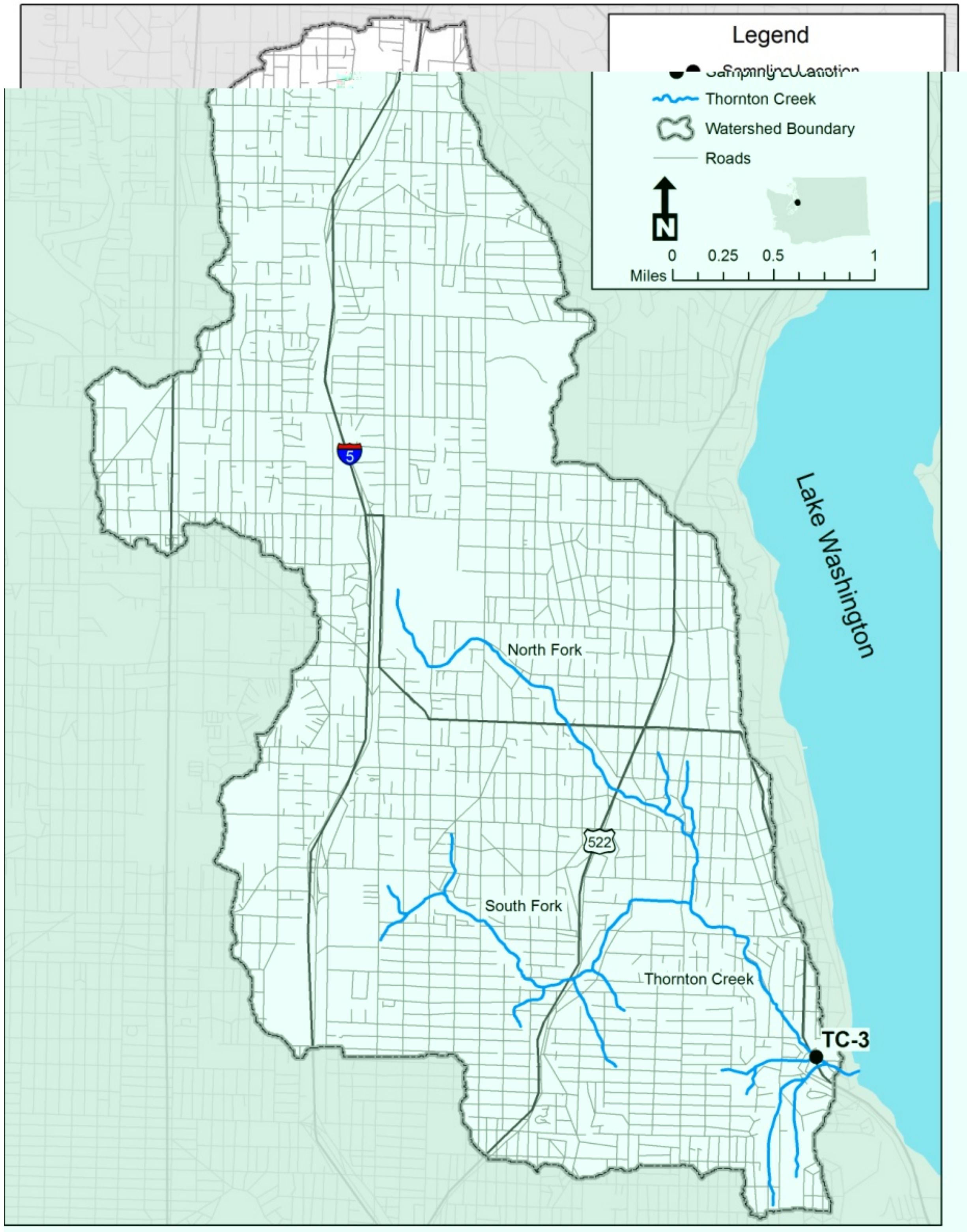


Figure 2. Thornton Creek sampling location in the Cedar-Sammamish basin, 2009-2011.

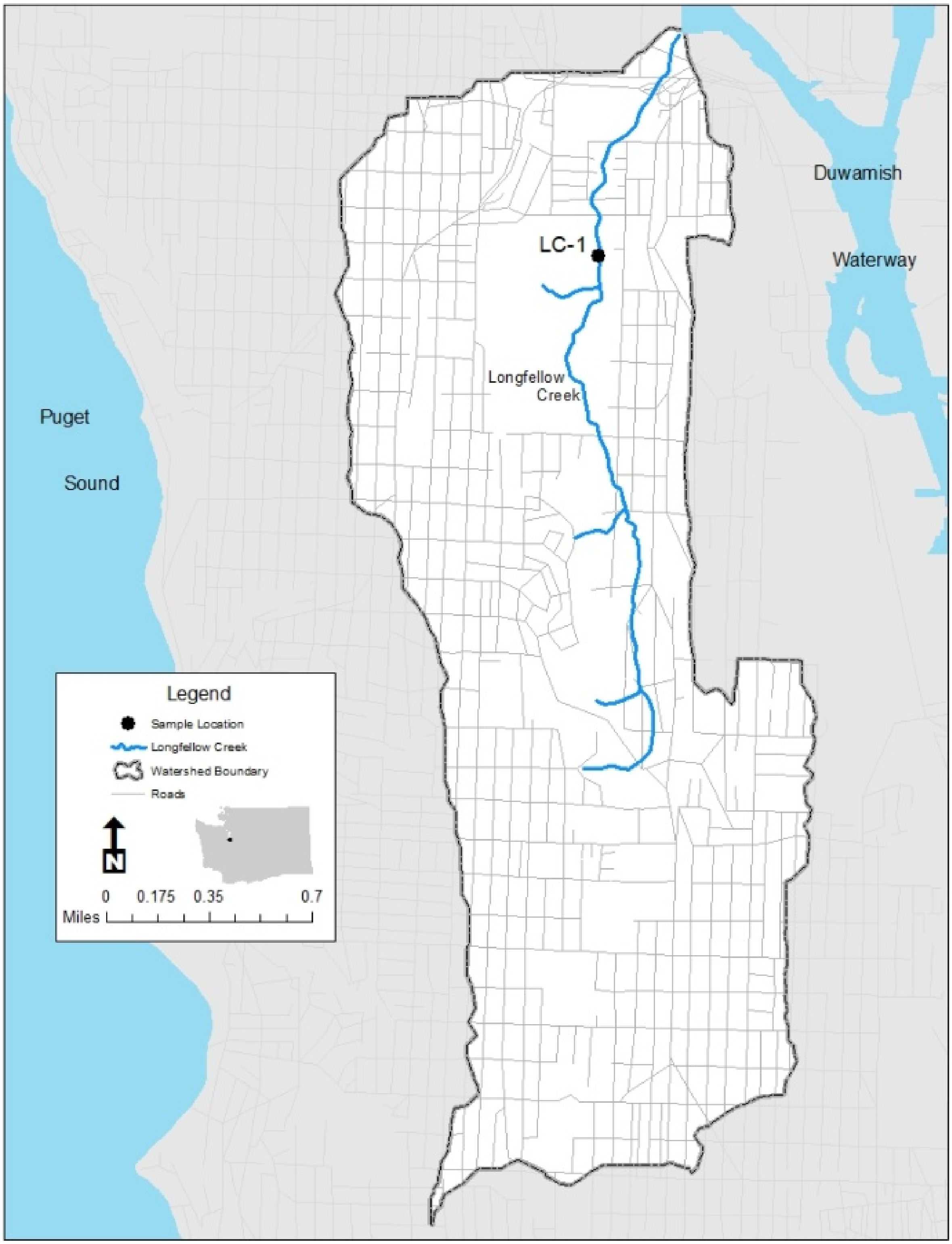


Figure 3. Longfellow Creek sampling location in the Green-Duwamish basin, 2009-2011.

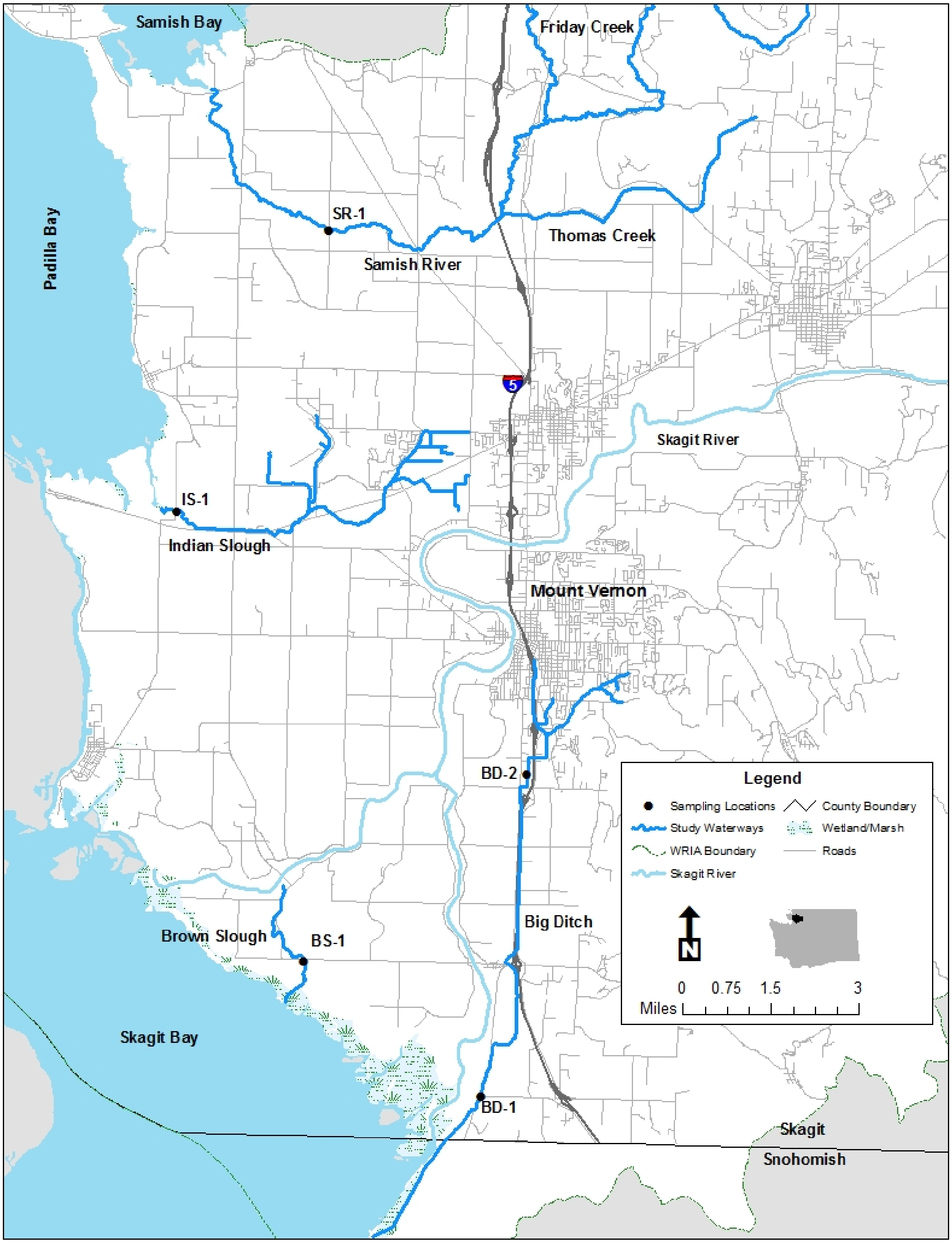


Figure 4. Sampling locations in the Lower Skagit-Samish basin, 2009-2011.

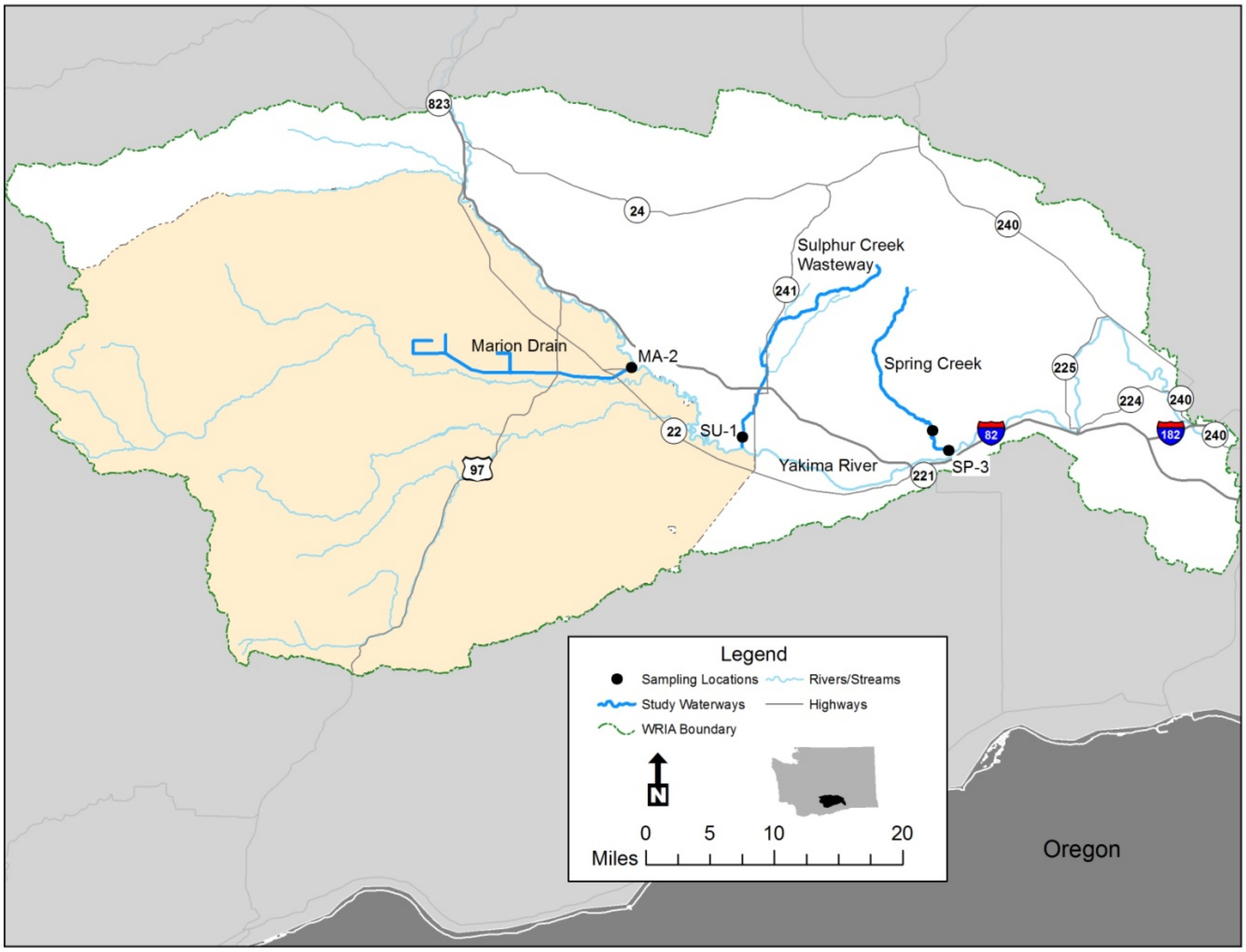


Figure 5. Sampling locations in the Lower Yakima basin, 2009-2011.

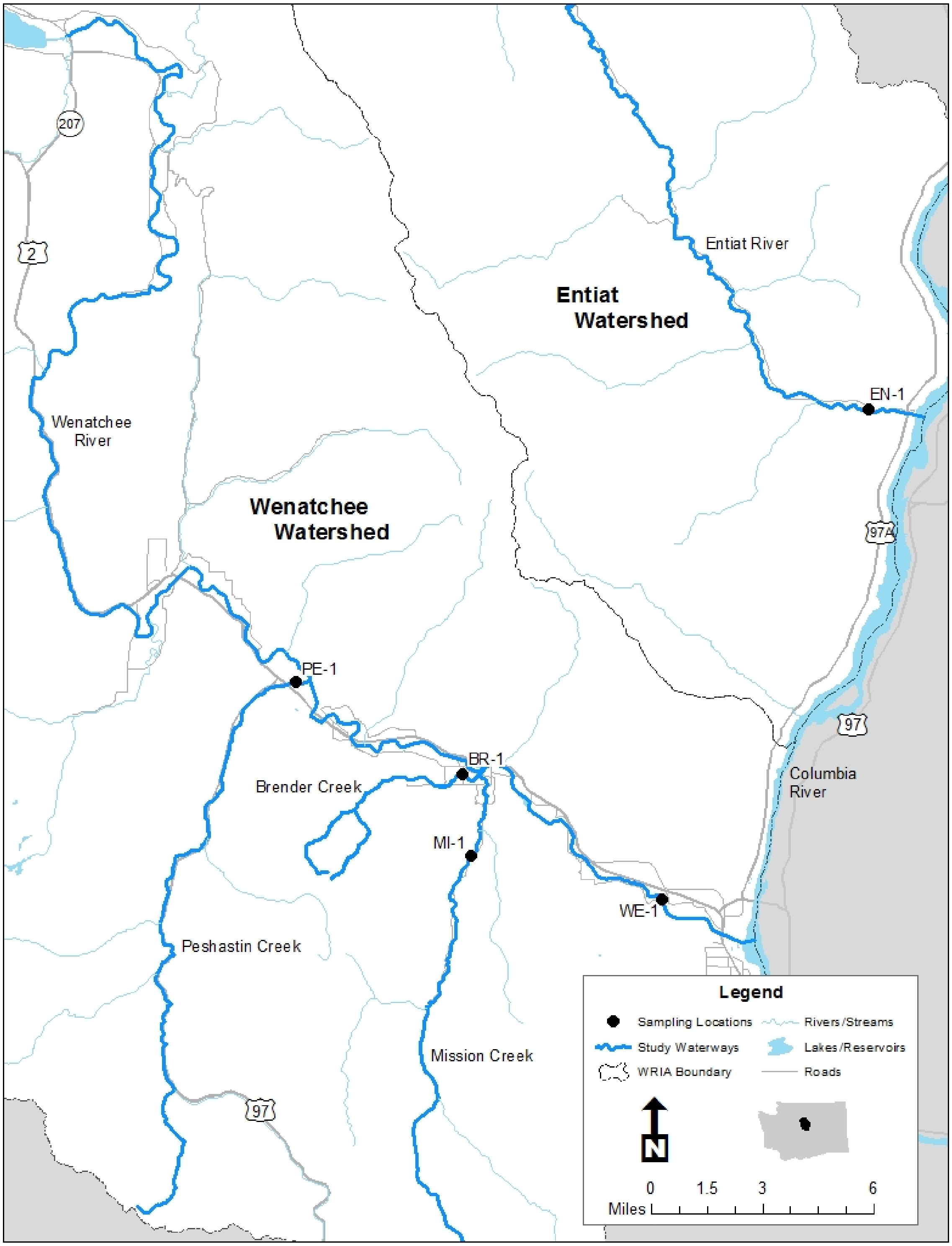


Figure 6. Sampling locations in the Wenatchee and Entiat basins, 2009-2011.

Agricultural Land Use

Appendix C includes information on land-use area and crop totals for the agricultural sites. A summary for each basin is included below.

Lower Skagit-Samish Basin – WRIA 3

All of the Skagit-Samish sites have a portion of their area in agricultural production. The most intensively cultivated subbasins are Browns Slough, Big Ditch, and Indian Slough. Appendix C includes crop area and land-use estimates for the Skagit-Samish subbasins.

Approximately 51% of the Big Ditch subbasin is in agricultural production. A variety of agricultural commodities are produced. Major crops include potatoes, wheat, grass hay, and corn. Land use immediately upstream of the upper Big Ditch site is largely industrial and commercial.

Browns Slough subbasin is mostly agricultural (91%). Major crops include potatoes, corn, wheat, grass-hay, and various vegetable seeds.

Indian Slough subbasin is 34% agricultural. Major crops include potatoes, grass-hay, and blueberries.

Samish River basin has the least cropped area acreage, 8%. Major crops and agricultural use includes grass-hay, pasture, potatoes, and corn.

Lower Yakima Basin – WRIA 37

The Yakima sites represent irrigated cropland agriculture. Estimated crop area and land use by subbasin is presented in Appendix C.

Approximately 72% of the Marion Drain subbasin is in agricultural production; major crops are hops, apples, wheat, mint, corn, and a variety of other vegetables. A total of 39% of the Sulphur Creek Wasteway drainage is in agricultural production; major crops include corn, grapes, apples, alfalfa hay, hops, and wheat. The Spring Creek subbasin has approximately 53% of its area in agricultural production; major crops are grapes, wheat, hops, and apples.

Wenatchee-Entiat Basins – WRIAs 45 and 46

The Wenatchee and Entiat basins produce a variety of agricultural products with orchard crops (tree fruit) being the major agricultural commodity. Appendix C has estimates of crop and land-use areas.

Approximately 1% of the Wenatchee basin is in agricultural production; major crops are pears and apples. In the Peshastin Creek subbasin 0.07% of land is in agricultural production; major crops are pears and apples. For Mission Creek, 1.3% of the subbasin is in agricultural production; the major crop is pears. The Brender Creek subbasin has the greatest area in agricultural production (13%); major crops are pears, apples, and cherries.

Less than 1% of the Entiat basin is in agricultural production; the major crop is pears.

Study Design and Methods

Study design and methods for this study are described in the Quality Assurance (QA) Project Plan (Johnson and Cowles, 2003), subsequent addendums (Burke and Anderson, 2006; Dugger et al., 2007; and Anderson and Sargeant, 2009), and the first triennial report (Burke et al., 2006). Changes to the program during 2003-2011 are described in detail in Appendix D. Major changes to the program for 2009-2011 are described below.

Sample Sites and Sampling Frequency

Sampling sites and frequency remained consistent during 2009-2011. Detail on sample site locations is included in Appendix B. Sample frequency included 27 weekly sample events from the second week in March through the second week in September. Sampling in Marion Drain continued for organophosphate pesticides through October. Samples were analyzed for pesticides and total suspended solids (TSS). Field measurements were obtained for pH, conductivity, temperature, dissolved oxygen, and flow discharge.

Field Procedures

Field procedures are defined in the QA Project Plans (Johnson and Cowles, 2003; Burke et al., 2006). Any changes to the original plan are documented in the first triennial report and yearly monitoring reports (Burke et al., 2006; Anderson et al., 2007; and Anderson and Dugger, 2008) and in QA Project Plan addendums (Burke and Anderson, 2006; Dugger et al., 2007; and Anderson and Sargeant, 2009).

Field methods are a direct application or modification of the US Geological Survey (USGS) or US Environmental Protection Agency (EPA) procedures. Surface water samples were collected by hand-compositing grab samples from quarter-point transects across each stream following Ecology's *Standard Operating Procedure for Sampling of Pesticides in Surface Waters*, SOP EAP003 (Anderson and Sargeant, 2010). In situations where streamflow was vertically integrated, a one-liter transfer container was used to dip and pour water from the stream into sample containers. Otherwise samples were collected using depth integrating equipment. Sample/transfer containers were delivered pre-cleaned by the manufacturer to EPA specifications (EPA, 1990). After collection, all samples were labeled and preserved according to the QA Project Plan (Johnson and Cowles, 2003).

In 2011, a side-by-side-comparison study of two sampling methods was conducted: (1) USGS DH-81 depth integrated sampler and (2) grab sampling using a handheld jar. Results showed no significant difference between the two sampling methods for the three sites sampled. Recommendations from this study include using grab sampling techniques for sampling water depths of one to four feet deep for the sites in our study, and discontinuing use of the DH-81 depth integrated sampler (Sargeant, 2011).

Temperature, pH, dissolved oxygen, and conductivity were measured in the field using Ecology SOP EAP033 *Standard Operating Procedure for Hydrolab DataSonde® and MiniSonde®*

Multiprobes (Swanson, 2010). Continuous, 30-minute interval, temperature data were collected year-round from 2009 to 2011. Temperature instruments were checked for calibration against a National Institute of Standards and Technology (NIST) primary reference (Wagner et al., 2000).

Discharge for sites other than Sulphur Creek Wasteway, Wenatchee River, and Entiat River were measured using a Marsh-McBirney flow meter and top-setting wading rod, as described in the USGS method for "Measurement of Discharge by Conventional Current-Meter Method" (Rantz et al., 1983). Discharge data for Sulphur Creek Wasteway were obtained from an adjacent U.S. Bureau of Reclamation gaging station, "SUCW – Sulphur Creek Wasteway at Holaday Road near Sunnyside." Wenatchee and Entiat River discharges were obtained from USGS at Wenatchee River at Monitor (Station 12462500) and Entiat River near Entiat (Station 12452990). Fifteen-minute discharges were available during the sampling period. The record closest to the actual sampling time was used in lieu of field measurements.

Laboratory Analyses

Ecology's Manchester Environmental Laboratory (MEL) analyzed all pesticide and TSS samples. Laboratory methods and changes during 2003-2011 are discussed in Appendix D. Laboratory methods and changes during 2009-2011 are discussed below and are included in Table 1.

In 2009, analytical methods remained the same as in 2008. In addition to NJ qualification of 1-naphthol, aldicarb sulfone, and aldicarb sulfoxide, all oxamyl detections for 2009 were qualified as UJ due to concerns regarding false positives.

In 2010, MEL methods remained the same as in previous years with the exception of carbamates (Table 1). In 2010, EPA Method 8321 AM, modified using electrospray ionization with jet stream technology and triple quadrupole mass spectrometry, was used for carbamate analysis. This allowed for improved detection accuracy and provided confirmation of detected analytes. In addition, the new instrumentation allowed for lower carbamate detection limits (Sargeant et al., 2011).

Table 1. Summary of laboratory methods, 2009-2011.

Analyte	Analytical Method[1]		Reference
	Extraction	Analysis	
Pesticides	3535	GC/MS	8270
Herbicides	3535/8151	GC/MS	8270
Carbamates	3535	HPLC/MS/MS	8321B
TSS	n/a	Gravimetric	EPA 160.2

[1]All analytical methods refer to EPA SW 846, unless otherwise noted.
n/a: not applicable.
TSS: total suspended solids.
GC/MS: gas chromatography/mass spectrometry.
HPLC/MS/MS: high performance liquid chromatography/triple quadrupole mass spectrometry.

In 2011, MEL methods remained the same as in previous years with the exception of carbamate analysis (Appendix D, Table D-7). In 2011, the sample extraction step for carbamates was eliminated. MEL went to a direct injection method continuing to use the LC/MS/MS for carbamate analysis. The benefits of direct injection included higher recoveries for some analytes and less qualified and rejected data.

Laboratory and Field Data Quality

Laboratory Data Quality

Performance of laboratory analyses is governed by quality assurance and quality control (QA/QC) protocols. The QA/QC protocol employs the use of blanks, replicates, surrogate recoveries, laboratory control samples, and matrix spike/matrix spike duplicates (MS/MSD). Laboratory surrogate recovery, blank, replicate, and control samples are analyzed as the laboratory component of QA/QC. Field blanks, replicates, and MS/MSDs integrate field and laboratory components. Percentage of field QA samples obtained as a percentage of field samples is presented in Table 2.

Table 2. Percentage of field QA samples obtained as a percentage of field samples, 2009-2011.

Field QA	2009	2010	2011
Field Replicates	7.9	7.7	7.6
Field Blanks	4.1	3.8	3.8
MS/MSD samples	3.8	3.8	3.8

Highlights of laboratory and field data quality are presented below; for a detailed discussion refer to Appendix E.

Laboratory Blanks

Very few laboratory blank detections occurred for the pesticide GCMS, herbicide, or carbamate analysis (Appendix E, Table E-9). In 2009 and 2010, blank detections occurred in approximately 0.2% of laboratory blanks. No laboratory blank detections occurred in 2011.

For the carbamate LCMS analysis there were eight blank detections in 2009. In 2010, when the carbamate analysis was analyzed on the LCMS\MS, there were four blank detections. For the pesticide GCMS analysis, there were seven blank detections in 2010. No laboratory blank detections were reported for the GCMS herbicide analysis. No laboratory blank detections were reported in 2011.

If a laboratory blank detection occurs, associated samples below five times the lab blank detection are reported as not detected at an estimated detection limit (UJ).

Field Blanks

Very few field blank detections occurred during 2009-2011. In 2009, there were two field blank detections, both for the pesticide GCMS analysis. In 2010, there were no field blank detections for the pesticide analysis, but there was a low level detection in a TSS field blank. In 2011, there were no field blank detections for the pesticide or TSS analyses. Data for the days field blank detections occurred were qualified as detailed in Appendix E.

Replicate Results

Pooled results for pesticide field replicates by analysis type and year are presented in Table 3. Precision between replicate pairs was calculated using relative percent difference (RPD). The RPD is calculated by dividing the absolute value of the difference between the replicates by their mean, then multiplying by 100 for a percent value.

Table 3. Pooled average RPD of consistent field replicate pairs by analysis type and year, 2009-2011.

Year	Herbicides		Carbamates		Pesticide GCMS		TSS	
	Pooled Average RPD	No. of Replicate Pairs	Pooled Average RPD	No. of Replicate Pairs	Pooled Average RPD	No. of Replicate Pairs	Pooled Average RPD	No. of Replicate Pairs
2009	10.9	34	6.3	4	9.1	65	13.1	32
2010	9.2	36	3.3	16	9.7	49	9.5	33
2011	11.5	34	10.7	16	8.9	37	10.3	33

The average RPD for each of the analytical methods was excellent. A total of 92% of the replicates were within the 20% RPD criterion. During 2009-11, of the consistently identified replicate pairs, 7 of the 87 pairs exceeded the 40% RPD criterion (Appendix E, Table E-6). Replicate pairs exceeding the 40% RPD criterion were due to very low level concentration paired results. The RPD statistic has limited effectiveness in assessing variability at low levels or near the detection limit (Mathieu, 2006).

MEL used laboratory split sample duplicates to ensure consistency of TSS analyses. Appendix E, Table E-8, presents the average RPD for laboratory duplicates by year. During 2009-2011, 5-8% of the replicate pairs did not meet the 20% RPD criteria. For these duplicates, results were low concentrations, again limiting the usefulness of the RPD statistic in assessing variability (Mathieu, 2006).

Surrogates, Matrix Spikes, and Laboratory Control Samples

Surrogates are used to evaluate recovery for a group of compounds. The majority of surrogate recoveries fell within the control limits established by MEL for all compounds. When surrogate recoveries fell outside the control limits, all related data were qualified as estimates (J qualifier).

Matrix spike/matrix spike duplicates (MS/MSDs) provide an indication of bias due to interferences from components of the sample matrix. The duplicate spike can be used to estimate analytical precision at the concentration of the spiked samples. Pesticide matrix spike recoveries were good, with the median ranging from 97-107% and the 25th and 75th quartiles ranging from 73-126% during the three-year period. Herbicide recoveries tended to be lower, with the median recovery ranging from 70-81%, and the 25th and 75th quartiles ranging from 57-92% during 2009-2011.

Carbamate analysis matrix spike recoveries varied each year. This is attributed to changes in laboratory analysis each year. In 2009, the carbamate analysis analytical method was LCMS; in 2010, it was LCMS/MS; and in 2011, the laboratory switched to direct injection, thereby eliminating the need for sample extraction. Median recoveries in 2009 and 2010 were similar, 75% and 77% respectively; the 25th and 75th quartile recoveries during these years were also similar, ranging from 63-88%. The switch to direct injection in 2011, and change to LCMS/MS in 2010, provided better recoveries with median recoveries of 100% in 2011.

Laboratory control samples (LCS) are prepared in the laboratory by spiking known concentrations of analyte compounds into deionized water, with LCS then subjected to routine analysis. They are used to evaluate accuracy of pesticide residue recovery for a specific analyte. During 2009-2011, pesticide mass spectrometer LCS recoveries were good, with the median value ranging from 90-107% and the 25th and 75th quartiles ranging from 72-126%. Herbicide LCS percent recoveries tended to be low, as with the MS/MSD recoveries, with a median range from 70-78%, and the 25th and 75th quartiles ranging from 60-88%.

Carbamate LCS and duplicate percent recoveries varied each year, as with the MS/MSD recoveries. Again this is likely due to changes in laboratory analysis for each year. Median recoveries in 2009 and 2010 were similar, at 78% and 74% respectively; the 25th and 75th quartile recoveries during these years were also similar, ranging from 54-91%. The change to direct injection in 2011 and LCMS/MS in 2010 provided better recoveries, with a median recovery of 99% in 2011 and 25th and 75th quartile recoveries of 88% and 108% respectively.

Field Data Quality

Field meters were calibrated at the beginning of the field day according to manufacturers' specifications, using Ecology SOP EAP033 *Standard Operating Procedure for Hydrolab DataSonde® and MiniSonde® Multiprobes* (Swanson, 2010). Meters were post-checked at the end of the field day, using known standards. Dissolved oxygen meter results were compared to Winkler laboratory titration results from grab samples.

To determine comparability of field methods, side-by-side field audits were conducted. Two audits were conducted in 2010, on May 21 and July 28, and one audit was conducted on June 21, 2011. Results of the field audits are described in Appendix E.

Field data quality for 2009-2011 was very good, with most data meeting measurement quality objectives (MQOs) as described in Anderson and Sargeant (2009). Data that did not meet MQOs were qualified, as described in Anderson and Sargeant (2009).

Data Analysis Methods

Field and laboratory data were compiled and organized using Excel® spreadsheet software and Access® database software (Microsoft Corporation, 2001). Water quality results from field and laboratory work were also entered into Ecology's Environmental Information Management (EIM) database (www.ecy.wa.gov/eim).

Protocols for Analysis of Pesticide Data

The following guidelines were used in reporting and analyzing data for this study.

Pesticide Detections

Laboratory data were qualified as needed, and qualifiers are described in Table 4. A positive pesticide detection included un-qualified values and values qualified with a J or E. Values qualified with NJ, U, or UJ were considered non-detects.

Table 4. Definitions of data qualifiers.

Qualifier	Definition
No qualifier	The analyte was detected at the reported concentration. Data are not qualified.
E	Reported result is an estimate because it exceeds the calibration range.
J	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
NJ	The analysis indicates the presence of an analyte that has been "tentatively identified," and the associated numerical value represents its approximate concentration.
NAF	Not analyzed for.
NC	Not calculated.
REJ	The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet QC criteria. The presence or absence of the analyte cannot be verified.
U	The analyte was not detected at or above the reported sample quantitation limit.
UJ	The analyte was not detected at or above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately measure the analyte in the sample.

MEL, 2000, 2008; EPA, 1999, 2007.

Comparison to Assessment Criteria and Water Quality Standards

Non-detect values (U, UJ, NJ) were not used for comparison to assessment criteria or water quality standards. When summing compound totals (such as total DDT and total endosulfan), the Toxic Studies Unit Guidance was used (Ecology, 2008). Non-detects (U, UJ) were assigned a value of zero (as in the guidance). Unlike the guidance, NJ values (tentatively identified compounds) were also assigned a value of zero.

Data Analysis

Graphs, plots, mass balance calculations, and some statistical analyses were made using Excel® software. The R statistical package (R Foundation for Statistical Computing, 2010) was also used for statistical analysis as well as the SEAWAVE-Q pesticide trend analysis model. For statistical trend analysis of conventional parameters and correlations, WQHYDRO software (Aroner, 2012) was used.

Replicate Values

Field and laboratory replicates were obtained to determine data quality. For comparison to assessment criteria and water quality standards, and for data analysis purposes, field and laboratory replicates were arithmetically averaged. If the sample value or the replicate value was a non-detect value while the other value was a detection, then the detected value was used.

When a laboratory replicate was performed on a field replicate, the laboratory replicate mean was calculated before the field replicate mean.

For select statistical analysis, NJ qualified data were used when detected pesticide values were not available. When this occurred, it is specified in the statistical test description.

Statistical Analysis

Summary Statistics

For the 2009-2011 study, the laboratory analyzed samples for over 170 pesticides including pesticide degradate compounds. For a majority of compounds, concentrations were below the analytical reporting limit of the laboratory and were reported as "less than" the reporting limit. These "less-than" reporting limit values make it difficult to analyze data statistically. Substituting a value of zero or a value of half the detection limit is not defensible, and results may vary depending on the substituted value selected. Statistical analysis of pesticide data is conducted using nondetect data analysis methods as described in Helsel (2005).

Correlations

Correlation analysis was used to examine the association between pesticide concentrations and variables such as TSS, flow, and rainfall. Various rainfall totals were examined including midnight to midnight rainfall the day of sampling (24 hours), the previous day's rainfall before sampling (24 hours), the day of sampling and the previous day's rainfall (48 hours), and the previous two days before sampling (48 hours). A two-tailed, Kendall's tau (a non-parametric correlation coefficient) was used to test for correlation between parameters. Kendall's tau is a non-parametric statistical correlation test capable of handling non-detect values and multiple detection limits. NJ qualified data were used as detected data for this test.

The following may help explain the meaning of correlation and tau: Let's say we measured a set of pesticide concentrations. For each of these concentrations, we know the streamflow during sample collection. Based on this information, we can calculate the correlation between pesticide concentration and streamflow. For example, let's say that we calculate tau=0.35. This number tells us that, for any two of our previously measured concentrations, the one collected during higher flow will be 35% more likely to have the higher concentration of the two samples, compared to the other way around.

It is important to note that correlation does not imply causality. In the above example, we cannot say that increased streamflow causes pesticide concentrations to increase. There may well be other factors which cause both streamflow and pesticide concentration to increase together. For the above example, maybe heavier irrigation usage increased both the flow and concentration, or maybe rainfall carried soil into the stream, or perhaps the streamflow simply tends to be higher during the months when pesticides are typically applied.

Appendix J, Tables J-1 through J-9, provides the tau coefficients which describe the "strength" of the correlation. Only significant correlations are included ($p < 0.05$). It is important to note, tau values are generally lower (by about 0.2) than values for traditional correlation coefficients like Pearson's r. For example, strong linear correlations of 0.9 or above correspond to tau values of about 0.7 or above. Negative tau values indicate an inverse relationship between environmental factors and the pesticide.

Trend Analysis

For determining TSS concentration, TSS loading, and flow trends, a seasonal-Kendall trend test was used comparing the months of March through September. The median monthly value was chosen for analysis.

To determine possible pesticide trends, a parametric regression model called SEAWAVE-Q (Vecchia et al., 2008) was used. This model was developed by USGS for analyzing long term trends in pesticide concentrations in streams. The model was applied to each site with five or more years of data and with ten or more detections during the sample period. Using the model results, we tested trend for statistical significance ($p<0.05$) for each site and pesticide data set that met model assumptions. Details regarding the model are presented in Appendix F.

Additive Effects of Pesticide Mixtures: Toxic Units

Pesticide registration toxicity and risk assessment criteria, and regulatory standards, apply to the effects of a single pesticide and its effects on aquatic life. However, organisms in the environment experience many stressors simultaneously, including those of a physical, biological, and chemical nature. For example, the criteria and standards do not take into account the additive (effect of the combination of chemicals is estimated from the sum of the concentrations), synergistic (more than additive toxicity), or antagonistic (less than additive toxicity) effect of pesticide mixtures. In addition, the effects of environmental stressors, such as high temperatures, low dissolved oxygen, or impacts to food sources, are not taken into consideration in the criteria or standards.

Understanding a chemical's mode of toxic action is essential in understanding how mixtures may act jointly. For example, if two organophosphate insecticides are used together, it is expected that they will both inhibit acetylcholinesterase (AChE), thus having an additive effect

(Lydy et al., 2004) In 2009, Laetz et al. found that two organophosphate insecticides (malathion and diazinon) worked synergistically, having more than an additive effect on exposed juvenile coho.

Assessing the effects of pesticide mixtures on aquatic life is extremely difficult and complex. It is not realistic to test every combination of pesticides found in the environment (Lydy et al., 2004).

A study by Broderius and Kahl (1985) found that when a large number of chemicals are included in mixture experiments, an additive response is typically found (Lydy et al., 2004). One of the most common methods of assessing the additive effects of pesticide mixtures is by using toxic units (TUs) (Lydy et al., 2004).

For this report TUs were used to estimate the additive effects of pesticide mixtures, as described by Faust et al. in 1993 (Lydy et al., 2004). For example, TUs are calculated for a two-component mixture using the formula and the LC_{50} as an assessment endpoint:

$$x_1/LC_{50}(X_1) + x_2/LC_{50}(X_2)=TU$$

In this equation, x_1 and x_2 are the concentrations of the mixture components. X_1 and X_2, $LC_{50}(X_1)$ and $LC_{50}(X_2)$, are the effect concentrations of the individual compounds that produce the same effect.

In this example, a TU value ≥ 1 means 50% or more of the organisms tested may experience lethality based on the lethality measure used. Lethality measures used in this study include acute and chronic fish and invertebrate exposure assessment concentrations described in Appendix G. A TU value ≥ 1 means a lethal or sublethal (for chronic criteria) effect may occur with an increasing likelihood depending on the degree to which TUs exceed 1.0.

Assessment Criteria and Washington State Water Quality Standards

Assessment of pesticide effects on endangered salmonid species is evaluated by comparing detected pesticide concentrations against three criteria:

- Pesticide registration toxicity and risk assessment criteria.
- EPA National Recommended Water Quality Criteria (NRWQC).
- Washington State water quality standards for the protection of aquatic life (WAC 173-201A).

For this report, pesticide registration toxicity and risk assessment criteria, NRWQC, and the water quality standards were reviewed for changes and additions to numeric criteria. While the NRWQC and water quality standards numeric criteria did not change since the last report, additional pesticide numeric criteria were added based on pesticide registration toxicity and risk assessment criteria.

EPA and Washington State aquatic life criteria are based on evaluating the effects of a single chemical on a specific species (often non-salmonid) and do not take into account the effects of multiple chemicals or pesticide mixtures on an organism.

Aquatic life criteria, pesticide regulatory criteria, and toxicity (acute and chronic) results for fish, invertebrates, and aquatic plants are presented in Appendix G. Numeric exceedances of values in Appendix G do not necessarily indicate that the water quality criteria have been exceeded. There is typically a temporal duration of exposure criteria in addition to numeric criteria for a water quality standard. In this report, pesticide registration toxicity, risk assessment criteria, and NRWQC will be referred to as *assessment criteria*. Washington State numeric water quality standards for pesticides will be referred to as *water quality standards*.

Pesticide Registration Toxicity Criteria

EPA uses risk quotients (RQ) to assess the potential risk of a pesticide to non-target organisms. A RQ is calculated by dividing the environmental concentration by either an acute or chronic toxicity value, which gives an evaluation of exposure over toxicity. The resulting RQ is a unitless value that is compared to Levels of Concern (LOC). The LOCs set by EPA are presented in Table 5 and are used to assess the potential risk of a pesticide to non-target organisms.

The endangered species LOC (0.05 for aquatic species) is used as a comparative value to assess potential risk to threatened or endangered salmonids. The endangered species RQ can also be expressed as $1/20^{th}$ of the acute Lethal Concentration 50 (LC_{50}) for aquatic organisms. To assess the potential risk of a pesticide to salmonids, the LC_{50} for rainbow trout is commonly used as a surrogate species. Thus the endangered species LOC presented in subsequent tables are $1/20^{th}$ of the rainbow trout LC_{50}. When available, the endangered species LOC for specific salmonids is also presented.

Table 5. Risk quotient criteria for direct and indirect effects on aquatic organisms.

Test Data	Risk Quotient	Presumption
Acute LC_{50}	>0.5	Potentially high acute risk to aquatic species.
	>0.1	Risk that may be mitigated through restricted use classification.
	>0.05	Endangered species may be affected acutely, including sublethal effects.
Chronic NOEC	>1	Chronic risk; endangered species may be affected chronically, including reproduction and effects on progeny.
Acute invertebrate LC_{50}	>0.5	May be indirect effects on T&E fish through food supply reduction.
Aquatic plant acute LC_{50}	>1	May be indirect effects on aquatic vegetative cover for T&E fish.

(Turner, 2003).
NOEC: No observable effect concentration.
T&E: Threatened and endangered.

Acute toxicity is calculated by standardized toxicity tests using lethality as the measured criteria. A properly conducted test will use a sensitive (representative) species, at a susceptible life stage (usually young, though not immature). The test also will subject the test species to a pesticide under a range of concentrations. The no observed effects concentration (NOEC) is the highest concentration in a toxicity test which does not show a statistically significant difference from the control. The lowest observed effects concentration (LOEC) is the lowest concentration in a toxicity test which shows a statistically significant difference from the control. The NOEC is by definition the next concentration below the LOEC in the concentration series. The dose response curve may be plotted graphically or fitted to a mathematical equation, and the LC_{50}, lethal concentration to cause mortality in 50% of test species can be derived.

For fish, the lethality test is conducted over 96 hours at a constant concentration. Acute invertebrate toxicity is normally calculated over 48 hours, with the criteria being mortality or immobility (LC_{50}, or effective concentration - EC_{50} for immobility). Acute toxicity testing for aquatic plants is conducted over 96 hours, and the biological endpoint is reduction in growth (EC_{50}).

Chronic fish tests normally use growth or developmental effects as the biological endpoint. A chronic toxicity test may assess a sublethal biological endpoint such as reproduction, growth, or development. It is generally longer than the 96-hour test (21 day for fish, 14 days for invertebrates, 4 to 60 days for plants) to simulate exposure resulting from a persistent chemical or effect of repeated applications.

Toxicity values such as those used for pesticide registration are determined from continuous exposure over time (e.g., LC_{50} freshwater fish acute toxicity tests are commonly run for 96 hours at a constant concentration). When comparing the monitoring data either to the aquatic life criteria or directly to the toxicity criteria, one must consider the duration of exposure as well as the numeric toxicity value. For pesticide registration criteria, it is not possible to determine if an aquatic life criterion has been exceeded based solely on an individual sample because the sampling frequency is usually weekly which does not allow for assessment of the temporal component of the criteria.

Pollutant concentrations in streams are constantly changing and may occur above aquatic life criteria for durations of time that are less than or greater than the test durations used to set the aquatic life criteria. If the stream concentration of a pollutant is above its aquatic life criterion for less time than the test duration, then comparison to the criterion overestimates risk. If the concentration for a pollutant is above its aquatic life criterion for a longer time than the test duration, then comparison to the criterion underestimates risk.

National Recommended Water Quality Criteria

The NRWQC are established by the EPA Office of Water for the protection of aquatic life, as established under the Clean Water Act (33 U.S.C. 1251 et. seq.). The pesticide criteria established under the Clean Water Act are closely aligned with invertebrate acute and chronic toxicity criteria. States often adopt the NRWQC as their promulgated (legal) standards. The NRWQC was updated in 2006, and those criteria are used in this report (EPA, 2006a).

Washington State Water Quality Standards

Pesticides

Washington State water quality standards are established in the Washington Administrative Code (WAC), Chapter 173-201A. Washington State water quality standards include numeric pesticide criteria for the protection of aquatic life.

The aquatic life criteria are designed to protect for both short-term (acute) and long-term (chronic) effects of chemical exposure. The criteria are primarily intended to avoid direct lethality to fish and other aquatic life within the specified exposure periods. The chronic criteria for some of the chlorinated pesticides are to protect fish-eating wildlife from adverse effects due to bioaccumulation.

The exposure periods assigned to the acute criteria are expressed as: (1) an instantaneous concentration not to be exceeded at any time, or (2) a one-hour average concentration not to be exceeded more than once every three years on average. The exposure periods for the chronic criteria are either: (1) a 24-hour average not to be exceeded at any time, or (2) a four-day average concentration not to be exceeded more than once every three years on the average. For 303(d) listing purposes, measurements of instantaneous concentrations are assumed to represent the averaging periods specified in the water quality standards for both acute and chronic criteria, unless additional measurements are available to calculate averages (Ecology, 2012).

Aquatic life criteria, pesticide regulatory criteria, and toxicity (acute and chronic) results for fish, invertebrates, and aquatic plants are presented in Appendix G.

Temperature, Dissolved Oxygen, and pH

Washington State water quality standards for conventional water quality parameters are set forth in Chapter 173-201A of the WAC. Waterbodies are required to meet numeric water quality standards based on the beneficial uses of the waterbody. Conventional parameters including temperature, dissolved oxygen, and pH were measured in this study.

Numeric Water Quality Standards

Thornton Creek subbasin in the Cedar-Sammamish basin

Thornton Creek beneficial uses include *Core Summer Salmonid Habitat* and *Extraordinary Primary Contact Recreation*. The numeric water quality standards for temperature, dissolved oxygen, and pH in Thornton Creek are described in Table 6. This table also includes *Supplemental Spawning and Incubation* criteria for temperature during September 15 - May 15.

Table 6. Freshwater water quality standard for temperature, dissolved oxygen, and pH for *Core Summer Salmonid Habitat* use and *Extraordinary Primary Contact Recreation* use.

Parameter	Condition	Value
Temperature	Highest 7- DADMax	16º C. Thornton Creek has *Supplemental Spawning and Incubation* criteria: During September 15 - May 15, the highest 7-DADMax should not exceed 13°C.
Dissolved Oxygen	Lowest 1-day minimum	9.5 mg/L.
pH	--	Range within 6.5 – 8.5, with a human-caused variation within the above range of < 0.2 units.

7-DADMax: 7-day average of the daily maximum temperature.

Longfellow Creek subbasin in the Green-Duwamish basin

Beneficial uses for Longfellow Creek include *Salmonid Spawning, Rearing, and Migration Habitat* and *Primary Contact Recreation*. The numeric water quality standards for temperature, dissolved oxygen, and pH are described in Table 7. These standards apply to the Longfellow Creek site.

Skagit-Samish basin

Beneficial uses for the Samish River, Indian Slough, Big Ditch, and Browns Slough are *Salmonid Spawning, Rearing, and Migration Habitat* and *Primary Contact Recreation*. The Samish River, Indian Slough, and Big Ditch sites are freshwater and must meet the water quality standards described in Table 7. The site on Browns Slough is marine (salt) water and must meet the water quality standards described in Table 8.

Lower Yakima basin

Beneficial uses for Marion Drain, Sulphur Creek Wasteway, and Spring Creek are *Salmonid Spawning, Rearing, and Migration Habitat*. The freshwater water quality standards described in Table 7 apply to these sites.

Wenatchee-Entiat basins

Beneficial uses for Mission Creek, Brender Creek, Wenatchee River, and Entiat River are *Salmonid Spawning, Rearing, and Migration*. The water quality standards described in Table 7 apply to these sites.

Table 7. Freshwater water quality standards for temperature, dissolved oxygen, and pH for *Salmonid Spawning, Rearing, and Migration Habitat* use and *Primary Contact Recreation* use.

Parameter	Condition	Value
Temperature	Highest 7- DADMax	17.5º C. The Wenatchee River site also has *Supplemental Spawning and Incubation* criteria: during October 1 - May 15, the highest 7-DADMax should not exceed 13°C.
Dissolved Oxygen	Lowest 1-day minimum	8 mg/L.
pH	--	Range within 6.5 – 8.5, with a human-caused variation within the above range of < 0.5 units.

7-DADMax: 7-day average of the daily maximum temperature.

Table 8. Marine water quality standard for temperature, dissolved oxygen, and pH for *Aquatic Life Excellent* use.

Temperature (highest 7- DADMax)	Dissolved Oxygen (lowest 1-day minimum)	pH (must be within the range)
16°C (60.8°F)	6.0 mg/L	7.0 – 8.5, with a human-caused variation within the above range of < 0.5 units.

7-DADMax: 7-day average of the daily maximum temperature.

Results

This study investigated pesticide occurrence in salmonid-bearing streams during the typical pesticide-use season in Washington. Basins and monitoring locations were chosen with a likely combination of off-site pesticide transport and salmonid utilization.

The following sections discuss data results from 2009-2011 and compare them with results from previous years, where data are available. Pesticide detection frequency, seasonal patterns, exceedances of assessment criteria and water quality standards, factors potentially affecting pesticide concentrations, and pesticide trends are presented below.

Results for the 2003-2005 monitoring can be found in *Surface Water Monitoring Program for Pesticides in Salmonid-Bearing Streams, 2003-2005* (Burke et al., 2006). Results for the 2006-2008 monitoring can be found in *Surface Water Monitoring Program for Pesticides in Salmonid-Bearing Streams, 2006-2008* (Sargeant et al., 2010). Monitoring results for all sites from 2003-2011 are available through Ecology's Environmental Information Management (EIM) system, www.ecy.wa.gov/eim; search User Study ID, DSAR0004.

Cedar-Sammamish WRIA 8: Thornton Creek

Thornton Creek sampling began in 2003. Monitoring sites in Thornton Creek have changed over the nine-year project period. Sampling during the past three years included a site at the mouth of Thornton Creek (Figure 2). During 2009-2011, 81 sample events were conducted from March through September.

Pesticide Occurrence

Pesticide Detections

A summary of pesticide detections for the Thornton Creek site is presented in Appendix H.

For most pesticide compounds, few detections were noted. Table 9 presents the percentage of pesticide detections per sample event for the most commonly detected pesticides during three triennial periods, 2003-2011. During 2009-2011, the most commonly detected herbicides were dichlobenil, 2,4-D, and diuron. Over the nine-year monitoring period, dichlobenil was by far the most frequently detected herbicide followed by 2,4-D, triclopyr, and mecoprop (MCPP).

The most commonly detected insecticides during 2009-2011 were propoxur, a carbamate insecticide, and imidacloprid, a neonicotinoid insecticide. During the first triennial period, diazinon was the most frequently detected insecticide. Since December 2004, diazinon has not been allowed for residential homeowner use.

Table 9. Most frequently detected pesticides at the Thornton Creek site, 2003-2011.

Pesticide	Use	2003-2005 n=77		2006-2008 n=87		2009-2011 n=81	
		Number of detections	% of sample events detected	Number of detections	% of sample events detected	Number of detections	% of sample events detected
Dichlobenil	Herbicide	60	78%	51	59%	73	90%
2, 4-D	Herbicide	25	32%	12	14%	17	21%
Diuron	Herbicide	1	1%	2	2%	12	15%
Triclopyr	Herbicide	29	38%	8	9%	9	11%
Mecoprop (MCPP)	Herbicide	31	40%	8	9%	7	9%
Propoxur	Insecticide	0	0%	0	0%	6	7%
Imidacloprid	Insecticide	n\a	n\a	n\a	n\a	5	6%
Diazinon	Insecticide	11	14%	4	5%	0	0%
Pentachlorophenol	Wood Preservative	30	39%	2	2%	16	20%

Co-occurrence of Pesticides

Co-occurrence of pesticides occurred during 53% of the sample events on Thornton Creek. The maximum number of pesticides detected during a sample event for each year was:

- May 2009: 6 pesticides
- April 2010: 7 pesticides
- April and May 2011: 4 pesticides

Pesticide co-occurrence most frequently occurred the last two weeks in April and the first week in May.

The mode of action for carbamate and organophosphate insecticides is AChE inhibition. When these insecticides occur at the same time (co-occur), they can have an additive or synergistic effect on aquatic life (Laetz et al., 2009).

During 2009-2011, eight carbamate and five neonicotinoid insecticides were detected in Thornton Creek. Figure 7 presents the insecticide detections for Thornton Creek in 2009 and 2010, with no insecticide detections in 2011. Carbamate insecticides have the same mode of action and are displayed as stacked bars in the graph. During 2009, only carbamate insecticides were detected. In 2010, the neonicotinoid insecticide, imidacloprid, was most frequently detected.

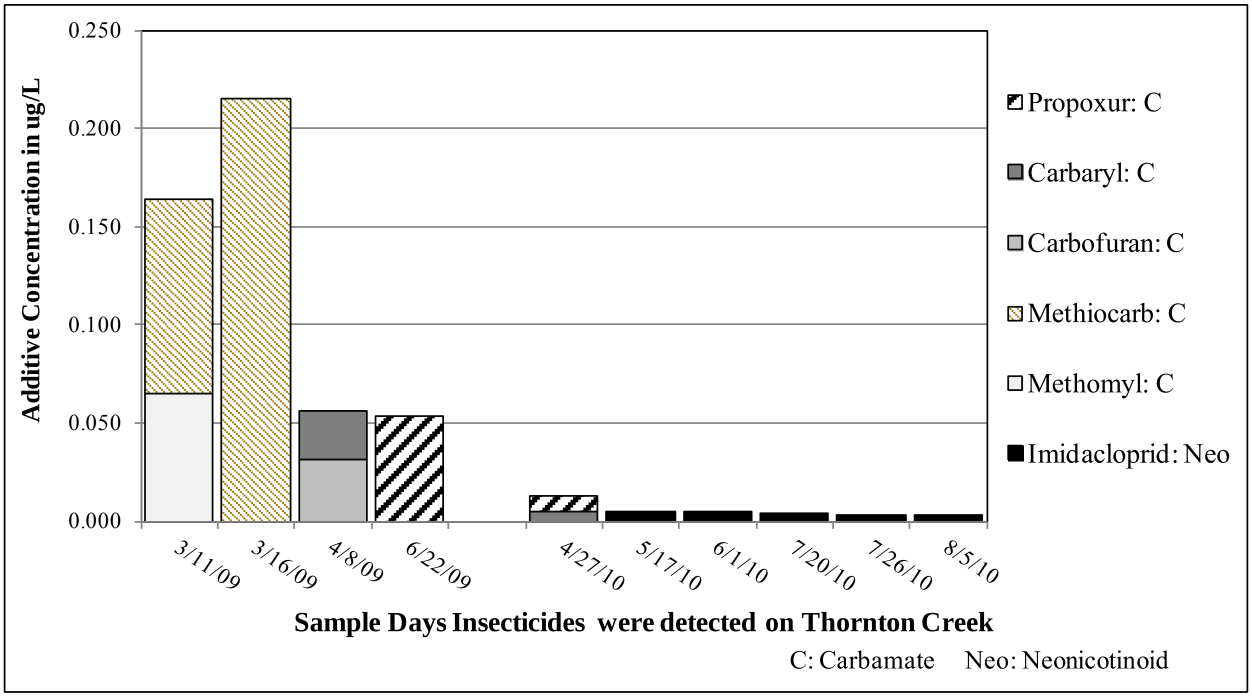


Figure 7. Cumulative total amount for insecticide detections for Thornton Creek, 2009-2010.

Pesticide Distribution

The distribution of detections by pesticide group has not changed dramatically since monitoring began in 2003 (Figure 8). Herbicides are the most frequently detected group, accounting for over 75% of detections. Insecticides make up a smaller fraction of detections.

A greater number of pentachlorophenol (wood preservative) detections were seen during the 2003-2005 and 2009-2011 periods, as opposed to 2006-2008. Changes in pentachlorophenol detections may be due to changes in the analytical method or data reporting. In 2007, the laboratory changed from liquid-liquid phase extraction to solid phase extraction. The laboratory's reporting procedures were modified in 2007, changing when pentachlorophenol is reported as detected (Appendix D).

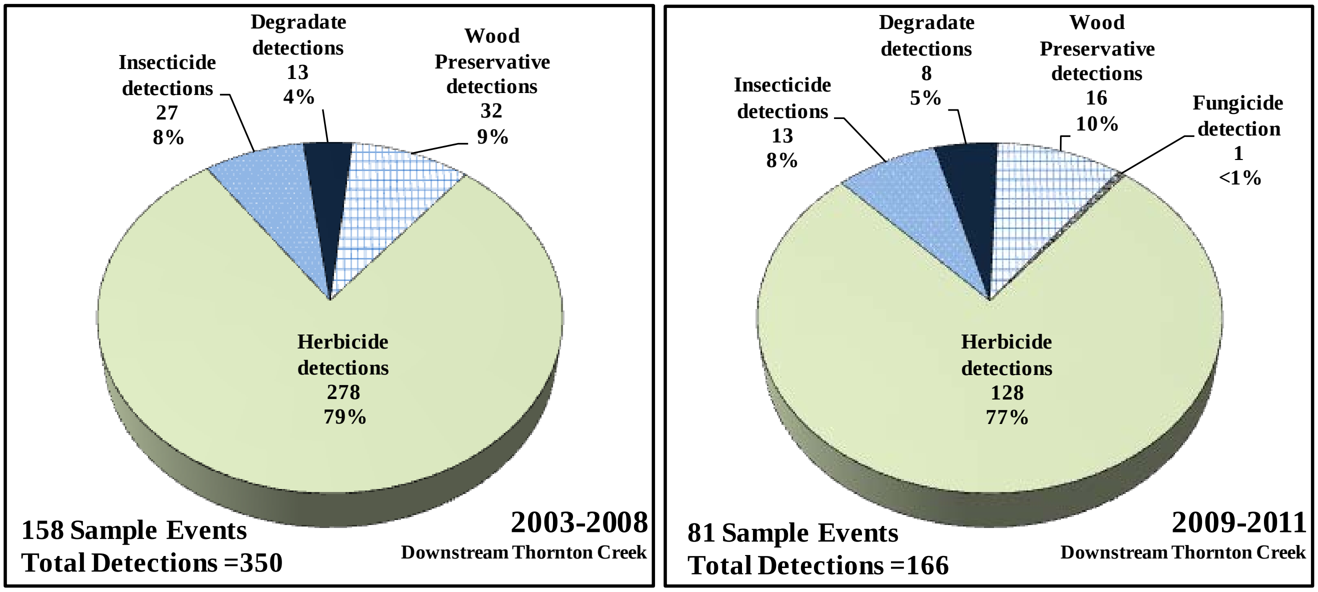


Figure 8. Pesticide distribution at the downstream Thornton Creek site, 2003-2008 and 2009-2011.

Factors Affecting Pesticide Detections

Environmental and Water Quality Factors

Appendix J, Table J-1, presents the correlation coefficients for the Kendall's tau test where statistically significant relationships ($p<0.05$, 2-tailed test) were seen.

There was a positive relationship with flow and the herbicides dichlobenil, 2,4-D, mecoprop (MCPP), dicamba I, and triclopyr and the wood preservative pentachlorophenol. Most of the pesticides tested had a positive relationship with flow, but correlation with rainfall was generally stronger.

Total suspended solids (TSS) was positively correlated to flow, with a moderate positive correlation to rainfall the day of sampling. There was also a moderate positive correlation with 2,4-D and TSS.

Temporal Factors

In the USGS publication, *Surface-Water Quality of the Skokomish, Nooksack, and Green Duwamish Rivers and Thornton Creek, Puget Sound Basin, Washington, 1995-98*, Embrey and Frans (2003) looked at correlations between pesticide concentrations and flow. They saw a weak positive correlation between prometon and diazinon concentrations and flow, but concluded that season and timing of application appeared to have the greatest influence on pesticide concentrations and detection frequencies in Thornton Creek. They saw some of the higher concentrations in samples collected in spring or early summer from about March through May, particularly if during a rain event.

As with the USGS study (Embrey and Frans, 2003), this study found that pesticide detections generally increase from March through May, then decrease after May. Figure 9 presents the number of detections by pesticide type and month for Thornton Creek from 2003 to 2011. The greatest number of herbicide and insecticide detections occurs in May. The greatest number of wood preservative detections occurs in May and June. The greatest number of pesticide degradates are detected in April and May.

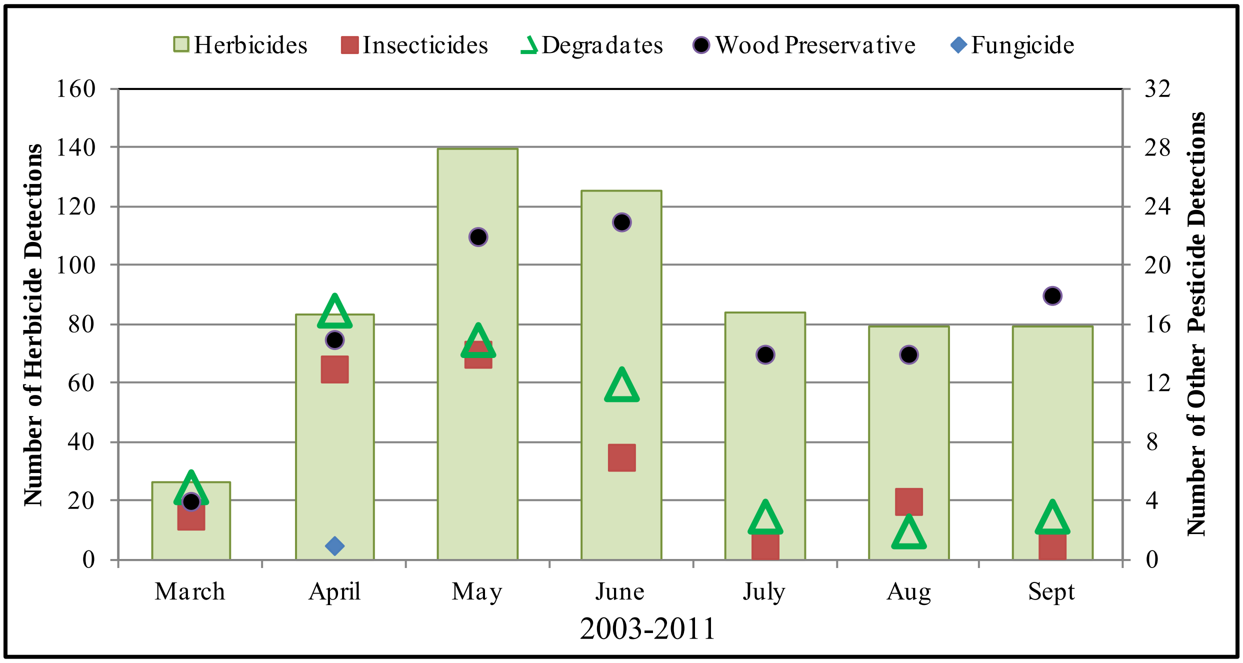


Figure 9. Number of compounds detected per month by pesticide type for the downstream Thornton Creek site, 2003-2011.

Comparison to Water Quality Standards and Other Assessment Criteria

Comparison to Numeric Criteria

The 2009-2011 pesticide data were compared to water quality standards and assessment criteria. Detailed summaries of the monitoring results can be found in pesticide calendars presented in Appendix I. The calendars provide a chronological overview of concentrations and detections during 2009-2011. Appendix I, Table I-1, presents the color codes used to compare detected pesticide concentrations to water quality standards and assessment criteria.

Pesticide calendars for Thornton Creek are presented in Appendix I, Tables I-2 – I-4. During the three-year period, there were two pesticide concentrations that were above an assessment criteria or water quality standard. In early March 2009, a methiocarb concentration was above the chronic invertebrate assessment criterion. In June 2011, a detection of a DDT degradate, 4,4'-DDD, was above the chronic water quality standard and the chronic NRWQC. The chronic water quality standard is based on a 24-hour average concentration. DDT is a legacy pesticide and has not been registered for use since 1972. Detection of DDT and its degradates are results of historic use and likely do not reflect current pesticide-use patterns.

Toxic Units

During 2009-2011, there were three occurrences where the TU value was ≥ 1. A TU value ≥ 1 means a lethal or sublethal (for chronic criteria) effect may occur with an increasing likelihood depending on the degree to which TUs exceed 1.0.

- March 11, 2009: TU=1.1 for the chronic invertebrate assessment criteria. Based on detections of methiocarb (0.099 µg/L) and methomyl (0.065 µg/L).
- March 16, 2009: TU=2.2 for the chronic invertebrate assessment criteria. Based on a single detection of methiocarb (0.215 µg/L) that was above the chronic invertebrate assessment criteria.
- June 28, 2011: TU=3.8 for the chronic invertebrate assessment criteria. Based on a single detection of 4'4'-DDD (0.061 µg/L) that was above the chronic water quality standard.

During 2009-2011, co-occurrence of acetylcholinesterase-inhibiting insecticides occurred twice in 2009. While cumulative concentrations were low, the March 11 co-occurrence of methiocarb and methomyl had a chronic invertebrate TU value > 1.

Trend Analysis

The Sea Wave model (Vecchia et al., 2008) was used to predict trends in pesticide concentrations and peak concentrations during 2003-2011. Table 10 summarizes pesticides with significant trends in concentration for Thornton Creek; Appendix F presents trend graphs for these pesticides.

Table 10. Thornton Creek periods with significant trends in pesticide concentrations.

Pesticide and Type	Trend Time Period	Trend Direction	P value=	Percent Change Per Year
Diazinon: I	2003-2011	decreasing	<0.002	-36%
Diuron: H	2003-2011	decreasing	0.004	-19%
Mecoprop: H	2003-2011	decreasing	<0.001	-11%
Triclopyr: H	2003-2011	decreasing	0.026	-7%

I: Insecticide; H: Herbicide

All of the observed pesticide trends for Thornton Creek were for decreasing concentrations over time. Trends in pesticide concentrations were seen for three herbicides and the organophosphate insecticide diazinon (Figure 10). Since December 2004, diazinon has not been allowed for homeowner use.

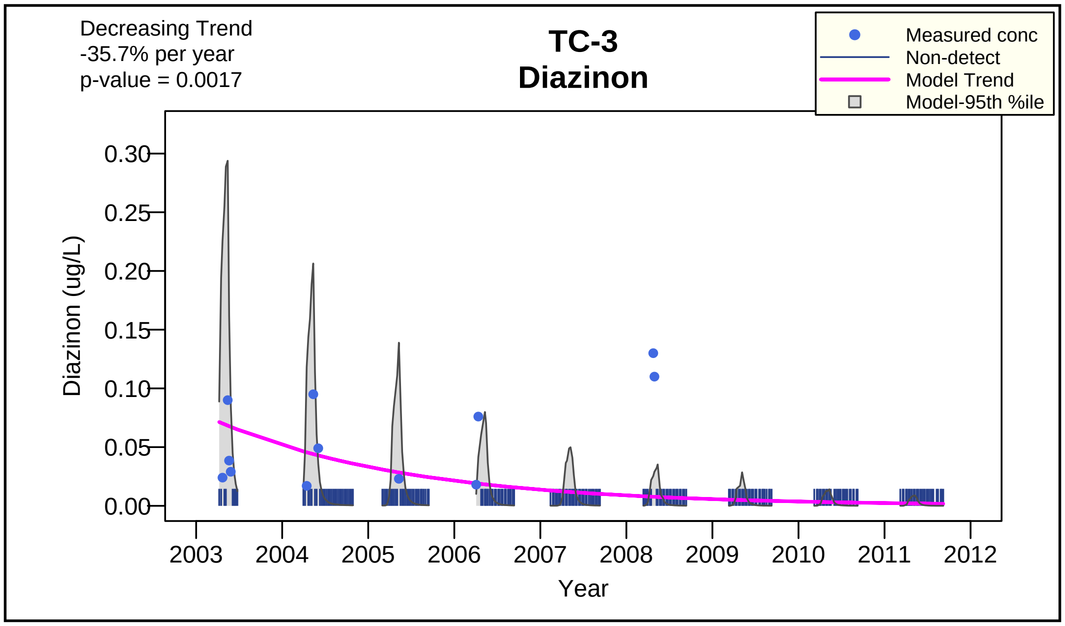


Figure 10. Decreasing trends in diazinon concentrations for Thornton Creek, 2003-2011.

Conventional Parameters

Conventional water quality parameters were measured in Thornton Creek. Table 11 summarizes results for TSS, streamflow, pH, conductivity, temperature, and dissolved oxygen (DO). All summaries are based on point (discrete) measurements obtained during the time of sampling. Thornton Creek must meet freshwater water quality standards as described in Table 6.

Table 11. Arithmetic mean and range for conventional parameters (grabs) for Thornton Creek (mouth), 2009-2011.

	Total Suspended Solids (mg/L)			Flow Discharge (cfs)			pH (standard units)			Conductivity (µmhos/cm)			Dissolved Oxygen (mg/L)		
	2009	2010	2011	2009	2010	2011	2009	2010	2011	2009	2010	2011	2009	2010	2011
Mean[1]	6.3	7.3	12.3	6.8	7.9	12.5	7.8	7.8	7.9	234	218	220	10.1	9.9	10.2
Minimum	2	2	3	2.6	3.7	3.7	7.4	7.2	7.4	144	132	104	8.7	8.3	9.1
Maximum	25	18	105	28.2	20.0	56.0	8.7	8.0	8.0	255	247	253	12.4	11.6	11.7
n	27	27	27	27	27	27	26[2]	26[2]	27	20[2]	27	27	27	27	27

[1]Arithmetic mean.
[2]Some field measurements rejected; did not meet measurement quality objectives (MQOs).

Comparison of Conventional Parameters to Water Quality Standards

One pH value of 8.7 did not meet the pH standard (6.5-8.5) in April 2009.

A number of DO measurements fell below the DO criterion of 9.5 mg/L:

- Seven measurements from June-August 2009, 8.7 - 9.3 mg/L.
- Nine continuous weekly measurements from July-September 2010, 8.3 - 9.4 mg/L.
- Four measurements from July-September 2011, 9.1 - 9.3 mg/L.

Continuous, 30-minute interval, temperature data were collected year-round from 2009-2011. Temperature profiles are presented in Appendix K, Figure K-1. The temperature standard was not met during the periods described in Table 12. During September 15 - May 15, the highest 7-DADMax[2] should not exceed 13°C; during the rest of the year, the highest 7-DADMax should not exceed 16°C.

Table 12. Thornton Creek periods when water temperature did not meet standards, 2009-2011.

Year	September 15-May 15 exceedances > 13°C	May 16-September 14 exceedances >16°C
2009	May 12-15; Sept 15-30; Oct 16-20	May 29-June 21; June 27-Sept 14
2010	May 12-15; Sept 15-Oct 13	July 6-Aug 27; Sept 14
2011	May 15; Sept 15-Oct 6; Oct 9	July 4-5; July 22-Aug 9; Aug 18-29

Total Suspended Solids

A Seasonal-Kendall trend test was used to examine trends in TSS concentrations, TSS loading, and flow for the months of March through September, 2003-2011. Over the nine-year period, TSS concentrations did not significantly increase, but TSS loading showed a significant increase (slope=10.3%, $p < 0.03$). Flow also showed a significant increase ($p<0.001$, slope=7.1%). The Kendall's tau test showed a significant relationship between flow and TSS ($p<0.01$, tau=0.31, two-tailed test). The increasing trend in TSS loading may be due in part to increasing flows measured during sample events.

The average 24-hour precipitation for the day of, and the day before, sampling for 2003-2011 is presented in Figure 11. Average precipitation the day of and the day before sampling increased from 2003-2009 (with a drop in 2006), then decreased from 2009-2011. Increases in precipitation the day of and the day before sampling resulted in increased flows measured when sampling.

[2] 7-day average of the daily maximum temperature.

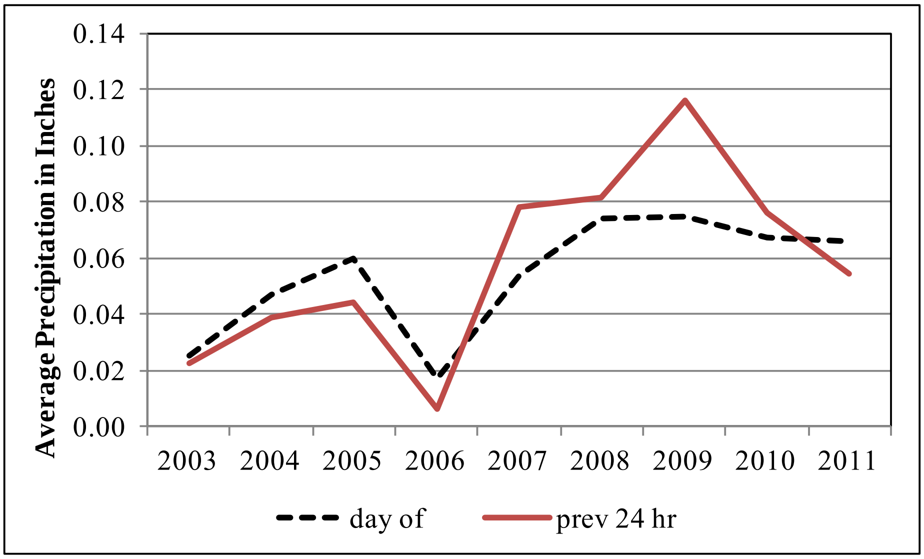


Figure 11. Thornton Creek average 24-hour precipitation the day of, and day before sampling, 2003-2011.
(Bruggers Bog Rain gauge, King County)

Green-Duwamish Basin 9: Longfellow Creek

Longfellow Creek has been sampled since 2009. Sampling included one site near the mouth of Longfellow Creek (Figure 3). During 2009-2011, 81 sample events were conducted from March through September.

Pesticide Occurrence

Pesticide Detections

A summary of pesticide detections for the Longfellow Creek site is presented in Appendix H, Table H-2.

For most pesticide compounds, few detections were observed. Table 13 presents the percentage of pesticide detections per sample event for the more commonly detected pesticides in 2009-2011. The most commonly detected herbicides were dichlobenil, triclopyr, and 2,4-D. This is similar to the type of herbicides detected at Thornton Creek, the other urban site. The most commonly detected insecticide was the neonicotinoid insecticide, imidacloprid.

Table 13. Most frequently detected pesticides at the Longfellow Creek site, 2009-2011.

Pesticide	Use	Number of Detections	% of Sample Events Detected
Dichlobenil	Herbicide	68	84%
Triclopyr	Herbicide	34	42%
2,4-D	Herbicide	25	31%
Imidacloprid	Insecticide	10	12%
Pentachlorophenol	Wood Preservative	12	15%

Co-occurrence of Pesticides

Co-occurrence of pesticides occurred during 58% of the sample events on Longfellow Creek. The maximum number of pesticides detected during a sample event for each year was:

- May 2009: 5 pesticides
- April 2010: 8 pesticides
- March and July 2011: 4 pesticides

During 2009-2011, one neonicotinoid, one organophosphate, and five carbamate insecticides were detected in Longfellow Creek. Co-occurrence of AChE-inhibiting insecticides (carbamate and organophosphate insecticides) occurred once in Longfellow Creek. On May 25, 2010, three carbamate insecticides were detected, at low concentrations. Toxic unit values did not exceed 1 on this day.

Pesticide Distribution

The distribution of detections by pesticide group in Longfellow Creek (Figure 12) is similar to the other urban site, Thornton Creek. Herbicides are the most frequently detected group, accounting for 80% of detections. Insecticides make up a smaller fraction of detections, followed by the wood preservative pentachlorophenol, pesticide degradates, and a fungicide.

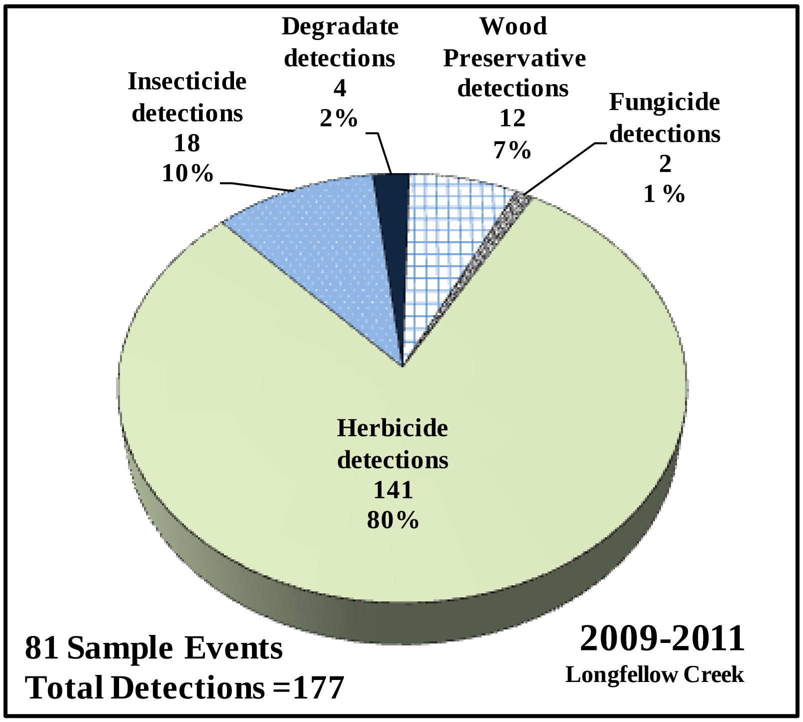


Figure 12. Pesticide distribution at the Longfellow Creek site, 2009-2011.

Factors Affecting Pesticide Detections

Environmental and Water Quality Factors

Appendix J, Table J-2, presents the correlation coefficients for the Kendall's tau test where a statistically significant relationship was seen during 2009-2011 in Longfellow Creek.

The herbicides dichlobenil, triclopyr, mecoprop (MCPP), and 2,4-D showed a positive relationship with rainfall. Dichlobenil and MCPP also showed a positive relationship with flow, but correlation with rainfall was better. There was also a positive relationship between TSS and flow.

Temporal Factors

As with the USGS study (Embrey and Frans, 2003), pesticide detections generally increased from March through May, then decreased after May (Figure 13). Figure 13 presents the number of detections by pesticide type and month for Longfellow Creek during 2009-2011. The greatest number of herbicide and insecticide detections occurred in May. Fungicide and pesticide degradate detections were highest in March.

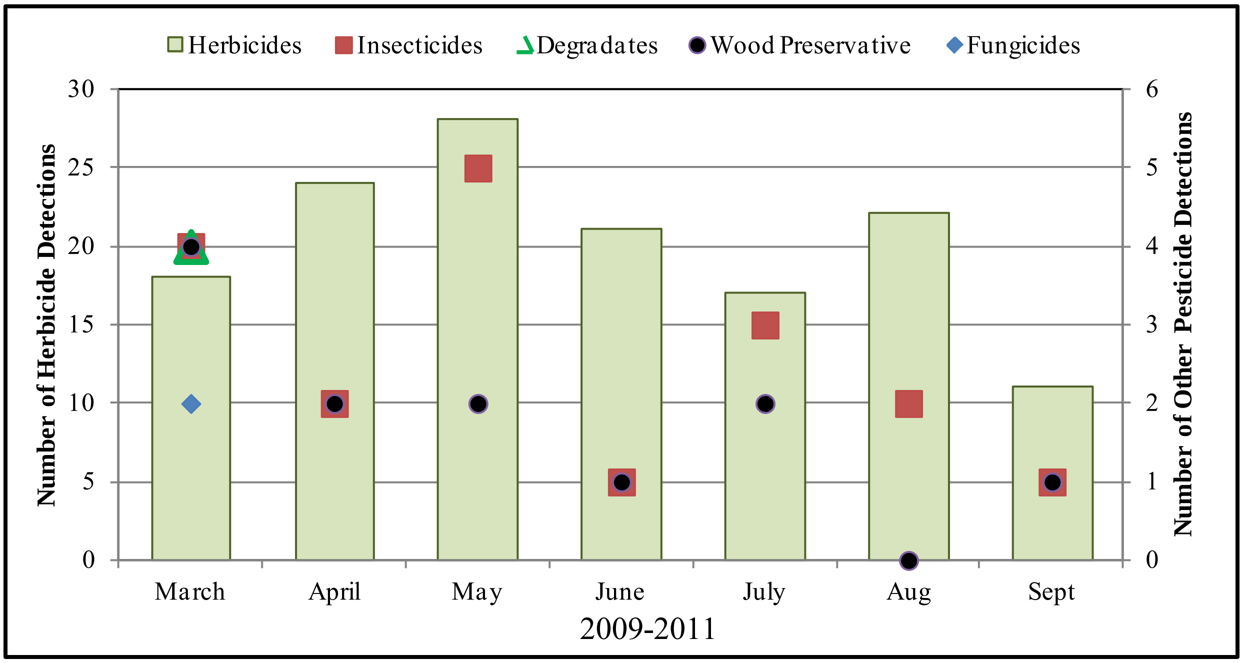


Figure 13. Number of compounds detected per month at the Longfellow Creek site, 2009-2011.

Comparison to Water Quality Standards and Other Assessment Criteria

Comparison to Numeric Criteria

The 2009-2011 pesticide data were compared to water quality standards and assessment criteria. Detailed summaries of the monitoring results can be found in pesticide calendars presented in Appendix I. Pesticide calendars for Longfellow Creek are presented in Appendix I, Table I-5 through Table I-7.

During the three-year period, there were two pesticide concentrations that did not meet an assessment criterion. In early March 2009, methiocarb concentrations did not meet the chronic invertebrate assessment criterion for two consecutive weeks. No other pesticide detections exceeded assessment criteria or water quality standards during 2009-2011.

Toxic Units

During 2009-2011, there were two occurrences where the TU value was ≥ 1. (TU value ≥ 1 means a lethal or sublethal (for chronic criteria) effect may occur with an increasing likelihood depending on the degree to which TUs exceed 1.0. Both of these occurrences were due to methiocarb concentrations above the chronic invertebrate assessment criterion:

- March 11, 2009: TU=1.2 for the chronic invertebrate assessment criterion. Based on a single detection of methiocarb (0.117 µg/L) that did not meet the chronic invertebrate assessment criterion.

- March 16, 2009: TU=2.0 for the chronic invertebrate assessment criterion. Based on a single detection of methiocarb (0.200 µg/L) that did not meet the chronic invertebrate assessment criterion.

During 2009-2011, co-occurrence of AChE- inhibiting insecticides (carbofuran=0.008 µg/L, methomyl=0.004 µg/L, and oxamyl=0.004 µg/L) occurred once on May 25, 2010. The highest TU for that day was 0.006 TU for the chronic invertebrate assessment endpoint.

Trend Analysis

Pesticide trend analysis was not conducted for Longfellow Creek data, as only three years of data are available.

Conventional Parameters

Conventional water quality parameters were measured in Longfellow Creek. Table 14 summarizes results for TSS, streamflow, pH, conductivity, temperature, and DO. All summaries are based on point (discrete) measurements obtained during the time of sampling. Longfellow Creek must meet freshwater standards as described in Table 7.

Table 14. Arithmetic mean and range for conventional parameters (grabs) for Longfellow Creek, 2009-2011.

	Total Suspended Solids (mg/L)			Flow Discharge (cfs)			pH (standard units)			Conductivity (µmhos/cm)			Dissolved Oxygen (mg/L)		
	2009	2010	2011	2009	2010	2011	2009	2010	2011	2009	2010	2011	2009	2010	2011
Mean[1]	6.4	4.4	11.9	1.6	1.6	2.7	7.9	8.0	8.0	278	284	282	10.2	10.3	10.5
Minimum	<1.0	2.0	1.0	0.5	0.7	0.6	7.1	7.4	7.7	125	167	182	8.8	9.2	9.4
Maximum	38	17	187	12.5	5.8	19.0	8.7	8.2	8.4	318	328	314	14.3	11.9	12.0
n	27	27	27	27	27	27	26	26	27	21	27	26	27	27	27

[1]Arithmetic Mean.
[2]Some field measurements rejected; did not meet MQOs.

Comparison of Conventional Parameters to Water Quality Standards

One pH value of 8.7 did not meet the pH standard in April 2009. All DO measurements met the 8.0 mg/L water quality standard.

Continuous, 30-minute interval, temperature data were collected year round from 2009-2011. Temperature profiles are presented in Appendix K, Figure K-2. The temperature standard was not met during the periods described in Table 15. The temperature standard for Longfellow Creek is: the 7-DADMax should not exceed 17.5°C.

Table 15. Longfellow Creek periods when water temperature did not meet standards, 2009-2011.

Year	Temperature exceedances > 17.5°C
2009	June 1-6, June 10-13, July 1-6, July 13-August 5, August 17-21
2010	July 9-10, August 14-16
2011	Met temperature standard

Lower Skagit-Samish Basin WRIA 3

Monitoring in the lower Skagit-Samish basin during 2009-2011 included five sites. Most sites have been sampled since 2006. In 2007, the upstream Big Ditch site was added, and an upstream site on the Samish River was discontinued.

Sample sites for 2009-2011 are presented in Figure 4. During 2009-2011, 81 sample events were conducted at each site from March through September.

Pesticide Occurrence

A summary of pesticide detections for the Skagit-Samish sites is presented in Appendix H, Tables H-3 - H-6.

Pesticide Detections

Big Ditch

Table 16 presents the most commonly detected pesticides observed at the upstream Big Ditch site for 2007-2008 and 2009-2011. During 2009-2011, the most commonly detected herbicides were dichlobenil, bromacil, and 2,4-D.

Of the Skagit-Samish sites, upstream Big Ditch had the most insecticide detections during 2009-2011(Table 16), followed by downstream Big Ditch (Table 17). The majority of insecticide detections at both sites were for imidacloprid, followed by carbamate insecticides, then an organophosphate insecticide. Imidacloprid was not added as an analyte until 2008. Imidacloprid detection frequency increased over time, possibly due to changes in laboratory methodology. Metalaxyl, a fungicide, and pentachlorophenol, a wood preservative, were also commonly detected pesticides.

Table 17 presents the most commonly detected pesticides observed at the downstream Big Ditch site for 2006-2011. During 2009-2011, the most commonly detected herbicides were metolachlor, dichlobenil, diuron, and 2,4-D. The most commonly detected insecticides for this period were imidacloprid, carbofuran, and ethoprop. Metalaxyl, a fungicide, and pentachlorophenol, a wood preservative, were also frequently detected.

Table 16. Most frequently detected pesticides at the upstream Big Ditch site, 2007-2008 and 2009-2011.

Pesticide	Use	2007-2008 n=58		2009-2011 n=81	
		Number of Detections	% of Sample Events Detected	Number of Detections	% of Sample Events Detected
Dichlobenil	Herbicide	30	34%	73	90%
Bromacil	Herbicide	27	31%	49	60%
Picloram	Herbicide	37	43%	18	22%
Tebuthiuron	Herbicide	31	36%	20	25%
2,4-D	Herbicide	18	21%	27	33%
Diuron	Herbicide	14	16%	21	26%
Triclopyr	Herbicide	6	7%	25	31%
Mecoprop (MCPP)	Herbicide	6	7%	19	23%
Imidacloprid	Insecticide	20	23%	48	59%
Oxamyl	Insecticide	2	2%	3	4%
Methiocarb	Insecticide	0	0%	4	5%
Metalaxyl	Fungicide	18	21%	16	20%
Pentachlorophenol	Wood Preservative	5	6%	23	28%

Table 17. Most frequently detected pesticides at the downstream Big Ditch site, 2006-2008 and 2009-2011.

Pesticide	Use	2006-2008 n=82		2009-2011 n=81	
		Number of Detections	% of Sample Events Detected	Number of Detections	% of Sample Events Detected
Metolachlor	Herbicide	32	37%	55	68%
Dichlobenil	Herbicide	22	25%	45	56%
2,4-D	Herbicide	27	31%	26	32%
Diuron	Herbicide	20	23%	28	35%
Bentazon	Herbicide	29	33%	8	10%
Eptam	Herbicide	26	30%	10	12%
MCPA	Herbicide	13	15%	21	26%
Triclopyr	Herbicide	13	15%	21	26%
Bromacil	Herbicide	21	24%	10	12%
Chlorpropham	Herbicide	10	11%	13	16%
Imidacloprid	Insecticide	4	5%	22	27%
Carbofuran	Insecticide	3	3%	8	10%
Ethoprop	Insecticide	4	5%	5	6%
Metalaxyl	Fungicide	20	23%	5	6%
Pentachlorophenol	Wood Preservative	9	10%	20	25%

Indian Slough

During 2009-2011, Indian Slough had the greatest total number of pesticide detections of any Skagit-Samish site. Table 18 presents the most commonly detected pesticides at the Indian Slough site for 2006-2011. During 2009-2011, the most commonly detected herbicides were bromacil, dichlobenil, tebuthiuron, and diphenamid.

The herbicide diphenamid has not been registered for use by EPA since 1991 (EPA, 2002). It is not known why diphenamid is detected in Indian Slough. Detections of diphenamid do not appear to be related to flow or have a seasonal pattern.

The most commonly detected insecticides for 2009-11 were diazinon, carbofuran, and imidacloprid. The wood preservative pentachlorophenol was also frequently detected.

Table 18. Most frequently detected pesticides at the Indian Slough site, 2006-2011.

Pesticide	Use	2006-2008 n=82		2009-2011 n=81	
		Number of Detections	% of Sample Events Detected	Number of Detections	% of Sample Events Detected
Diphenamid	Herbicide	52	60%	39	48%
Bromacil	Herbicide	22	25%	66	81%
Dichlobenil	Herbicide	32	37%	50	62%
Tebuthiuron	Herbicide	42	48%	38	47%
2,4-D	Herbicide	36	41%	32	40%
Metolachlor	Herbicide	28	32%	26	32%
Triclopyr	Herbicide	25	29%	29	36%
Diuron	Herbicide	13	15%	29	36%
Hexazinone	Herbicide	5	6%	31	38%
Bentazon	Herbicide	18	21%	13	16%
Diazinon	Insecticide	4	5%	3	4%
Carbofuran	Insecticide	0	0%	6	7%
Imidacloprid	Insecticide	0	0%	5	6%
Pentachlorophenol	Wood Preservative	7	8%	15	19%

Browns Slough

Table 19 presents the most commonly detected pesticides at the Browns Slough site for 2006-2011. For 2009-2011, the most commonly detected herbicides were DCPA, metolachlor, and diuron. The most commonly detected insecticides for this period were imidacloprid and carbofuran.

Table 19. Most frequently detected pesticides at the Browns Slough site, 2006-2008 and 2009-2011.

Pesticide	Use	2006-2008 n=82		2009-2011 n=81	
		Number of Detections	% of Sample Events Detected	Number of Detections	% of Sample Events Detected
DCPA	Herbicide	19	22%	52	64%
Bentazon	Herbicide	26	30%	15	19%
Diuron	Herbicide	14	16%	26	32%
Metolachlor	Herbicide	9	10%	27	33%
Simazine	Herbicide	22	25%	13	16%
2,4-D	Herbicide	19	22%	11	14%
Eptam	Herbicide	18	21%	12	15%
Dichlobenil	Herbicide	6	7%	14	17%
Imidacloprid	Insecticide	4	5%	10	12%
Diazinon	Insecticide	7	8%	1	1%
Oxamyl	Insecticide	6	7%	0	0%
Carbofuran	Insecticide	1	1%	7	9%
Metalaxyl	Fungicide	5	6%	2	2%

Samish River

Table 20 presents the most commonly detected pesticides at the Samish River site between 2006 and 2011. The Samish River has the least number of pesticide detections of any of the Skagit-Samish sites. This is likely due to dilution from higher flow in the Samish River, which averages 10 to 100 times greater than flow at the other Skagit-Samish sites. During 2009-2011, pesticides were rarely detected, but the most commonly detected herbicides were dichlobenil and 2,4-D.

Table 20. Most frequently detected pesticides at the Samish River site, 2006-2008 and 2009-2011.

Pesticide	Use	2006-2008 n=82		2009-2011 n=81	
		Number of Detections	% of Sample Events Detected	Number of Detections	% of Sample Events Detected
2,4-D	Herbicide	7	8%	7	9%
Bromacil	Herbicide	9	10%	0	0%
Dicamba I	Herbicide	3	3%	5	6%
Dichlobenil	Herbicide	0	0%	9	11%
Pentachlorophenol	Wood Preservative	2	2%	2	2%

Co-occurrence of Pesticides

Big Ditch

In 2009-2011, there was frequent co-occurrence of pesticides at both Big Ditch sites. For the upstream site, there were two or more pesticides detected during 98% of the sample events. The greatest period of co-occurrence varied from late April through mid-June. The maximum number of pesticides detected during a sample event for each year at the upstream site was:

- May 2009: 10 pesticides
- April and June 2010: 10 pesticides
- April and May 2011: 10 pesticides

At the downstream site, two or more pesticides were detected during 69% of sample events. The maximum number of pesticides detected during a sample event for each year was:

- May 2009: 13 pesticides
- June 2010: 13 pesticides
- May 2011: 11 pesticides

For the downstream site, pesticide co-occurrence peaked in early May and decreased to a low in early July, with a slight increase in September (Figure 14).

Co-occurrence of AChE-inhibiting insecticides (carbamate and organophosphate insecticides) did not occur at the upstream Big Ditch site. At the downstream site, there were three sample days during the three-year period when AChE-inhibiting insecticides occurred. Figure 15 presents additive concentrations for AChE-inhibiting insecticides at the downstream site during 2009-2011.

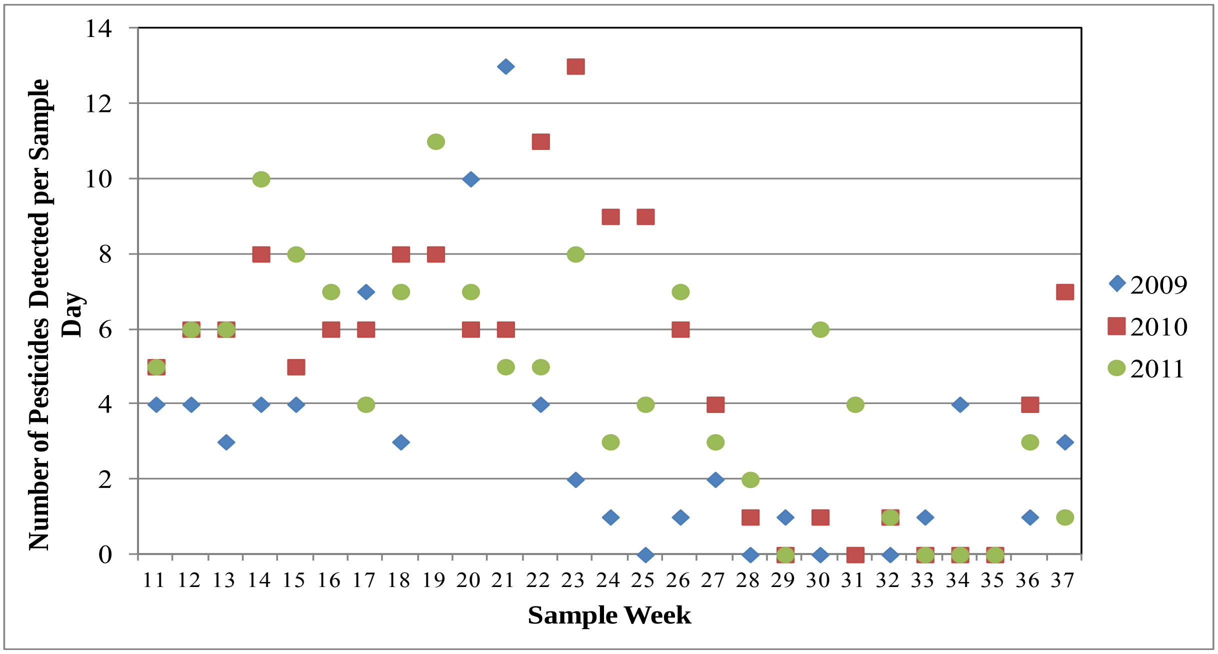


Figure 14. Number of pesticides co-occurring per sample event at the downstream Big Ditch site, 2009-2011.

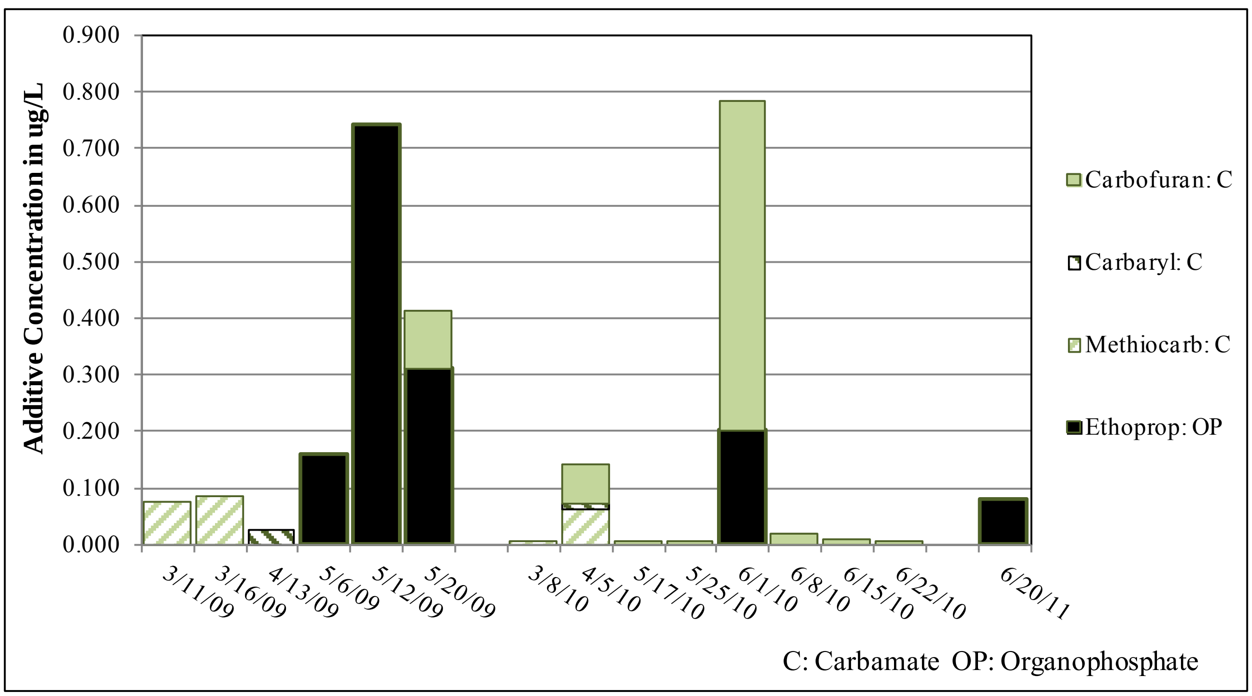


Figure 15. Cumulative total amount for AChE-inhibiting insecticide detections for the downstream Big Ditch site, 2009-2011.

Indian Slough

Co-occurrence of pesticides occurred during most sample events on Indian Slough. During 2009-2011, there were two or more pesticides detected during 99% of the sample events. The greatest period of co-occurrence varied from mid-April through mid-July. The maximum number of pesticides detected during a sample event for each year was:

- July 2009: 11 pesticides
- June 2010: 14 pesticides
- April and July 2011: 9 pesticides

Of the Skagit-Samish sites sampled from 2009-2011, Indian Slough had the greatest number of herbicide detections. Co-occurrence of AChE-inhibiting insecticides occurred once during the three-year period. On June 1, 2010, the carbamate insecticides carbaryl and carbofuran and the organophosphate insecticide ethoprop were detected (Figure 16).

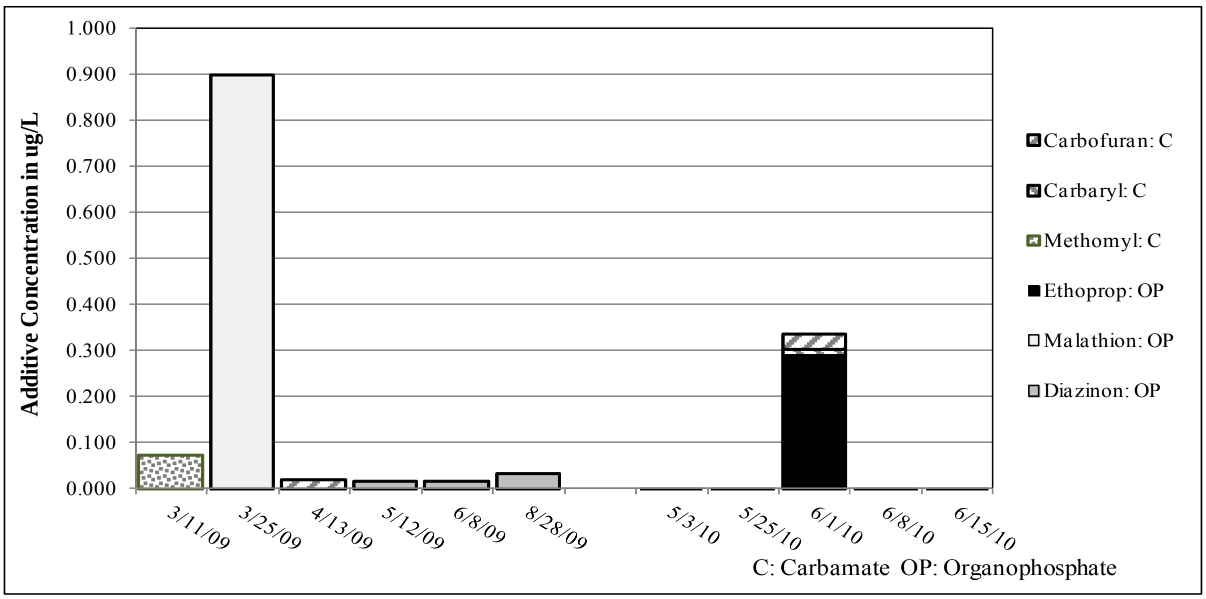


Figure 16. Cumulative total amount for AChE-inhibiting insecticide detections for Indian Slough, 2009-2011.

Browns Slough

Co-occurrence of pesticides occurred during 64% of sample events on Browns Slough. The greatest period of co-occurrence varied from early-April through early-June. The maximum number of pesticides detected during a sample event for each year was:

- May 2009: 6 pesticides
- June 2010: 14 pesticides
- April 2011: 8 pesticides

Co-occurrence of AChE-inhibiting insecticides (carbamate and organophosphate insecticides) did not occur in Browns Slough during 2009-2011.

Samish River

Co-occurrence of pesticides rarely occurred at the Samish River site. During 2009-2011, more than one pesticide was detected during 11% of the sample events. The maximum number of pesticides detected during a sample event for each year was:

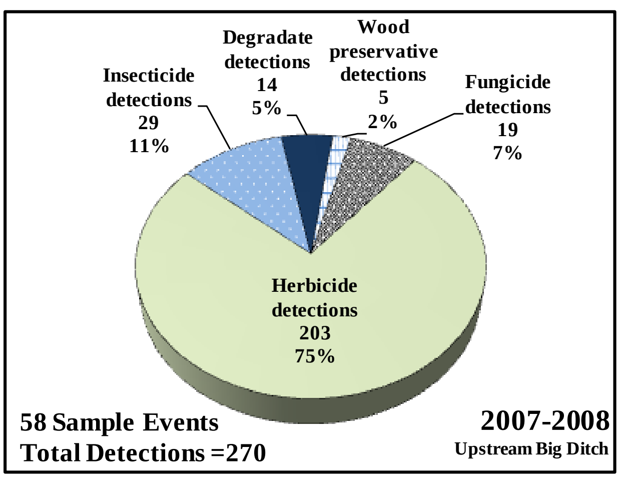
- May 2009: 7 pesticides
- June and September 2010: 2 pesticides
- August 2011: 2 pesticides

Co-occurrence of AChE-inhibiting insecticides (carbamate and organophosphate insecticides) did not occur at the Samish River site during 2009-2011.

Pesticide Distribution

Big Ditch

In Big Ditch, the distribution of detections by pesticide group is similar for the upstream and downstream sites (Figures 17 and 18). The most frequently detected compounds at both sites were herbicides followed by insecticides. As with most of the Skagit-Samish basin sites, a greater number of fungicide detections were observed at both sites than were seen in the other project areas. Detection frequency of the wood preservative pentachlorophenol increased during 2009-2011 as compared to 2006-2008 at both Big Ditch sites. This may be due in part to changes in laboratory methodology and reporting (Appendix D).



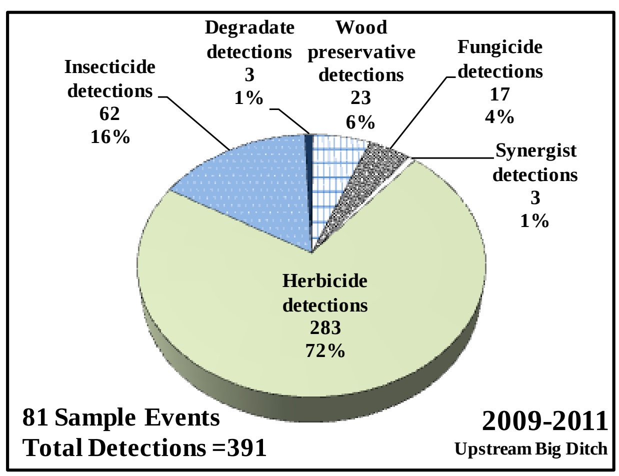


Figure 17. Pesticide distribution at the upstream Big Ditch site, 2007-2008 and 2009-2011.

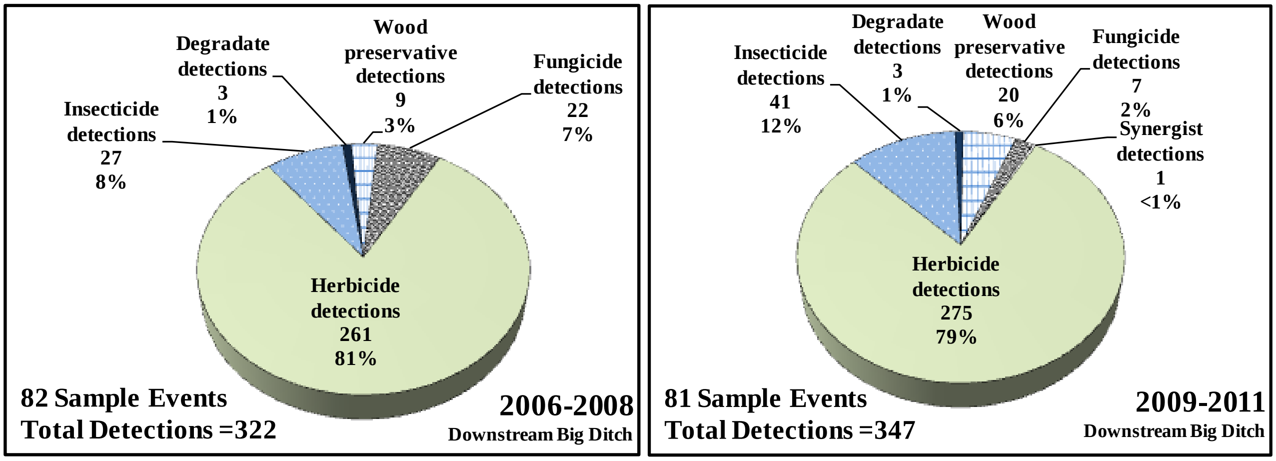


Figure 18. Pesticide distribution at the downstream Big Ditch site, 2006-2008 and 2009-2011.

Indian Slough

In Indian Slough, over 90% of pesticides detected for both triennial periods were herbicides (Figure 19). After herbicides the most frequently detected pesticides are insecticides. The distribution of pesticides was similar for both triennial periods.

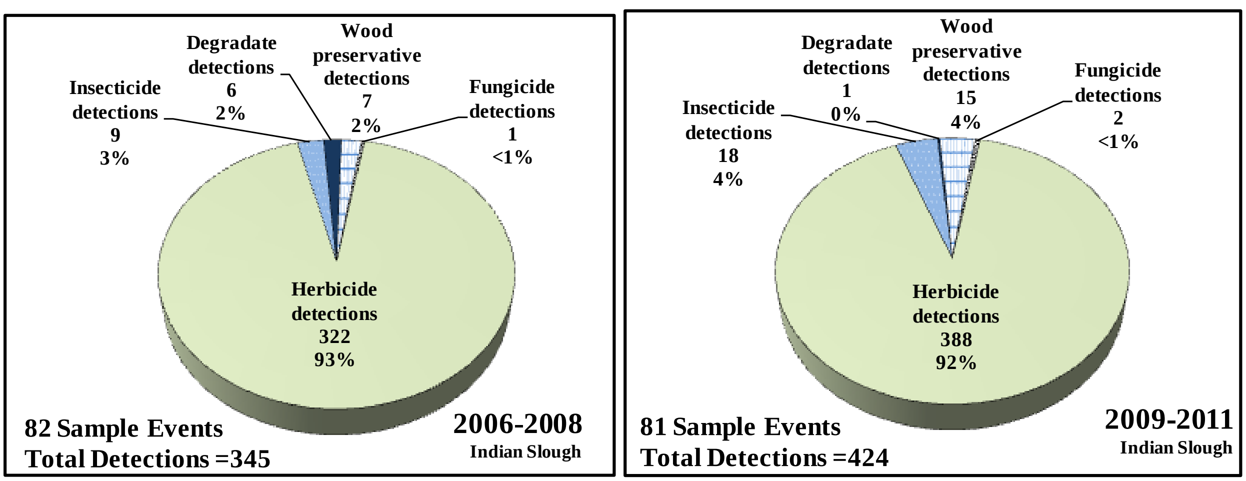


Figure 19. Pesticide distribution at Indian Slough, 2006-2008 and 2009-2011.

Browns Slough

In Browns Slough, the most frequently detected pesticides were herbicides (> 80%) followed by insecticides (Figure 20). The distribution of pesticides was similar for both triennial periods.

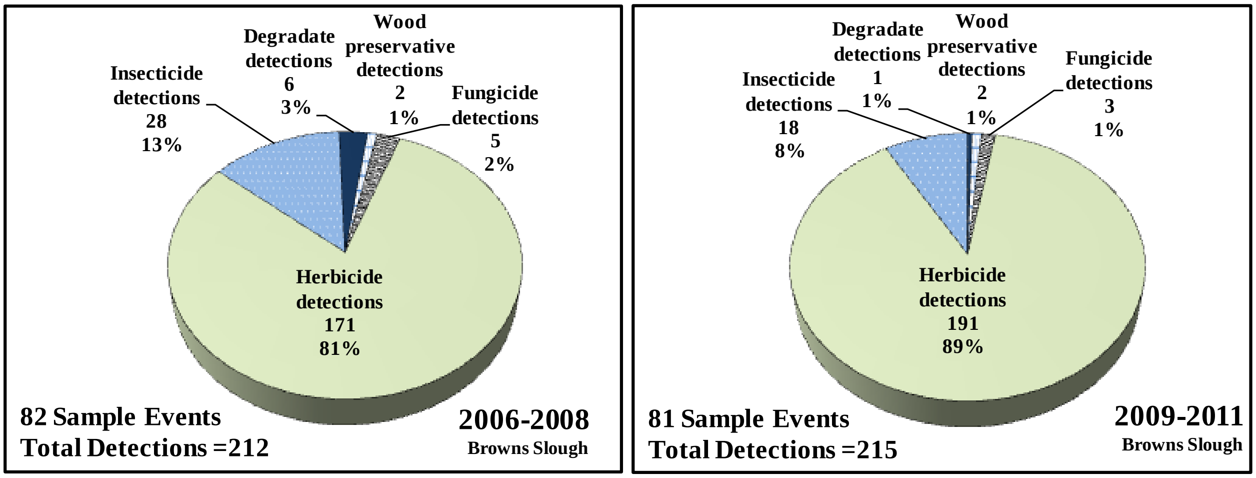


Figure 20. Pesticide distribution at Browns Slough, 2006-2008 and 2009-2011.

Samish River

For the Samish River, the most frequently detected type of pesticides were herbicides (>80%) (Figure 21).

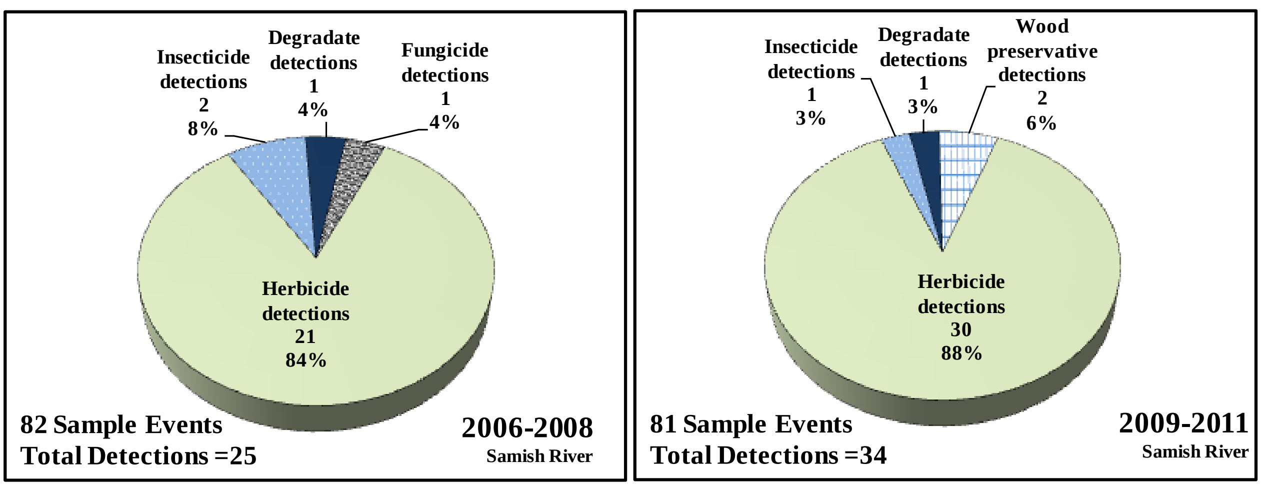


Figure 21. Pesticide distribution at Samish River, 2006-2008 and 2009-2011.

Factors Affecting Pesticide Detections

Environmental and Water Quality Factors

For the Skagit-Samish sites, data from all six years (2006-2011) were used for analysis, except the Samish River site. The Samish River had too few pesticide detections to compare. Appendix J, Tables J-3 – J-5, present the correlation coefficients for the Kendall's tau test for the pesticides where a statistically significant relationship ($p<0.05$, 2-tailed test) was seen. Below is a summary of findings for each site.

Big Ditch

At the upstream Big Ditch site, there was a positive relationship between rainfall and the herbicides 2,4-D, dichlobenil, mecoprop (MCPP), triclopyr; and the insecticide imidacloprid. In addition, there was a negative relationship between rainfall and the herbicide picloram and the fungicide metalaxyl. There was a positive relationship between flow and dichlobenil, 2,4-D, and MCPP and the insecticide imidacloprid. There was a negative relationship between flow and bromacil, picloram, tebuthiuron, metalaxyl, and pentachlorophenol.

At the downstream Big Ditch site, there was a positive relationship between rainfall and the herbicides 2,4-D, atrazine, bromacil, chlorpropham, dicamba I, dichlobenil, diuron, MCPA, mecoprop (MCPP), metolachlor, and triclopyr. There was also a positive relationship between rainfall and the insecticides imidacloprid and carbofuran. There was a positive relationship between TSS and diuron and imidacloprid. There was also a positive relationship between TSS and flow.

Indian Slough

For Indian Slough, there was a positive relationship between rainfall and the herbicides 2,4-D, bromacil, dichlobenil, diuron, metolachlor, and triclopyr. There was a negative relationship between rainfall and the herbicide tebuthiuron. The herbicides bromacil, dichlobenil, diuron, hexazinone, and metolachlor had a positive relationship with flow as well, but not as strong as rainfall. There was also a positive relationship between TSS and flow.

Browns Slough

For Browns Slough, there was a positive relationship between rainfall and the herbicides bentazon, DCPA, diuron, metolachlor, and simazine. There was also a positive relationship between flow and the herbicides bentazon, DCPA, diuron, and simazine. There was a negative relationship between TSS and flow and between TSS and bentazon.

Samish River

For the Samish River there was a positive relationship between TSS and flow. The relationship between pesticides and environmental factors was not tested due to the low number of pesticide detections for Samish River.

Temporal Factors

Pesticide detections followed the pattern seen by the USGS study (Embrey and Frans, 2003). Detections of pesticides increased from March through May, then decreased after May (Figure 22).

The greatest number of herbicide detections for all sites occurred in May. For both Big Ditch sites, the greatest number of insecticide and fungicide detections also occurred in May. For Indian and Browns Sloughs, the greatest number of insecticide detections occurred in June. Wood preservative detections were generally the greatest in March, then decreasing every month after that.

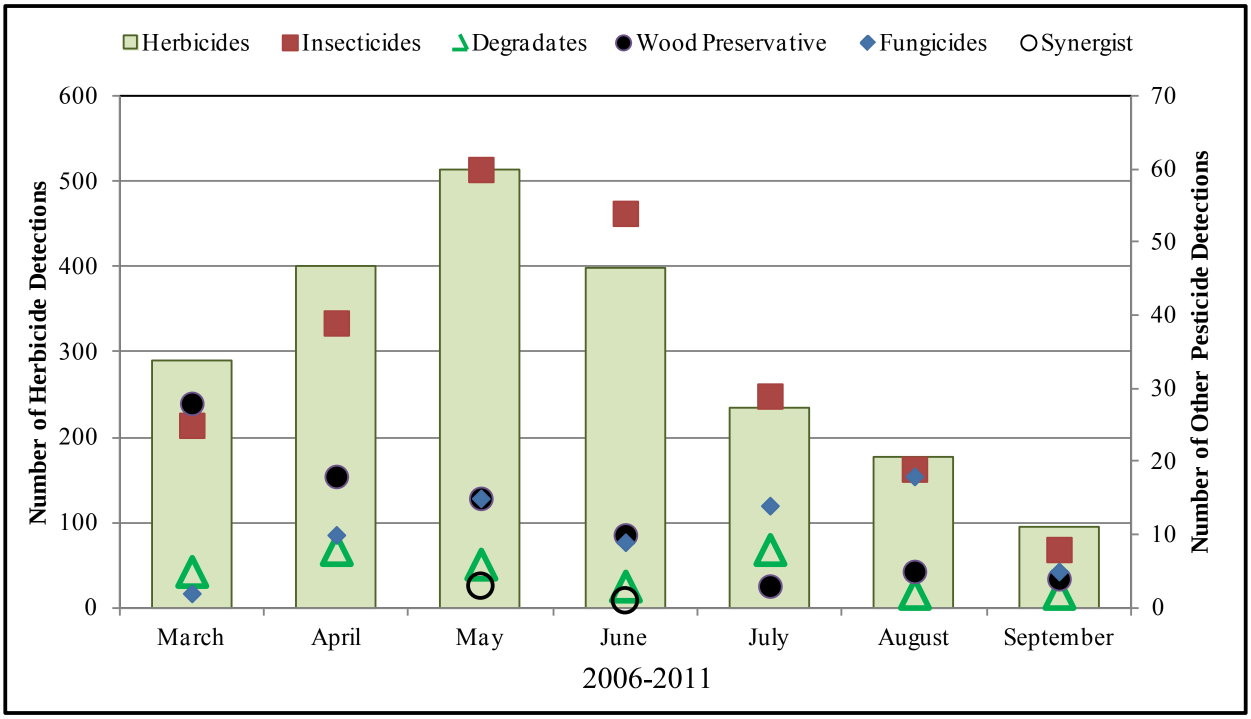


Figure 22. Number of pesticide detections by pesticide type and month for all Skagit-Samish sites, 2006-2011.

Comparison to Water Quality Standards and Other Assessment Criteria

Comparison to Numeric Criteria

The 2009-2011 pesticide data were compared to water quality standards and assessment criteria. Detailed summaries of the monitoring results can be found in pesticide calendars presented in Appendix I. Pesticide calendars for Skagit-Samish sites are presented in Appendix I, Tables I-8 – I-22. Highlights of findings are summarized below.

In Big Ditch during the three-year period, the upstream site had five pesticide concentrations above an assessment criteria or water quality standard.

- 2009: malathion (1 detection did not meet (exceeded) the ESLOC[3] for fish, the chronic invertebrate NRWQC[4], and the water quality standard).
- 2009: methiocarb (1 detection was above the chronic invertebrate assessment criterion).
- 2011: bifenthrin (3 detections did not meet the ESLOC for fish and the chronic invertebrate assessment criteria; 2 of the 3 detections also did not meet the chronic fish assessment criterion).

The downstream Big Ditch site had four pesticide concentrations above an assessment criterion.

- 2009: metolachlor (2 May detections did not meet the chronic invertebrate assessment criterion).
- 2011: metolachlor (1 May detection was above the chronic invertebrate assessment criterion).
- 2011: bifenthrin (1 detection did not meet the ESLOC for fish and the chronic invertebrate assessment criterion).

The 2011 bifenthrin exceedance at the downstream Big Ditch site may have been a result of high bifenthrin concentrations found at the upstream site the same day, April 25. Bifenthrin loading at the upstream site was higher than the downstream site: 4.6 g/day versus 2.0 g/day at the downstream site.

In Indian Slough during the three-year period, one pesticide detection did not meet a water quality standard and assessment criterion.

- 2009: malathion (1 detection did not meet the ESLOC for fish, the chronic invertebrate NRWQC, and the water quality standard).

In Browns Slough and the Samish River, no pesticide detections were above an assessment criteria or water quality standard during 2009-2011.

Toxic Units

During 2009-2011, Big Ditch and Indian Slough had some sample events where the TU value was ≥ 1. TU value ≥ 1 means a lethal or sublethal (for chronic criteria) effect may occur with an increasing likelihood depending on the degree to which TUs exceed 1.0. In most cases, a TU value > 1 was due to the higher concentration of a single pesticide rather than a mixture of pesticides.

Table 21 describes the incidences where TU values were greater than 1, the assessment endpoint exceeded, and major contributing pesticides. Samish River and Browns Slough had no TU values ≥ 1 over the three-year period.

[3] Endangered Species Level of Concern
[4] National Recommended Water Quality Criteria

Table 21. Skagit-Samish sites, dates, criteria assessment endpoint, and contributing pesticides where TU values were ≥ 1, 2009-2011.

Date	Chronic Assessment Endpoint TU		Contributing Pesticides
	Invertebrate	Fish	
Upstream Big Ditch			
3/16/2009	1.1	---	methiocarb
5/20/2009	15.7	---	malathion
4/25/2011	84.6	2.8	bifenthrin
7/5/2011	43.8	1.4	bifenthrin
7/12/2011	24.6	---	bifenthrin
Downstream Big Ditch			
5/6/2009	1.5	---	metolachlor
5/12/2009	1.3	---	ethoprop, metolachlor
5/20/2009	2.3	---	metolachlor
4/25/2011	1.1	1.1	bifenthrin
5/3/2011	6.2	---	metolachlor
Indian Slough			
3/25/2009	15.0	---	malathion

Trend Analysis

Skagit-Samish sites with significant trends (p value ≤ 0.05) are presented in Table 22, and trend graphs are presented in Appendix F.

Table 22. Skagit-Samish sites with significant trends in pesticide concentrations.

Site	Pesticide and Type	Trend Time Period	Trend Direction	P value=	Percent Change Per Year
Upstream Big Ditch	Picloram: H	2007-2011	decreasing	< 0.001	-45%
	Tebuthiuron: H	2007-2011	decreasing	< 0.001	-43%
Downstream Big Ditch	Bentazon: H	2006-2011	decreasing	< 0.001	-18%
	Eptam: H	2006-2011	decreasing	0.013	-23%
	Metalaxyl: F	2006-2011	decreasing	0.005	-26%
	Picloram: H	2006-2011	decreasing	< 0.001	-29%
	Chlorpropham: H	2006-2011	increasing	0.010	+68%
	MCPA: H	2006-2011	increasing	0.004	+38%
Indian Slough	Tebuthiuron: H	2006-2011	decreasing	0.001	-11%
	Hexazinone: H	2006-2011	increasing	0.002	+20%
	Metolachlor: H	2006-2011	increasing	0.010	+16%
Browns Slough	Diuron: H	2006-2011	decreasing	0.001	-27%
	Simazine: H	2006-2011	decreasing	< 0.001	-29%
	DCPA: H	2006-2011	increasing	< 0.001	+63%
	MCPA: H	2006-2011	increasing	0.019	+59%
	Metolachlor: H	2006-2011	increasing	< 0.001	+94%

H: Herbicide; F: Fungicide

Big Ditch

Several trends were noted for the Big Ditch sites. At both these sites, trends toward decreasing concentrations of the herbicide picloram were seen (Figures 23 and 24). At the upstream Big Ditch site, there were also decreasing trends in tebuthiuron concentrations (Table 22).

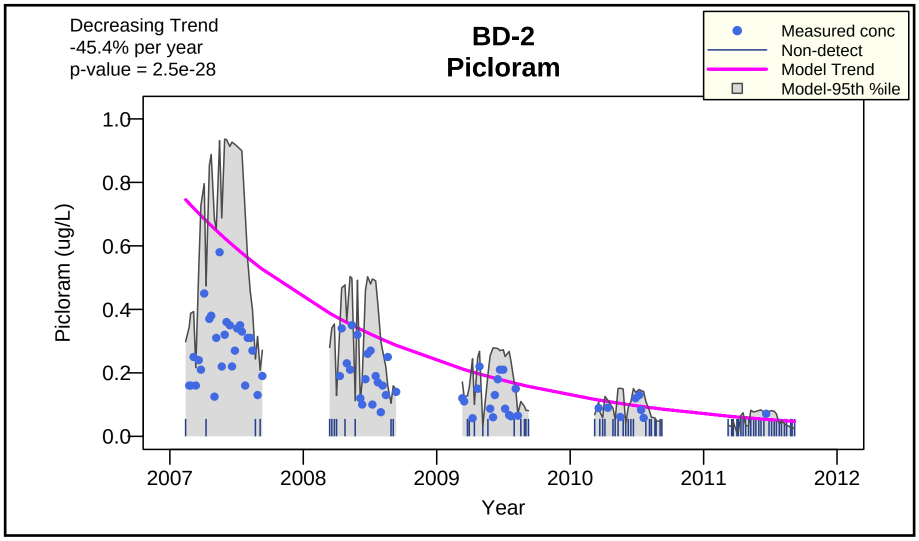


Figure 23. Decreasing trends in picloram concentrations at the upstream Big Ditch site, 2007-2011.

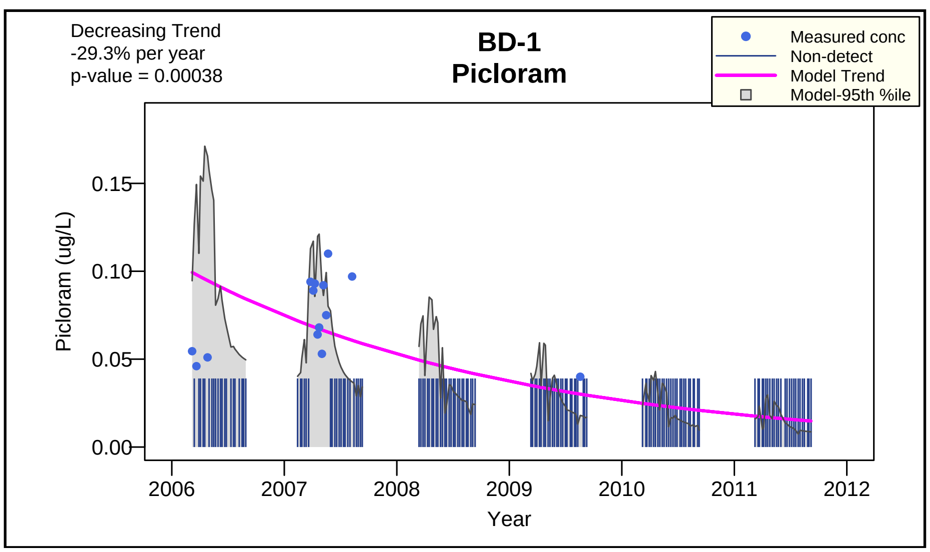


Figure 24. Decreasing trends in picloram concentrations at the downstream Big Ditch site, 2006-2011.

At the downstream Big Ditch site, decreasing trends in concentrations were seen for the herbicides bentazon (Figure 25), eptam, and picloram, and the fungicide metalaxyl. Increasing trends in concentrations were observed for the herbicides chlorpropham and MCPA (Table 22).

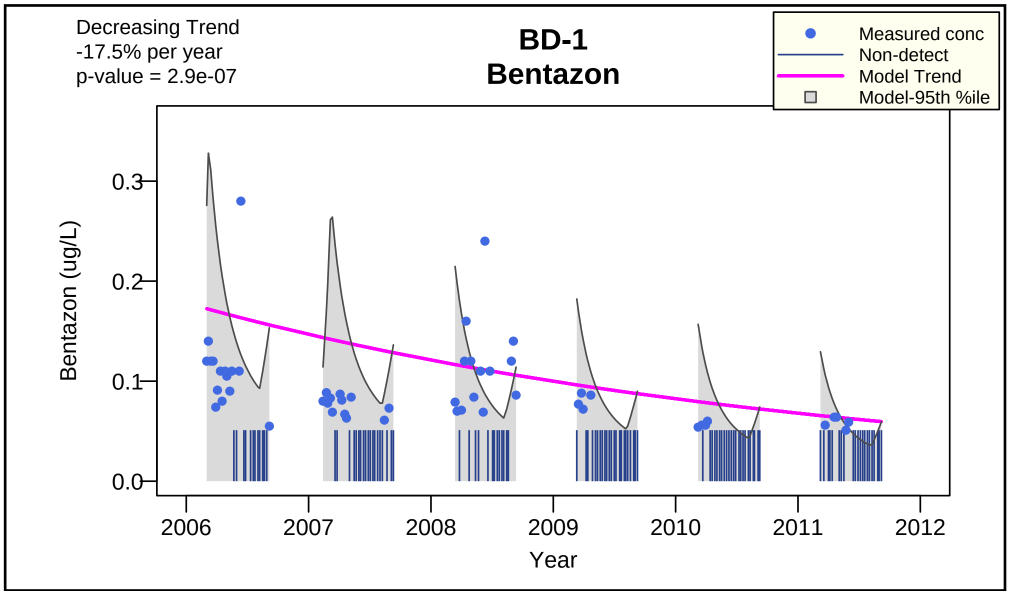


Figure 25. Decreasing trends in bentazon concentrations at the downstream Big Ditch site, 2006-2011.

With the exception of the herbicide bentazon, all the pesticides with trends are registered for use. Registration of bentazon was voluntarily cancelled in May 2010, but the sodium salt formation of bentazon is still registered for use. The laboratory analysis captures both forms of bentazon. Bentazon was commonly used in green pea production which was a major crop in rotation in the Skagit delta until the closure of a processing facility in 2008.

In Indian Slough, there were trends toward increasing concentrations of the herbicides hexazinone and metolachlor (Table 22, Figure 26) and decreasing concentrations for the herbicide tebuthiuron.

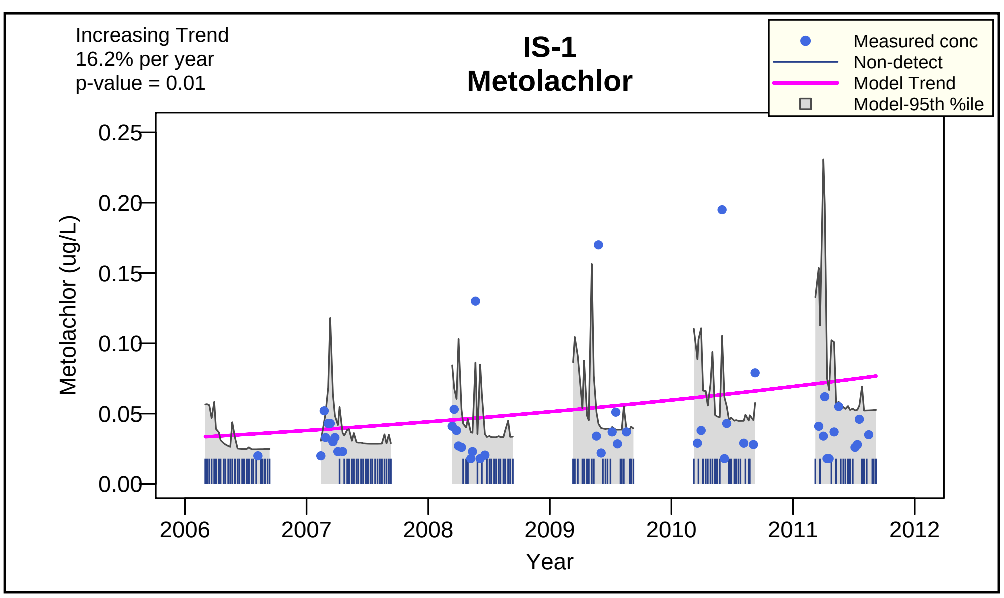


Figure 26. Increasing trends in metolachlor concentrations in Indian Slough, 2006-2011.

Browns Slough also showed an increasing trend in metolachlor concentrations over the six-year period (Figure 27). Browns Slough also had trends toward increasing concentrations of the herbicides DCPA (dacthal) and MCPA and decreasing concentrations for the herbicides diuron and simazine (Table 22).

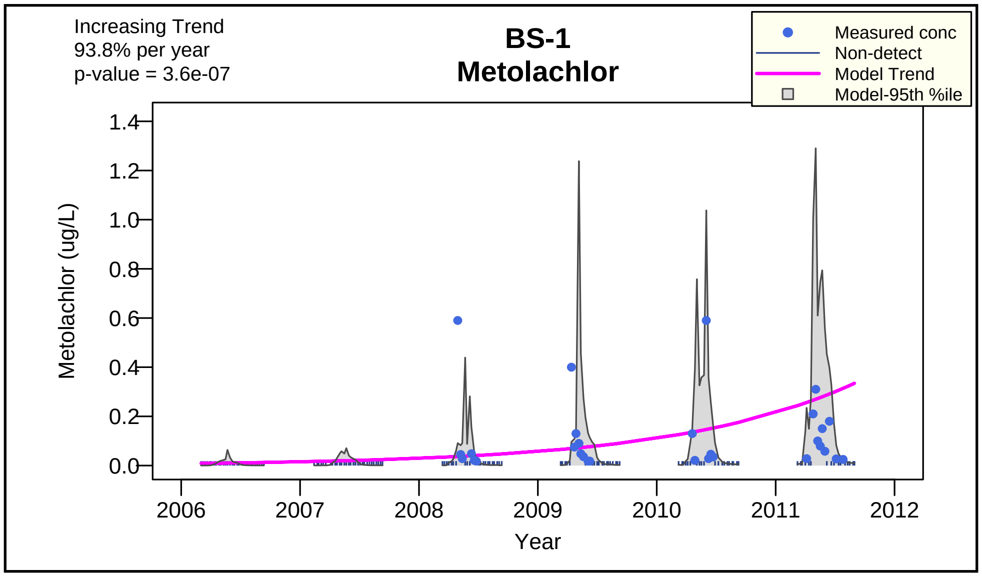


Figure 27. Increasing trends in metolachlor concentrations in Browns Slough, 2006-2011.

Samish River

There were not enough pesticide detections to conduct trend analysis for the Samish River site.

Conventional Parameters

Conventional water quality parameters were measured at all Skagit-Samish basin sites. Table 23 summarizes results for TSS, flow, pH, conductivity, and DO for all of the sites. All summaries are based on point (discrete) measurements obtained during the time of sampling. Browns Slough is a marine site and must meet marine water quality standards; all other Skagit-Samish sites must meet freshwater water quality standards.

Table 23. Arithmetic mean and range for conventional parameters (grabs) for Skagit-Samish basin sites, 2009-2011.

Summary Statistics by Site	Total Suspended Solids (mg/L)			Flow (cfs)			pH (standard units)			Conductivity (umhos/cm)			Dissolved Oxygen (mg/L)		
	2009	2010	2011	2009	2010	2011	2009	2010	2011	2009	2010	2011	2009	2010	2011
Big Ditch (upstream)															
Number	27	27	27	25[2]	27	22[2]	26[2]	26[2]	27	27	27	27	27	27	27
Mean[1]	17	7	12	2.6	2.3	5.4	7.0	7.0	7.1	315	319	438	8.8	8.5	8.6
Minimum	3	3	1	0.4	0.5	0.5	6.7	6.8	6.8	135	213	63	6.1	6.1	4.5
Maximum	118	16	57	13	6.2	32	7.5	7.3	7.6	426	448	834	11.6	10.3	13.9
Big Ditch (downstream)															
Number	24	27	27	27	24[2]	22[2]	26[2]	26[2]	27	27	27	27	27	27	27
Mean[1]	12	7	11	11.8	13.3	17.6	7.3	7.6	7.4	344	475	294	9.5	10.6	8.2
Minimum	1	<1	3	1.7	2.4	3.3	6.7	6.8	6.5	44	50	114	6.3	6.1	5.7
Maximum	38	25	72	23.6	34	39	9.4	9.4	9.4	933	925	415	14.3	16.0	10.8
Indian Slough															
Number	26[2]	27	27	25[2]	27	26[2]	26[2]	26[2]	27	27	27	27	27	27	27
Mean[1]	8	8	7	15.1	26.5	36.8	7.0	7.0	7.0	937	1040	964	7.1	7.4	7.3
Minimum	2	2	<4	1.3	0.7	6.9	6.7	6.6	6.6	2961	268	157	5.2	4.4	4.1
Maximum	23	22	43	31	56	108	7.7	7.5	7.5	2296	7400	4950	9.6	11.2	12.7
Browns Slough															
Number	27	27	27	16[2]	27	26[2]	26[2]	26[2]	27	27	27	27	27	27	27
Mean[1]	9	7	7	4.3	4.7	8.3	7.5	7.6	7.3	13245	10083	7460	10.1	10.3	8.3
Minimum	4	2	<2	0.5	<0.1	0.9	7.0	7.1	6.9	918	90	1397	2.9	2.8	2.2
Maximum	18	17	48	6.6	13	19	8.7	8.7	8.4	30450	19106	14395	16.4	20.1	17.1
Samish River															
Number	27	27	27	26[2]	27	27	26[2]	26[2]	27	27	27	27	27	27	27
Mean[1]	13	15	19	167	196	342	7.2	7.5	7.3	122	99	91	10.3	10.7	10.6
Minimum	2	2	3	26.5	34	25	6.7	6.9	6.5	53	54	46	8.8	9.8	9.6
Maximum	89	151	117	699	859	1840	7.6	8.4	7.7	442	135	130	12.8	12.8	11.9

[1]Arithmetic mean.

[2]Some field measurements rejected; did not meet MQOs or meter malfunction.

Comparison to Water Quality Standards

Results for discrete pH and DO measurements and for continuous temperature results were compared to water quality standards (Tables 7 and 8).

pH

The upstream Big Ditch site, Indian Slough, and Samish River met the pH freshwater water quality standard during 2009-2011. The downstream Big Ditch site failed to meet the freshwater standard range for pH (6.5 – 8.5 s.u.) once during 2009 and three times during 2010. In 2011, there was one pH value that fell below the criteria and three values were above the criteria.

Browns Slough is a marine site and must meet the marine pH water quality standard range of 7.0 – 8.5 s.u. In 2009, Browns Slough fell below the pH criteria three times. In 2010 and 2011, the pH standard was exceeded once during each year.

Dissolved Oxygen

Both the upstream and downstream Big Ditch sites and Indian Slough did not meet (fell below) the DO freshwater standard minimum of 8.0 mg/L numerous times during 2009-2011.

Brown Slough is a marine site and as such must meet the DO marine water quality standard minimum of 6.0 mg/L. DO levels fell below the 6.0 mg/L minimum standard twice during 2009, four times during 2010, and eight times during 2011. Browns Slough had some of the lowest DO levels seen in the study. During 2009-2011, the lowest DO levels were < 3.0 mg/L. Some of the highest DO levels were also seen at this site; maximums ranged from 16.4 – 20.1 mg/L. These fluctuations indicate possible eutrophication issues in Browns Slough.

The Samish River met DO freshwater water quality standards for all three years.

Temperature

In addition to discrete temperature measurements, continuous (30-minute interval) measurements were collected year-round from 2009-2011. Temperature profiles based on continuous temperature measurements are presented in Appendix K, Figures K-3 - K-7. For the freshwater sites, the 7-DADMax temperature should not exceed 17.5°C, and for marine water, the 7-DADMax should not exceed 16°C. The temperature standard was not met (exceeded) during the periods described in Table 24.

All of the Skagit-Samish sites exceeded temperature standards during various periods. Browns Slough did not meet the standard on the greatest number of days but, as a marine site, it must meet a more stringent standard. Upstream and downstream Big Ditch, Indian Slough, and Brown Slough all had long periods when temperature did not meet standards during the summer months.

Table 24. Periods when water temperature did not meet standards for the Skagit-Samish basin sites, 2009-2011.

Site / Standard	2009	2010	2011
Big Ditch (upstream) >17.5°C	May 29-June 18 June 20-21 June 24-July 8 July 11-Sept 20	August 12-21	None
Big Ditch (downstream) >17.5°C	Apr 28-May 1 May 18-June 4 June 10-June 12 June 28-Sept 25	May 10-19 June 3-29 July 4-Sept 9 Sept 15-18	June 1-July 15 July 21-Sept 15 Sept 20-27
Indian Slough >17.5°C	May 25-Sept 23	June 21-28 July 4-Sept 2 Sept 5-25	June 4-9 June 23 -26 June 30-Sept 17 Sept 21-26
Browns Slough > 16°C	Apr 18-May 3 May 5-Sept 25 Oct 2-3	Apr 13-21 Apr 25-May 1 May 6-Oct 8	Apr 20-21 May 1-7 May 11-Sept 30
Samish River >17.5°C	June 15-June 20 June 29-July 4 July 13-Aug 6 Aug 28-Sept 2	July 8-14 July 22-Aug 6 Aug 11-19	Aug 23-27

During the previous triennial period (2006-2008), it was noted that the 7-DADMax temperatures at Brown Slough were elevated when compared to other sites in the Skagit-Samish WRIA (Table 24). The site at Browns Slough is tidally influenced. To determine if upstream water or flooding marine water were contributing to higher temperatures, an upstream temperature sensor was installed. This upstream temperature sensor was installed upstream of the tidegate at Fir Island Road from January through December 2010.

Comparison of the upstream and sample site data show that there is a difference in temperature between the sites. The upstream water temperatures are up to 8°C cooler than those at the sampling location. Figure 28 shows the differences between the two sites from April until early October. Maximum differences can be seen during July through September when ambient air temperatures are highest and the days are longer.

The slow-moving water during the flood tide flowing over tidal flats heated during the day, combined with warm air temperatures, are likely the cause of warmer temperatures at the sample site as compared to the upstream non-tidally influenced water.

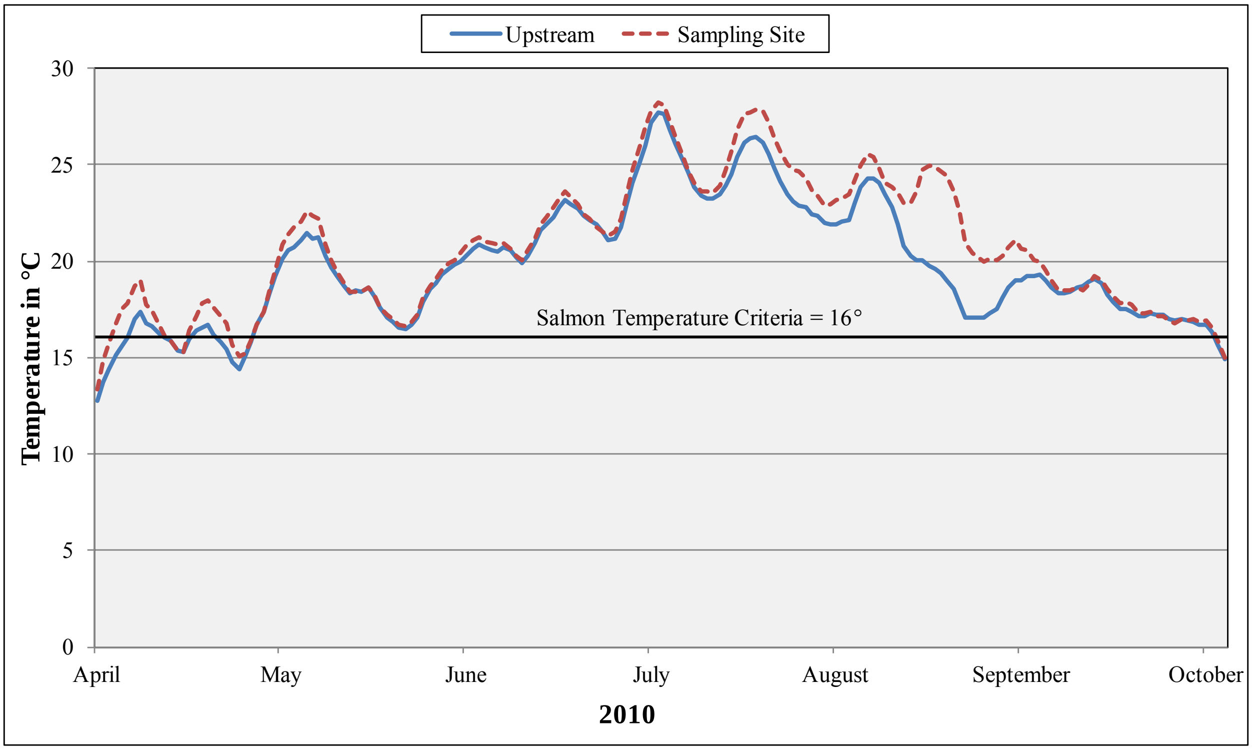


Figure 28. Comparison of 7-day average daily maximum (7-DADMax) temperatures at the Browns Slough site and an upstream site, April – October 2010.

Total Suspended Solids

Statistical trends in TSS and loading were examined for all the Skagit-Samish sites for March through September 2006-2011 and for the upstream Big Ditch site for 2007-2011.

For the Big Ditch sites and Browns Slough, TSS concentrations and loading showed no significant trends over the period tested. For the Samish River, there was no trend in TSS concentrations, but TSS loading showed a significant increasing trend from 2006-2011 ($p<0.05$, 2-tailed test). During the same period, there was a significant trend toward increasing flows (for instantaneous flow measurements during sampling) ($p<0.004$, 2-tailed test). At the Samish River site, there was a strong positive correlation between flow and TSS ($p<0.001$, tau= 0.75). The increasing trend in TSS loading is likely due to increasing flows measured during sample events.

There was a significant increasing trend in TSS concentrations in Indian Slough. There was also a significant increasing trend in TSS loading ($p<0.0003$, slope 17.6%) and flow ($p=0.007$, slope 13.1%) in Indian Slough from 2006-2011. In Indian Slough, there was a strong positive relationship between flow and TSS. The increasing trend in TSS loading may be due in part to increasing flows measured during sampling.

Lower Yakima Basin WRIA 37

Sampling in the Lower Yakima basin began in 2003. During 2009-2011, four sites were sampled: two on Spring Creek, one on Marion Drain, and one on Sulphur Creek Wasteway (Figure 5). The upstream Spring Creek site was sampled every other week, while the other sites were sampled weekly during the monitoring season (March – September). Marion Drain sampling continued weekly through October for select pesticides, TSS, and field parameters. During 2009-2011, upstream Spring Creek was sampled 42 times and the other sites 81 times, with an additional 21 sample events for select pesticides in Marion Drain.

Pesticide Occurrence

A summary of pesticide detections for the Yakima sites is presented in Appendix H, Tables H-7 - H-9.

Pesticide Detections

Spring Creek

Table 25 presents the most commonly detected pesticides observed at the upstream Spring Creek site from 2003 through 2011. During 2009-2011, the most commonly detected herbicides were 2,4-D, atrazine, bentazon, and dicamba I. The most commonly detected insecticides for this period were imidacloprid, chlorpyrifos, and carbaryl. Imidacloprid was added as an analyte in 2008, and changes in laboratory methodology lowered the reporting limit from 0.008 to 0.002 µg/L in 2010 (Appendix D).

Table 25. Most frequently detected pesticides at the upstream Spring Creek site, 2003, 2005, 2006-2008, and 2009-2011.

Pesticide	Use	2003 and 2005 n=27		2006-2008 n=42		2009-2011 n=42	
		Number of Detections	% of Sample Events Detected	Number of Detections	% of Sample Events Detected	Number of Detections	% of Sample Events Detected
Atrazine	Herbicide	20	74%	25	60%	10	24%
2,4-D	Herbicide	9	33%	14	33%	14	33%
Bentazon	Herbicide	10	37%	12	29%	10	24%
Chlorpyrifos	Insecticide	8	30%	10	24%	5	12%
Norflurazon	Herbicide	6	22%	8	19%	5	12%
Simazine	Herbicide	3	11%	10	24%	1	2%
Bromacil	Herbicide	11	41%	3	7%	0	0%
Dicamba I	Herbicide	0	0%	3	7%	9	21%
Oryzalin	Herbicide	0	0%	1	2%	7	17%
Pendimethalin	Herbicide	5	19%	0	0%	3	7%
Pentachlorophenol	Wood Preservative	2	7%	3	7%	3	7%
Carbaryl	Insecticide	1	4%	1	2%	5	12%
Diazinon	Insecticide	0	0%	3	7%	4	10%
Imidacloprid	Insecticide	0	0%	0	0%	7	17%

Table 26 presents the most commonly detected pesticides observed at the downstream Spring Creek site for the 2003-2005, 2006-2008, and 2009-2011 triennial periods. During 2009-2011, the most commonly detected herbicides were 2,4-D, bromacil, and dicamba I. The most commonly detected insecticides for this period were chlorpyrifos, carbaryl and imidacloprid.

Table 26. Most frequently detected pesticides at the downstream Spring Creek site, 2003-2005, 2006-2008, and 2009-2011.

Pesticide	Use	2003-2005 n=80		2006-2008 n=82		2009-2011 n=81	
		Number of Detections	% of Sample Events Detected	Number of Detections	% of Sample Events Detected	Number of Detections	% of Sample Events Detected
2,4-D	Herbicide	58	73%	34	41%	51	63%
Atrazine	Herbicide	41	51%	45	55%	7	9%
Bromacil	Herbicide	24	30%	26	32%	24	30%
Chlorpyrifos	Insecticide	18	23%	17	21%	14	17%
Simazine	Herbicide	8	10%	24	29%	3	4%
Dicamba I	Herbicide	1	1%	7	9%	20	25%
Bentazon	Herbicide	17	21%	6	7%	4	5%
Norflurazon	Herbicide	8	10%	10	12%	6	7%
Pendimethalin	Herbicide	9	11%	0	0%	9	11%
Azinphos-methyl	Insecticide	10	13%	5	6%	0	0%
Carbaryl	Insecticide	0	0%	3	4%	11	14%
Diazinon	Insecticide	3	4%	5	6%	5	6%
Dichlobenil	Herbicide	2	3%	0	0%	11	14%
MCPA	Herbicide	6	8%	1	1%	6	7%
Diuron	Herbicide	1	1%	3	4%	8	10%
Imidacloprid	Insecticide	0	0%	0	0%	11	14%

Marion Drain

Table 27 presents the most commonly detected pesticides at the Marion Drain site for 2003-2005, 2006-2008, and 2009-2011. Since 2006 Marion Drain sampling has continued weekly through October for select pesticides, TSS, and field parameters. Continued sampling for select organophosphates (specifically chlorpyrifos) occurred during 2006-2011 due to fall chlorpyrifos detections during 2003-2005 that did not meet (exceeded) water quality standards and the ESLOC for fish (Burke et al., 2006). During 2009-2011, the most commonly detected herbicides were terbacil, 2,4-D, and dicamba I. The most commonly detected insecticides for this period were imidacloprid, ethoprop, and chlorpyrifos.

Table 27. Most frequently detected pesticides at the Marion Drain site, 2003-2005, 2006-2008, and 2009-2011.

Pesticide	Use	2003-2005 n=84		2006-2008 n=103		2009-2011 n=102	
		Number of Detections	% of Sample Events Detected	Number of Detections	% of Sample Events Detected	Number of Detections	% of Sample Events Detected
Terbacil	Herbicide	62	74%	75	73%	75	74%
2,4-D	Herbicide	50	60%	33	32%	51	50%
Atrazine	Herbicide	55	65%	41	40%	10	10%
Chlorpyrifos	Insecticide	30	36%	53	51%	15	15%
Bentazon	Herbicide	23	27%	35	34%	38	37%
Dicamba I	Herbicide	4	5%	21	20%	53	52%
Pendimethalin	Herbicide	22	26%	26	25%	30	29%
Trifluralin	Herbicide	14	17%	25	24%	26	25%
Bromoxynil	Herbicide	16	19%	9	9%	16	16%
MCPA	Herbicide	17	20%	7	7%	14	14%
Malathion	Insecticide	18	21%	12	12%	7	7%
Ethoprop	Insecticide	12	14%	4	4%	17	17%
Diuron	Herbicide	1	1%	3	3%	27	26%
Metolachlor	Herbicide	10	12%	12	12%	6	6%
Simazine	Herbicide	19	23%	5	5%	3	3%
Imidacloprid	Insecticide	0	0%	0	0%	20	20%

Sulphur Creek Wasteway

Table 28 presents the most commonly detected pesticides at the Sulphur Creek Wasteway for 2003-2005, 2006-2008, and 2009-2011. For 2009-2011, the most commonly detected herbicides were 2,4-D, dicamba I, and bromacil. The most commonly detected insecticides for this period were carbaryl, imidacloprid, and chlorpyrifos.

Table 28. Most frequently detected pesticides at the Sulphur Creek Wasteway site, 2003-2005, 2006-2008, and 2009-2011.

Pesticide	Use	2003-2005 n=81		2006-2008 n=82		2009-2011 n=81	
		Number of Detections	% of Sample Events Detected	Number of Detections	% of Sample Events Detected	Number of Detections	% of Sample Events Detected
2,4-D	Herbicide	70	86%	49	60%	67	83%
Bromacil	Herbicide	40	49%	29	35%	46	57%
Atrazine	Herbicide	43	53%	29	35%	9	11%
Dicamba I	Herbicide	1	1%	20	24%	48	59%
Terbacil	Herbicide	24	30%	18	22%	13	16%
Chlorpyrifos	Insecticide	17	21%	16	20%	15	19%
Diuron	Herbicide	1	1%	15	18%	26	32%
DCPA	Herbicide	0	0%	20	24%	21	26%
Bentazon	Herbicide	22	27%	8	10%	10	12%
Carbaryl	Insecticide	1	1%	17	21%	21	26%
Trifluralin	Herbicide	19	23%	11	13%	8	10%
MCPA	Herbicide	7	9%	4	5%	11	14%
Dichlobenil	Herbicide	1	1%	7	9%	12	15%
Hexazinone	Herbicide	13	16%	0	0%	7	9%
Azinphos-methyl	Insecticide	14	17%	3	4%	0	0%
Imidacloprid	Insecticide	0	0%	1	1%	16	20%
Norflurazon	Herbicide	8	10%	7	9%	1	1%

Co-occurrence of Pesticides

Spring Creek

There was frequent co-occurrence of pesticides at both Spring Creek sites. During 2009-2011, there were two or more pesticides detected at the upstream site during 64% of the sample events and at the downstream site during 70% of the sample events. The greatest period of co-occurrence was the same for both sites, early to mid May. The maximum number of pesticides detected during a sample event for each year and site was:

- 2009: upstream 6 pesticides (April, May, and June); downstream 8 pesticides (May)
- 2010: upstream 5 pesticides (May); downstream 6 pesticides (May)
- 2011: upstream 7 pesticides (May); downstream 7 pesticides (May)

Co-occurrence of AChE-inhibiting insecticides (carbamate and organophosphate insecticides) rarely occurred at the Spring Creek sites during 2009-2011. There were two occurrences of AChE-inhibiting insecticides at the downstream site, one in 2009 and one in 2011; at the upstream site, there was one occurrence in 2009.

Marion Drain

There was frequent co-occurrence of pesticides in Marion Drain. During 2009-2011, there were two or more pesticides detected during 77% of the sample events. The Marion Drain sampling period extended for seven weeks longer than the rest of the sites. During the last two weeks of sampling, no pesticides were detected during 2009-2011.

The greatest period of co-occurrence varied from May through July. The maximum number of pesticides detected during a sample event for each year was:

- May and June 2009: 9 pesticides
- May 2010: 12 pesticides
- July 2011: 14 pesticides

Co-occurrence of AChE-inhibiting insecticides occurred three to five times during each year (2009-2011). Figure 29 presents the dates and AChE-inhibiting insecticides that co-occurred during 2009-2011.

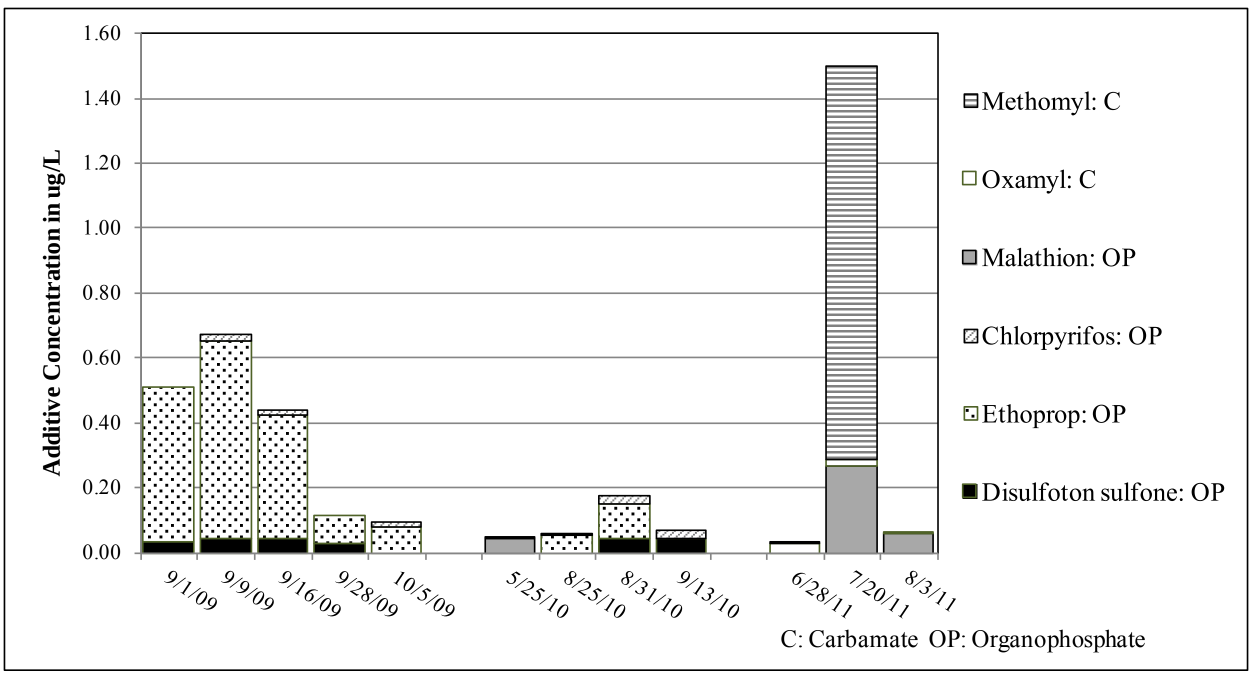


Figure 29. Cumulative total amount for AChE-inhibiting insecticide detections for Marion Drain, 2009-2011.

Sulphur Creek Wasteway

There was frequent co-occurrence of pesticides in Sulphur Creek Wasteway. During 99% of the 2009-2011 sample events, two or more pesticides were detected. The greatest period of co-occurrence varied from May to June. The maximum number of pesticides detected during a sample event for each year was:

- May and June 2009: 8 pesticides
- June 2010: 9 pesticides
- May 2011: 11 pesticides

Co-occurrence of AChE-inhibiting insecticides (carbamate and organophosphate insecticides) occurred two or three times a year in Sulphur Creek Wasteway during 2009-2011. Figure 30 presents the cumulative total amount for AChE-inhibiting insecticide detections for Sulphur Creek Wasteway.

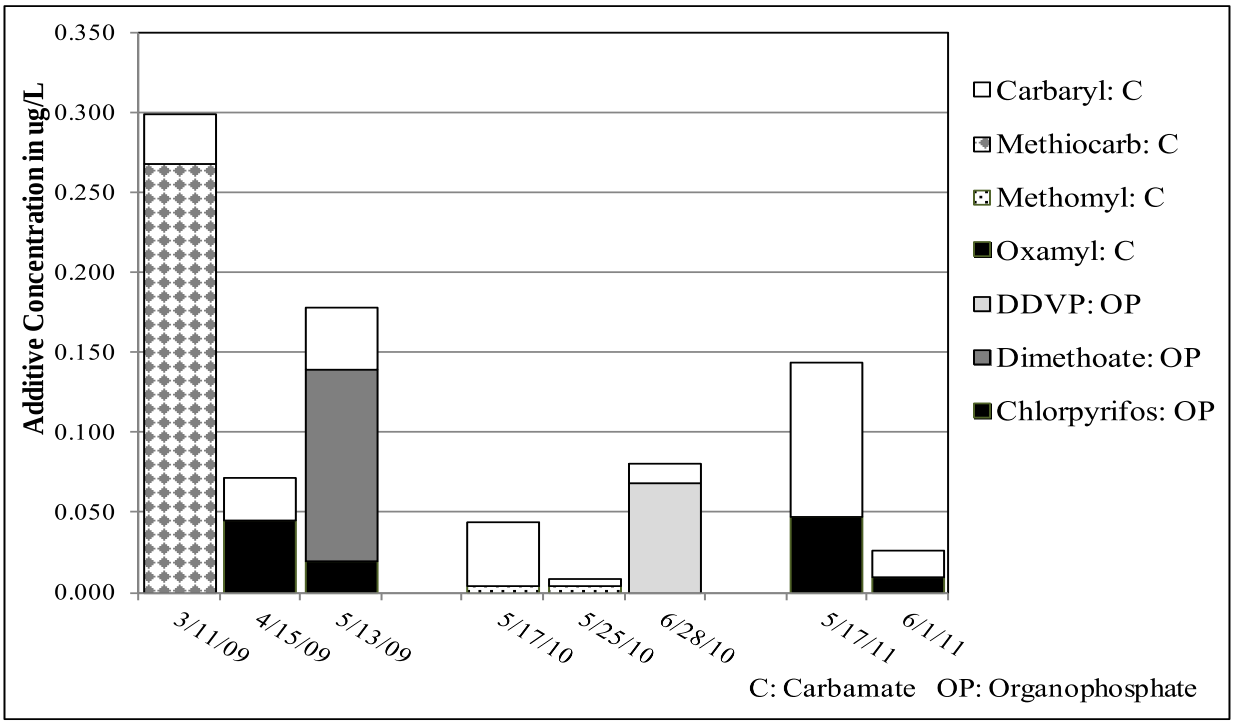


Figure 30. Cumulative total amount for AChE-inhibiting insecticide detections for Sulphur Creek Wasteway, 2009-2011.

Pesticide Distribution

Spring Creek

In Spring Creek, the distribution of detections by pesticide group is similar for the upstream and downstream sites (Figures 31 and 32). Distribution of pesticide groups remained similar for 2003-2008 and 2009-2011. The upstream site had > 75% herbicide detections and 15-18% insecticide detections with pesticide degradates and wood preservative being 2% of detections (Figure 31). The downstream site was similar with > 75% herbicide detections and 18-22% insecticide detections, with degradates and wood preservatives being 1-2% of detections (Figure 32).

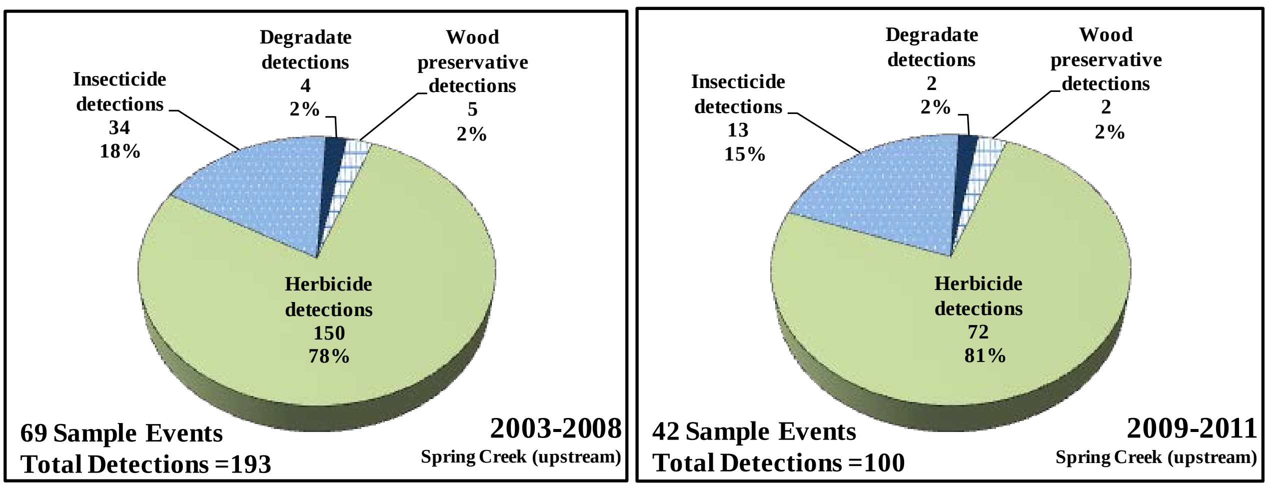


Figure 31. Pesticide distribution at the upstream Spring Creek site, 2003-2008 and 2009-2011.

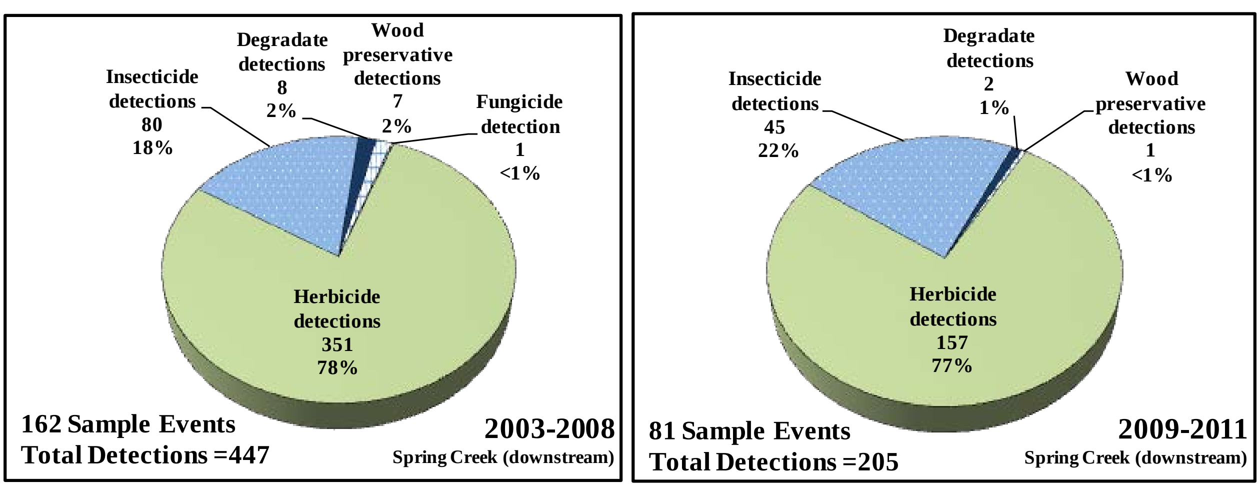


Figure 32. Pesticide distribution at the downstream Spring Creek site, 2003-2008 and 2009-2011.

Marion Drain

Marion Drain had a similar pesticide distribution as the other Yakima sites; the most frequently detected pesticides were herbicides, followed by insecticides (Figure 33). Marion Drain pesticide distribution by type was also similar over time, with 77-79% of detections being herbicides and 20-21% insecticides, and less than 2% of detections being pesticide degradates, wood preservatives, and fungicides (Figure 33).

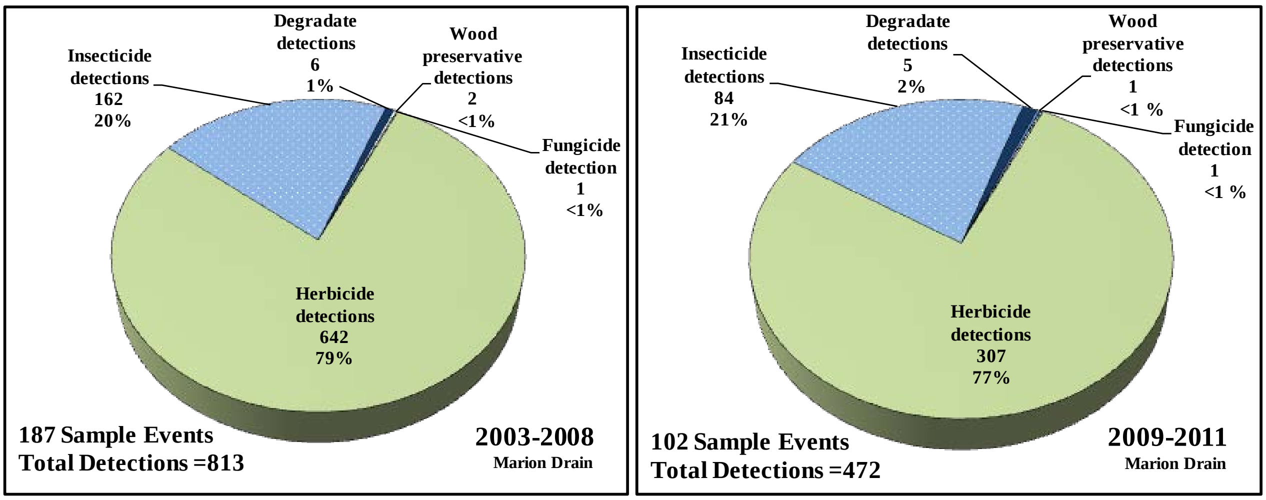


Figure 33. Pesticide distribution at Marion Drain, 2003-2008 and 2009-2011.

Sulphur Creek Wasteway

Sulphur Creek Wasteway pesticide distribution was similar to the other Yakima sites, with herbicides being the majority of pesticides detected followed by insecticides (Figure 34). Very few pesticide degradates and wood preservative detections were observed. Pesticide distribution has remained the same during all sampling periods, 2003-2011.

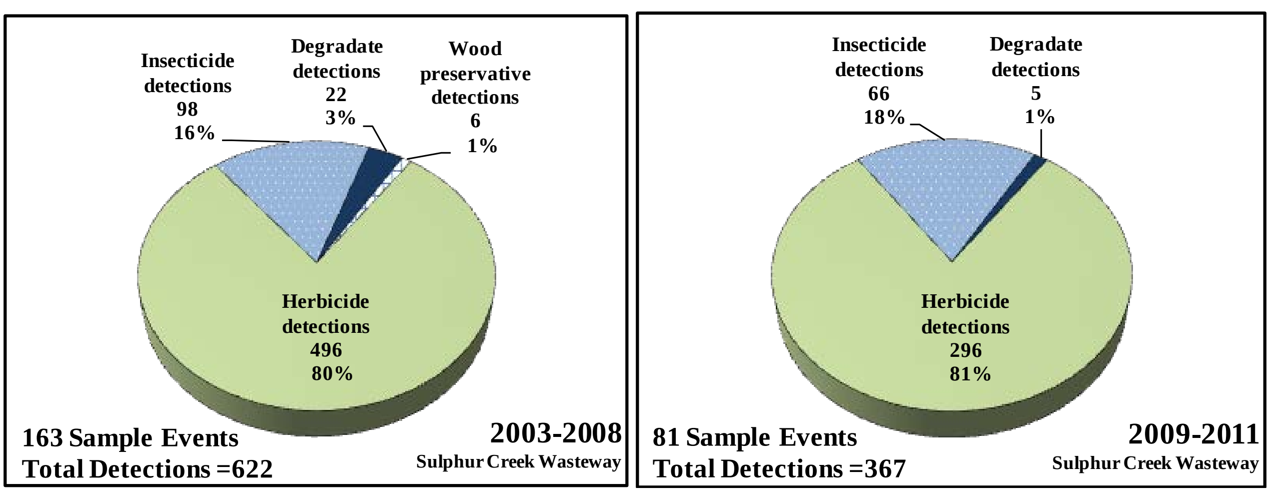


Figure 34. Pesticide distribution at Sulphur Creek Wasteway, 2003-2008 and 2009-2011.

Factors Affecting Pesticide Detections

Environmental and Water Quality Factors

Appendix J, Tables J-6 – J-8, present the correlation coefficients for the Kendall's tau test for the pesticides tested where a statistically significant relationship was seen (2003-2011). Below is a summary of findings for each site.

Spring Creek

For the upstream Spring Creek site, 14 pesticides were tested. There was a positive relationship between the herbicide oryzalin and flow and rainfall. There was a negative relationship between flow and the herbicides atrazine and bentazon. There was also a positive relationship between the herbicide 2,4-D and flow and TSS. There was a positive relationship between flow and TSS as well.

For the downstream Spring Creek site, 16 pesticides were tested. There was a positive relationship between rainfall and the herbicides 2,4-D, MCPA, and simazine and the insecticides azinphos-methyl, chlorpyrifos, and imidacloprid. There was a negative relationship between flow and atrazine. There was also a positive relationship between flow and TSS.

Marion Drain

For Marion Drain, 16 pesticides were tested. There was a negative relationship between the herbicide bentazon and flow and TSS. There was a positive relationship between the herbicide pendimethalin and TSS. There was a positive relationship between rainfall and the herbicides atrazine and MCPA. There was also a positive relationship between flow and TSS.

Sulphur Creek Wasteway

For Sulphur Creek Wasteway, 17 pesticides were tested. There was a positive relationship between rainfall and the herbicides atrazine, bromacil, and diuron and the insecticide chlorpyrifos. There was also positive relationship between flow and TSS.

Temporal Factors

Pesticide detections followed the pattern seen by the USGS study (Embrey and Frans, 2003). Pesticide detections increased from March through May, then decreased after May (Figures 35 and 36).

At the Spring Creek sites, the greatest number of herbicide detections occurred in May. In Marion Drain and Sulphur Creek Wasteway, the greatest number of herbicide detections occurred in May and June.

In Spring Creek, the greatest number of insecticide detections occurred in April and June (Figure 35). In Sulphur Creek Wasteway, the greatest number of insecticides were detected in

June. In Marion Drain, the greatest number of insecticides were detected in June with another peak in September (Figure 36).

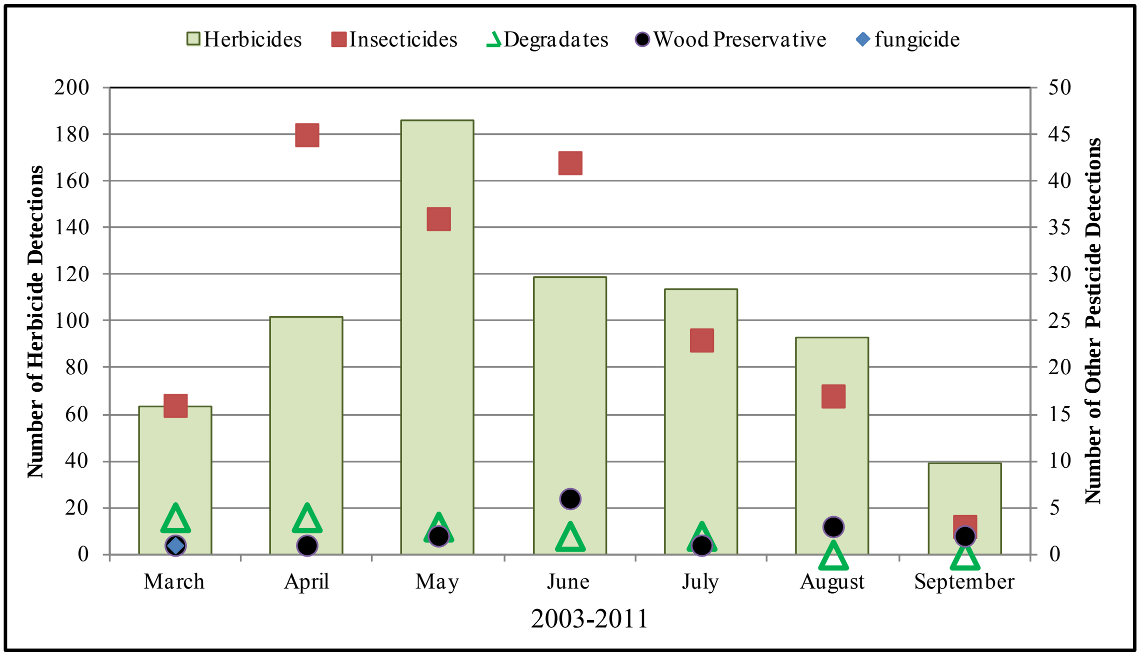


Figure 35. Number of pesticide detections by pesticide type and month for the Spring Creek sites, 2003-2011.

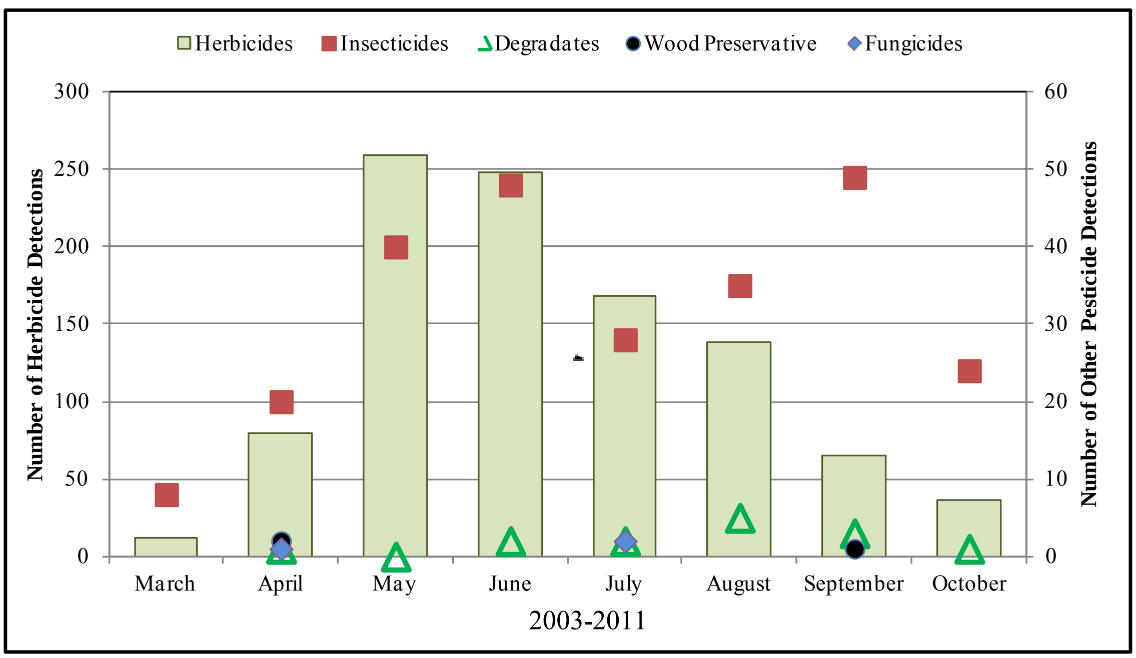


Figure 36. Number of pesticide detections by pesticide type and month for Marion Drain, 2003-2011.

Comparison to Water Quality Standards and Other Assessment Criteria

Comparison to Numeric Criteria

The 2009 through 2011, pesticide data were compared to water quality standards and assessment criteria. Detailed summaries of the monitoring results can be found in pesticide calendars. Pesticide calendars for the Yakima basin sites (Appendix I, Tables I-23 – I-34) present a chronological overview of detections. Highlights of findings are summarized below.

In Spring Creek, the upstream site had two pesticide detections that did not meet (exceeded) an assessment criteria or water quality standard, and the downstream site had six. Seven of the eight detections that did not meet an assessment criteria or water quality standard were for chlorpyrifos. Spring Creek pesticide detections that did not meet an assessment criteria or water quality standard are described in Table 29.

In Marion Drain, there were six pesticide detections that did not meet an assessment criteria or water quality standard. Pesticide detections that did not meet an assessment criteria or water quality standard are described in Table 29.

Of all the Yakima basin sites, Sulphur Creek Wasteway had the greatest number of pesticide detections that did not meet an assessment criteria or water quality standard. There were 14 detections that did not meet an assessment criteria or water quality standard; eight of the 14 were for chlorpyrifos. During 2009-2011, there were two to three consecutive sampling weeks each year when chlorpyrifos did not meet a chronic standard or assessment criteria. Sulphur Creek Wasteway pesticide detections that did not meet an assessment criteria or water quality standard are described in Table 29.

- 2009: For three consecutive weeks, chlorpyrifos detections did not meet the chronic NRWQC and water quality standard. For one of these weeks, the acute NRWQC and water quality standard were also exceeded. Three 4,4'-DDE[5] detections did not meet the chronic water quality standard for DDT (and metabolites). One detection of methiocarb was above the chronic invertebrate assessment criteria.
- 2010: For two consecutive weeks, chlorpyrifos detections did not meet the chronic NRWQC and water quality standard. For one of these weeks, the acute NRWQC and water quality standard was not met. One detection of malathion was above the chronic invertebrate assessment criteria. One detection of the organophosphate insecticide DDVP also was above the chronic invertebrate assessment criteria.
- 2011: Three detections of chlorpyrifos did not meet the chronic NRWQC and water quality standard. Two of these detections also did not meet the acute NRWQC and water quality standard. One detection of 4,4'-DDT did not meet the chronic NRWQC and water quality standard.

[5] Degradate of the legacy insecticide DDT

Table 29. Lower Yakima basin sites that did not meet (exceeded) an assessment criteria or water quality standard, 2009-2011.

Date	Pesticide	Assessment Criteria or Water Quality Standard of Concern
Upstream Spring Creek		
4/22/2009	4,4'-DDE	Chronic water quality standard for DDT (and metabolites).
4/5/2011	Chlorpyrifos	EPA's chronic NRWQC; chronic invertebrate assessment criteria; chronic water quality standard.
Downstream Spring Creek		
3/30/2009	Chlorpyrifos	EPA's chronic NRWQC; chronic invertebrate assessment criteria; chronic water quality standard.
4/6/2009	Chlorpyrifos	
4/15/2009	Chlorpyrifos	
3/30/2010	Chlorpyrifos	EPA's chronic NRWQC; chronic invertebrate assessment criteria; chronic water quality standard.
3/30/2011	Chlorpyrifos	EPA's chronic NRWQC; chronic invertebrate assessment criteria; chronic water quality standard.
4/5/2011	Chlorpyrifos	EPA's chronic and acute NRWQC; chronic invertebrate assessment criteria; chronic and acute water quality standard.
Marion Drain		
4/15/2009	Chlorpyrifos	Chronic invertebrate assessment criteria
5/17/2010	Malathion	Chronic invertebrate assessment criteria
7/20/2011	Malathion	ESLOC for fish, EPA's chronic NRWQC; chronic water quality standard; chronic invertebrate assessment criteria
8/3/2011	Malathion	Chronic invertebrate assessment criteria
9/7/2011	Ethoprop	Chronic invertebrate assessment criteria
7/20/2011	Methomyl	Chronic invertebrate assessment criteria
Sulphur Creek Wasteway		
3/30/2009	Chlorpyrifos	EPA's chronic NRWQC; chronic invertebrate assessment criteria; chronic water quality standard.
4/6/2009	Chlorpyrifos	EPA's chronic and acute NRWQC; chronic invertebrate assessment criteria; chronic and acute water quality standard.
4/15/2009	Chlorpyrifos	EPA's chronic NRWQC; chronic invertebrate assessment criteria; chronic water quality standard.
3/23/2009	4,4'-DDE	Chronic water quality standard for DDT (and metabolites).
3/30/2009	4,4'-DDE	Chronic water quality standard for DDT (and metabolites).
4/28/2009	4,4'-DDE	Chronic water quality standard for DDT (and metabolites).
3/11/2009	Methiocarb	Chronic invertebrate assessment criteria
3/23/2010	Chlorpyrifos	EPA's chronic and acute NRWQC; chronic invertebrate assessment criteria; chronic and acute water quality standard.
3/30/2010	Chlorpyrifos	EPA's chronic NRWQC; chronic invertebrate assessment criteria; chronic water quality standard.
6/28/2010	DDVP	Chronic invertebrate assessment criteria
3/29/2011	Chlorpyrifos	EPA's chronic and acute NRWQC; chronic invertebrate assessment criteria; chronic and acute water quality standard.
4/5/2011	Chlorpyrifos	EPA's chronic and acute NRWQC; chronic invertebrate assessment criteria; chronic and acute water quality standard.
5/17/2011	Chlorpyrifos	EPA's chronic NRWQC; chronic invertebrate assessment criteria; chronic water quality standard.
5/17/2011	4,4'-DDE	Chronic water quality standard for DDT (and metabolites).

Toxic Units

During 2009-2011, the Yakima sites had occurrences where the TU value was ≥ 1. When the TU value ≥ 1, 76% of the time it was due to a higher concentration of a single pesticide rather than a mixture of pesticides. Table 30 describes the incidences where TU values were greater than 1, the assessment endpoint exceeded, and major contributing pesticides.

Table 30. Yakima basin sites, dates, criteria assessment endpoint, and contributing pesticides where TU values were > 1, 2009-2011.

Date	Invertebrate Assessment Endpoint TU		Contributing Pesticides
	Chronic	Acute	
Upstream Spring Creek			
4/5/2011	1.4	---	chlorpyrifos
Downstream Spring Creek			
3/30/2009	1.1	---	chlorpyrifos
4/6/2009	1.9	---	chlorpyrifos, carbaryl
4/15/2009	1.2	---	chlorpyrifos
4/28/2010	1.5	---	chlorpyrifos
3/30/2011	1.3	---	chlorpyrifos
4/5/2011	2.8	1.1	chlorpyrifos
Sulphur Creek Wasteway			
3/11/2009	2.7	---	methiocarb
3/23/2009	1.4	---	4,4'-DDE
3/30/2009	2.6	---	4,4'-DDE, chlorpyrifos
4/6/2009	7.0	2.8	chlorpyrifos
4/15/2009	1.2	---	chlorpyrifos
3/23/2010	2.4	---	chlorpyrifos
3/30/2010	1.3	---	chlorpyrifos
6/28/2010	11.9	---	DDVP
3/29/2011	2.8	1.1	chlorpyrifos
4/5/2011	3.3	1.3	chlorpyrifos
5/17/2011	3.1	---	4,4'-DDE, chlorpyrifos
Marion Drain			
4/15/2009	1.0	---	chlorpyrifos
9/22/2009	1.5	---	ethoprop, chlorpyrifos
9/28/2009	1.3	---	ethoprop, chlorpyrifos
5/17/2010	1.1	---	malathion
8/31/2010	1.1	---	chlorpyrifos, ethoprop, disulfoton sulfone
7/20/2011	6.4	---	malathion, methomyl, propargite, chlorothalonil
8/3/2011	1.0	---	malathion

Trend Analysis

Yakima basin sites with significant trends in pesticide concentrations are presented in Table 31, and trend graphs are presented in Appendix F. Of the project areas analyzed, the Yakima sites had the greatest number of significant trends in concentrations, both increasing and decreasing.

Table 31. Yakima sites with significant trends in pesticide concentrations.

Site	Pesticide and Type	Trend Time Period	Trend Direction	P value=	Percent Change per Year
Upstream Spring Creek	Dicamba I: H	2004-2011	increasing	0.025	+16%
Downstream Spring Creek	Azinphos-methyl: I	2003-2011	decreasing	0.028	-14%
	Diuron: H	2003-2011	decreasing	0.001	-18%
	Simazine: H	2003-2011	decreasing	0.039	-12%
	Dicamba-I: H	2004-2011	increasing	< 0.001	+20%
Marion Drain	Atrazine: H	2003-2011	decreasing	0.018	-6%
	Chlorpyrifos: I	2003-2011	decreasing	0.036	-7%
	Clopyralid: H	2007-2011	decreasing	0.001	-17%
	Simazine: H	2003-2011	decreasing	0.050	-7%
	Dicamba-I: H	2004-2011	increasing	< 0.001	+17%
	Ethoprop: I	2003-2011	increasing	0.022	+24%
	Pendimethalin: H	2003-2011	increasing	0.019	+5%
	Terbacil: H	2003-2011	increasing	0.012	+6%
	Trifluralin: H	2003-2011	increasing	0.009	+6%
Sulphur Creek Wasteway	Azinphos-methyl: I	2003-2011	decreasing	< 0.001	-17%
	Diuron: H	2003-2011	decreasing	0.024	-10%
	Norflurazon: H	2003-2011	decreasing	0.003	-14%
	DCPA: H	2003-2011	increasing	< 0.001	+11%
	Dicamba-I: H	2004-2011	increasing	< 0.001	+21%
	MCPA: H	2004-2011	increasing	0.010	+11%
	Pendimethalin: H	2003-2011	increasing	< 0.001	+19%

H: Herbicide; I: Insecticide

All four of the Yakima sites showed an increasing trend in concentrations for the herbicide dicamba I for 2004-2011, with Sulphur Creek Wasteway having the greatest percent increase in concentrations (Figure 37).

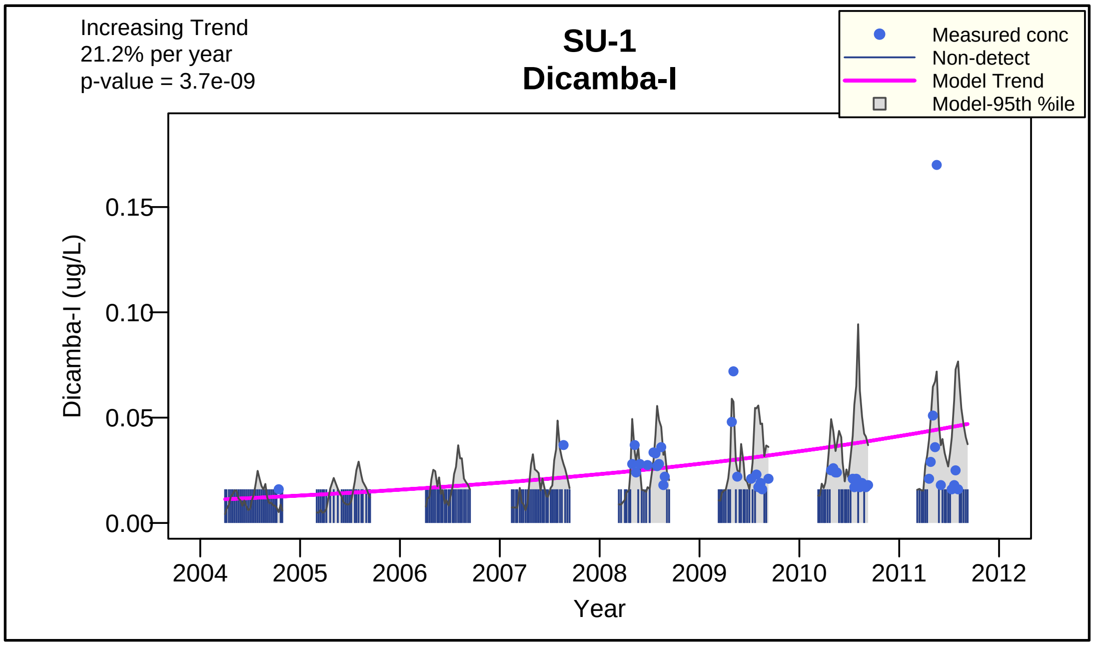


Figure 37. Increasing trends in dicamba I concentrations in Sulphur Creek Wasteway, 2004-2011.

Both the downstream Spring Creek site and the Sulphur Creek Wasteway site showed decreasing concentration trends for the insecticide azinphos-methyl. Figure 38 presents 2003-2011 azinphos-methyl trend data for Sulphur Creek Wasteway.

In addition to decreases in concentration, all Yakima sites showed a decreasing trend in azinphos-methyl detections during 2003-2011 (Figure 39).

Due to concerns about risks to agricultural workers, water quality, and aquatic ecosystems, phase out of azinphos-methyl began in September 2008 (EPA, 2006b). Distribution and sale of azinphos-methyl was prohibited after September 20, 2012, and after September 2013 use of existing stocks of azinphos-methyl will be prohibited.

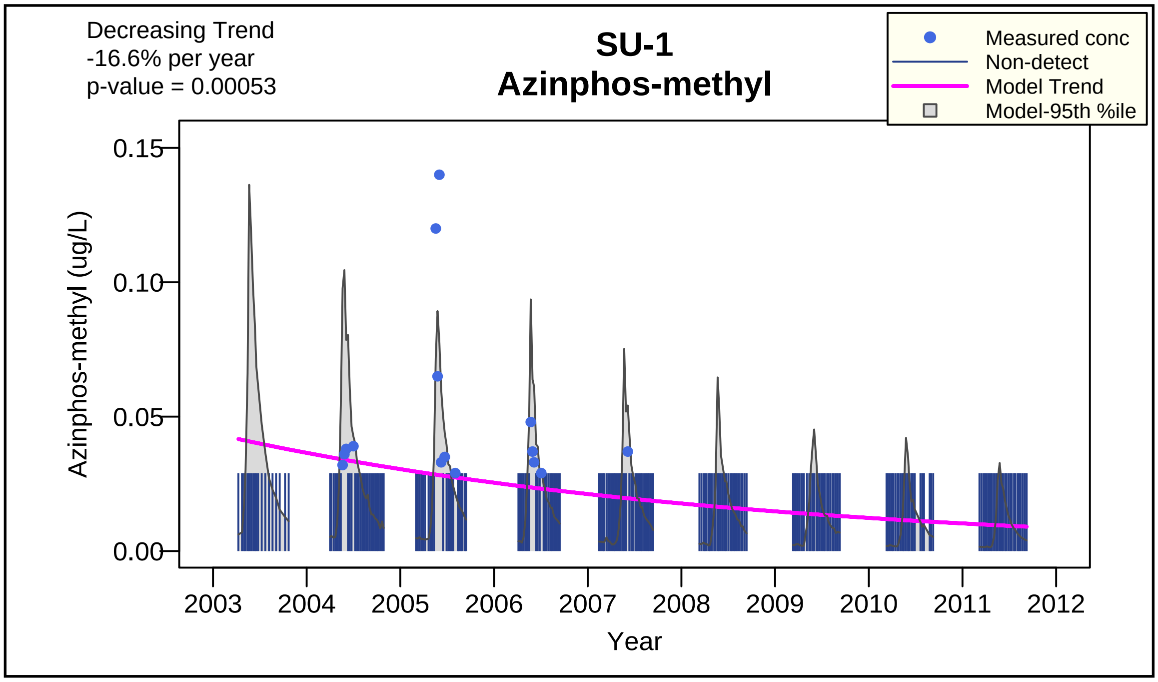


Figure 38. Decreasing trends in azinphos-methyl concentrations in Sulphur Creek Wasteway, 2003-2011.

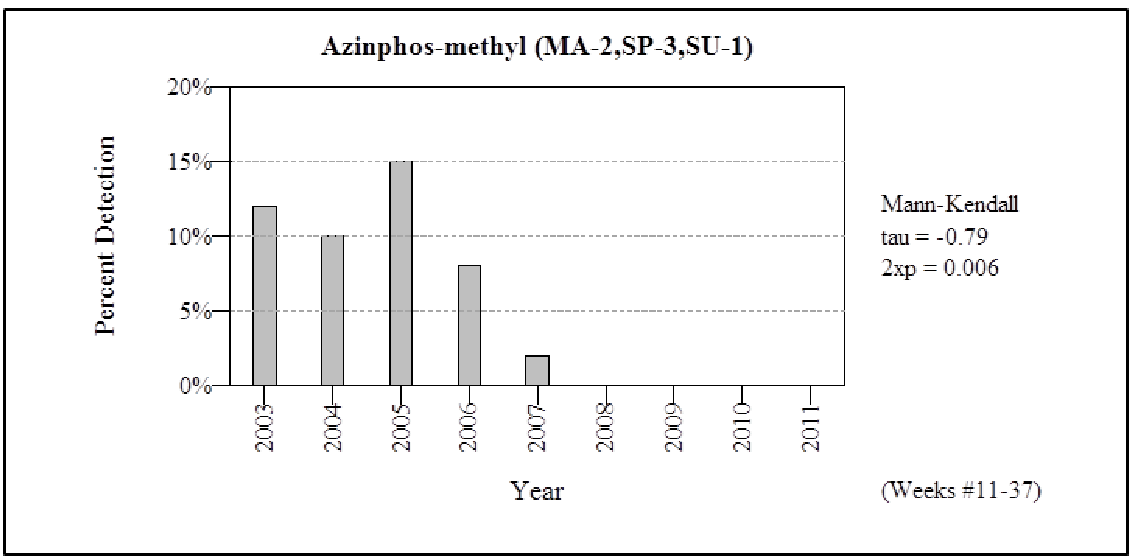


Figure 39. Significant decreasing trend in percentage of azinphos-methyl detections for the Yakima basin sites (Marion Drain, Spring Creek, and Sulphur Creek Wasteway), 2003-2011.

In Marion Drain, there was a significant decrease in concentrations of the insecticide chlorpyrifos but a significant increasing trend in concentrations of the insecticide ethoprop, both organophosphate insecticides (Figures 40 and 41). In addition, chlorpyrifos detections appear to be decreasing over time, though the change is not statistically significant (p=0.07) (Figure 42).

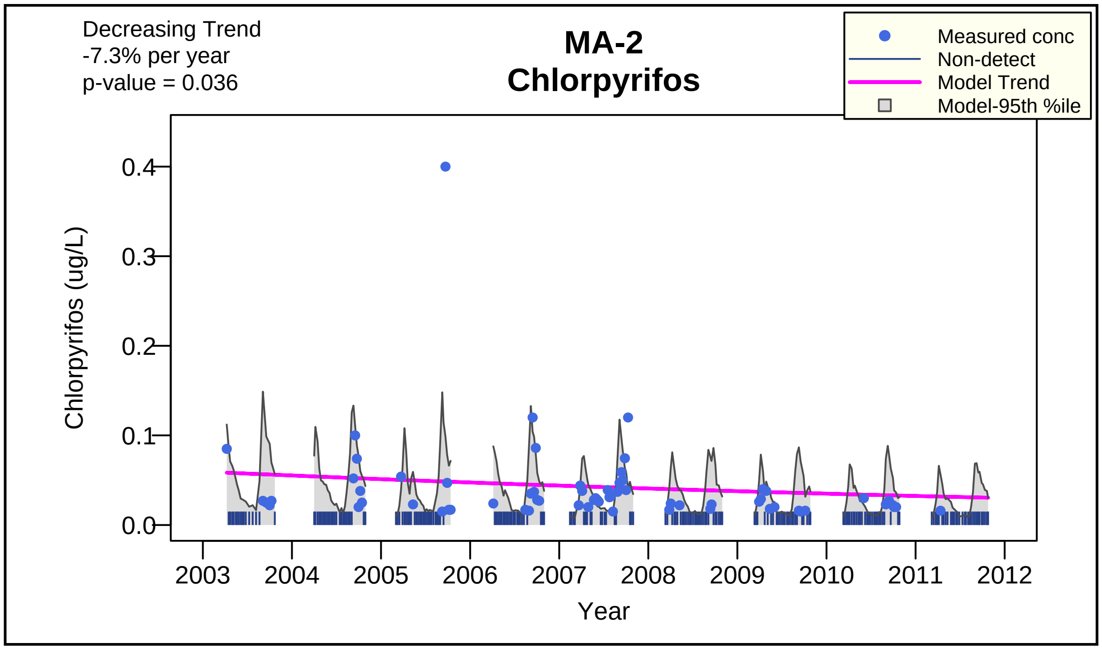


Figure 40. Decreasing trends in chlorpyrifos concentrations in Marion Drain, 2003-2011.

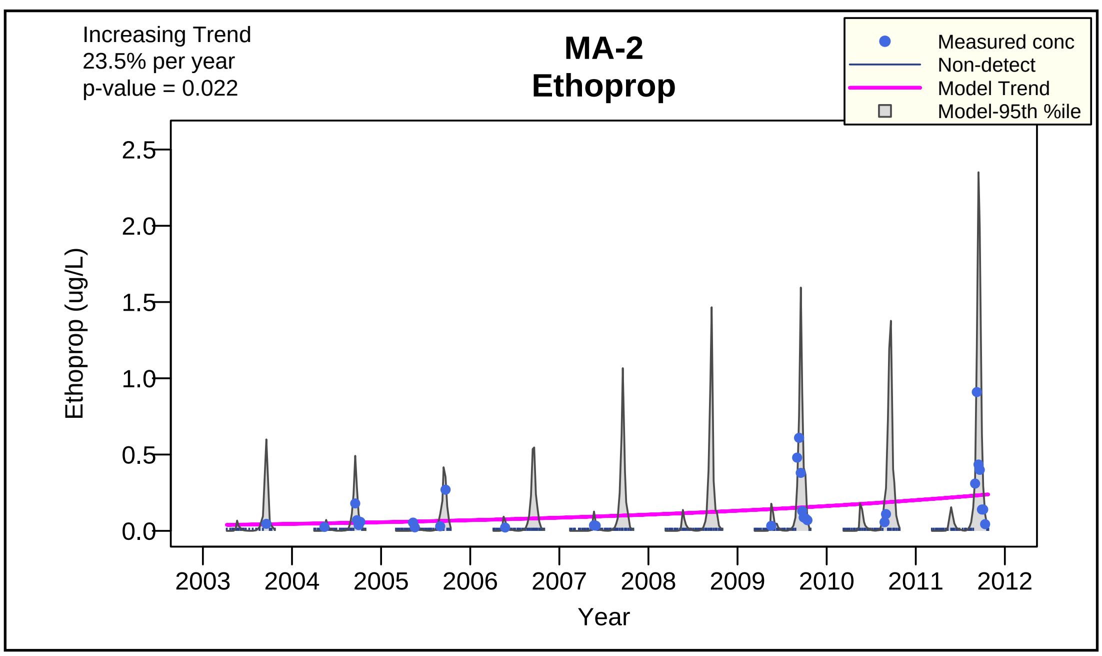


Figure 41. Increasing trends in ethoprop concentrations in Marion Drain, 2003-2011.

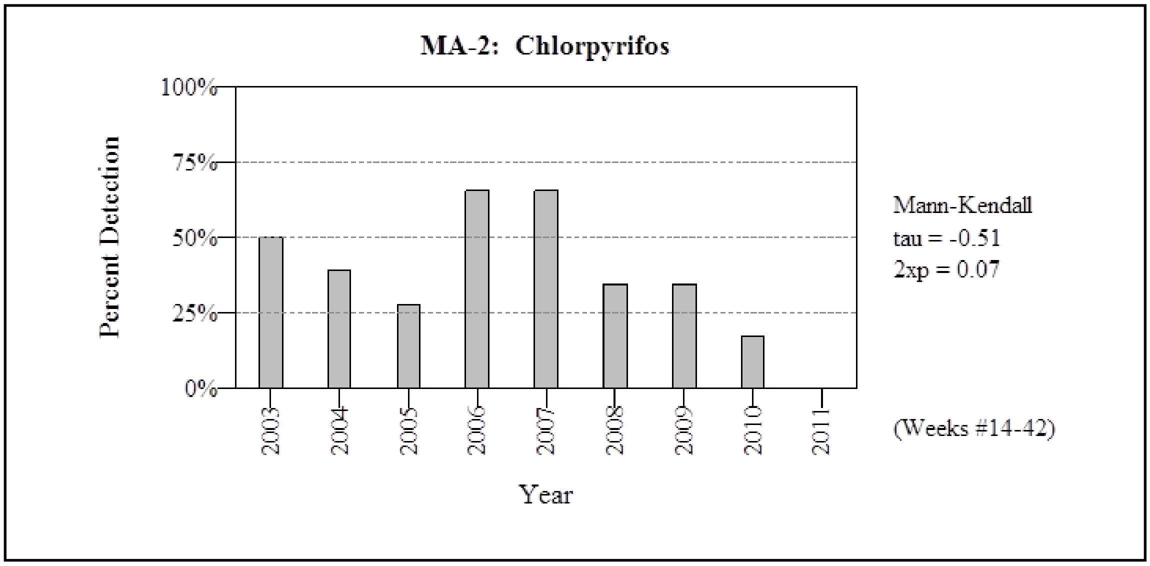


Figure 42. Percent detections of chlorpyrifos in Marion Drain; decreasing detections not statistically significant (p=0.07), 2003-2011.

Conventional Parameters

Conventional water quality parameters were measured at all of the Yakima basin sites. Table 32 summarizes results for TSS, flow, pH, conductivity, and DO for all of the sites. All summaries are based on point (discrete) measurements obtained during the time of sampling. All Yakima sites must meet freshwater water quality standards.

Table 32. Arithmetic mean and range for conventional parameters (grabs) for Yakima basin sites, 2009-2011.

Summary Statistics by Site	Total Suspended Solids (mg/L)			Flow (cubic feet per second)			pH (standard units)			Conductivity (umhos/cm)			Dissolved Oxygen (mg/L)		
	2009	2010	2011	2009	2010	2011	2009	2010	2011	2009	2010	2011	2009	2010	2011
Spring Creek (upstream)															
Number	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
Mean[1]	22	30	34	6.4	5.9	8.0	8.0	8.1	8.0	366	462	411	9.4	9.6	9.8
Minimum	4	7	3	1.9	2.3	2.7	7.5	7.8	7.7	266	334	283	7.9	7.8	8.5
Maximum	68	143	77	11.9	11.3	13.4	8.5	8.3	8.6	502	656	669	12.1	11.2	12.0
Spring Creek (downstream)															
Number	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27
Mean[1]	14	9	14	8.7	12	15.5	8.6	8.7	8.8	338	407	370	9.9	10.3	10.5
Minimum	1	2	1	1	1.9	2.2	7.9	8.4	8.1	180	190	180	8.1	8.7	8.5
Maximum	50	30	62	17	57.2	64.1	9.4	9.5	9.7	478	624	656	13.6	12.4	13.5
Marion Drain															
Number	34	34	34	32[2]	33[2]	29[2]	34	34	34	34	34	34	34	34	34
Mean[1]	13	13	19.9	116	158	111	8.1	8.1	7.9	226	262	263	12.5	12	12.3
Minimum	2	1	1	12.7	24.1	21.6	7.5	7.5	7.1	138	191	178	9.3	8.8	9.5
Maximum	40	48	193	265	324	302	9.3	8.9	9.0	341	368	377	17.6	16.6	16.0
Sulphur Creek Wasteway															
Number	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27
Mean[1]	40	44	34	260	233	452	8.4	8.4	8.3	264	311	324	10.3	10.6	10.6
Minimum	7	7	3	49	51.4	94	7.8	8.1	7.7	164	193	207	9.1	9.2	9.3
Maximum	98	251	130	641	493	1230	8.8	8.8	9.0	535	775	785	12.1	12.1	12.8

[1]Arithmetic mean.
[2]Some field measurements rejected; did not meet MQOs or meter malfunction.

Comparison to Water Quality Standards

Results for discrete pH and DO measurements, as well as continuous temperature results, were compared to water quality standards (Table 7).

pH

All of the sites except the upstream Spring Creek did not meet (exceeded) the pH water quality standard range of 6.5-8.5 s.u. for 2009-2011. The upstream Spring Creek site had one exceedance of the pH standard in 2011.

Dissolved Oxygen

With the exception of upstream Spring Creek, all Yakima basin sites met the DO water quality standard of 8.0 mg/L during 2009-2011. Upstream Spring Creek did not meet (fell below) the standard one time in 2009 and one time in 2010.

Temperature

In addition to discrete temperature measurements, continuous (30-minute interval) measurements were collected year-round from 2009-2011. Temperature profiles based on continuous temperature measurements are presented in Appendix K, Figures K-8 – K-11. At all of the Lower Yakima basin sites, the 7-DADMax temperature should not exceed 17.5°C. Temperature did not meet standards during the periods described in Table 33.

Table 33. Periods when water temperature did not meet standards for the Yakima basin sites, 2009-2011.

Site	2009	2010	2011
Spring Creek (upstream) >17.5°C	May 20-Sept 6 Sept 11-17	Apr 17-28 May 11-Sept 24 Sept 28-Oct 5	June 4 June 6-Sept 2 Sept 6-13
Spring Creek (downstream) >17.5°C	Apr 18-23 May 13-Sept 23	May 17-21 June 9-19 June 23-Aug 30 Sept 16-22	May 11-13 May 19-Sept 24
Marion Drain >17.5°C	May 25-Aug 13	May 28 June 22-Sept 1 Sept 17-21 Oct 2-3	June 18-Sept 26
Sulphur Creek Wasteway > 17.5°C	May 17-Sept 26	May 15-21 June 10-Sept 23 Oct 1-5	June 3-Sept 18 Sept 20-25

Total Suspended Solids

Statistical trends in TSS were examined for the Yakima sites using a Seasonal-Kendall trend test. TSS concentrations and loading were compared for March through September.

For Sulphur Creek Wasteway and Marion Drain, there were no significant trends in TSS concentrations or loading for the period tested. Both Spring Creek sites had significant trends in TSS, TSS loading, and flow (Table 34).

Table 34. Seasonal Kendall trend statistics for TSS, TSS loading, and flow for the Spring Creek sites, 2003-2011.

Site	TSS		TSS Loading		Flow	
	P value	% change	P value	% change	P value	% change
Upstream Spring Creek	<0.0001	+ 26.6%	<0.0001	+21.2%	= 0.02	+5.8%
Downstream Spring Creek	< 0.001	-17.7%	<0.0004	-35.7%	< 0.01	-16.4%

There was a significant increase in TSS concentrations, TSS loading, and flow at the upstream Spring Creek site during 2003-2011.

There was a significant decrease in TSS concentrations, TSS loading, and flow at the downstream Spring Creek site during 2003-2011.

The Sunnyside Canal siphons underneath Spring Creek between the upstream and downstream Spring Creek sites, but occasionally irrigation water is spilled into Spring Creek. During 2003-2005, spill from the Sunnyside irrigation canal discharged to Spring Creek when flows in the canal were too high. In 2006, excess water from the canal was stored in a re-regulation reservoir, leaving less water to spill into Spring Creek (Figure 43; Brouillard, 2012). Generally, with no spillage from Sunnyside Canal, there is about 60% more flow at the downstream site than the upstream site.

TSS loading at both sites is compared in Figure 44. Boxplots show that TSS loading is decreasing at the downstream site from 2003 through 2011, and TSS loading increased after 2005 at the upstream site. Figure 44 also shows that during 2006-2008, TSS loading was similar at the upstream and downstream sites.

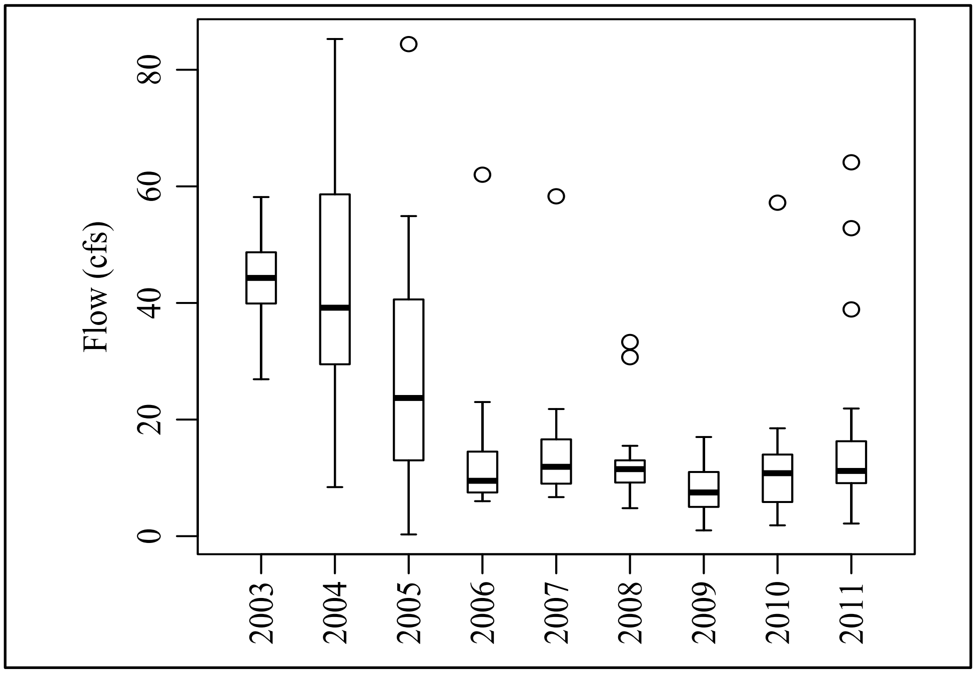


Figure 43. Boxplot of flow at the downstream Spring Creek site, 2003-2011.

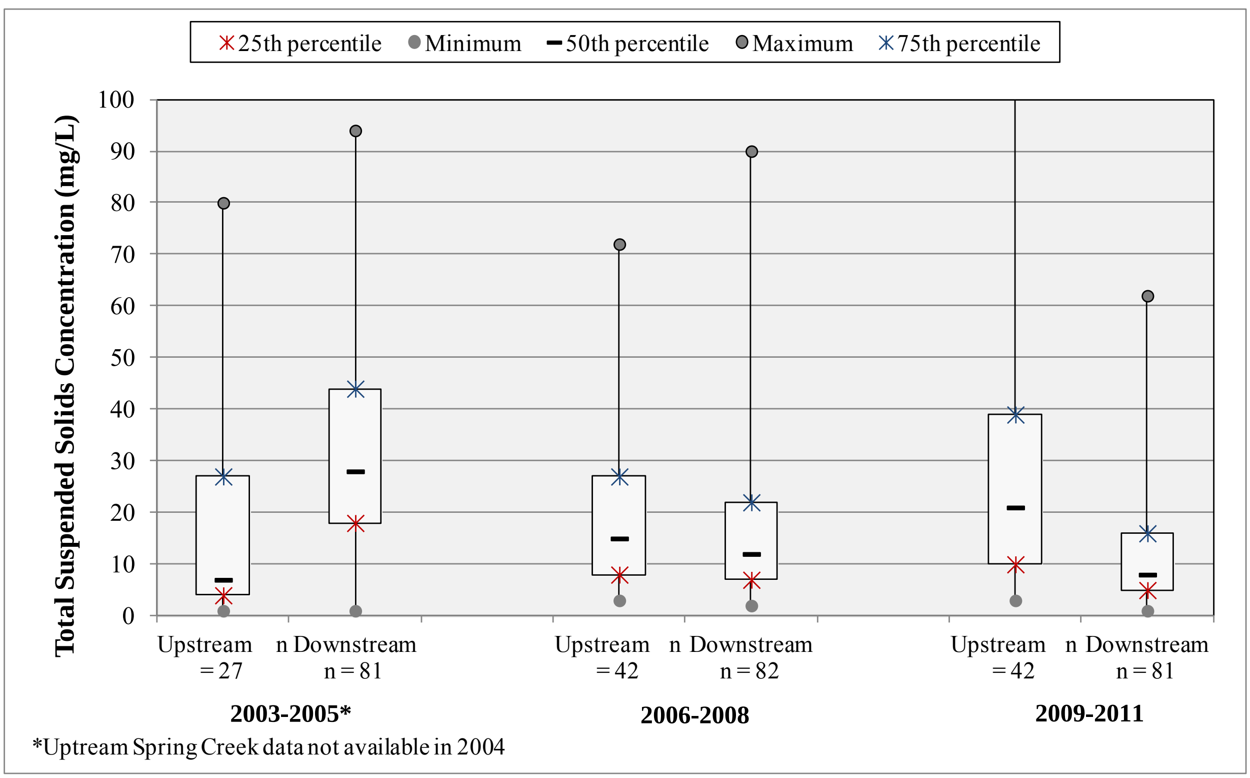


Figure 44. Boxplots comparing TSS loading (pounds per day) at the upstream and downstream Spring Creek sites, 2003-2011.

Wenatchee-Entiat Basin WRIAs 45 and 46

Monitoring in the Wenatchee and Entiat basin during 2009-2011 included five sites (Figure 6). All five sites have been sampled since 2007. During 2009-2011, 81 sample events were conducted at each site from March through September.

Pesticide Occurrence

Pesticide Detections

A summary of pesticide detections for the Wenatchee-Entiat sites is presented in Appendix H, Tables H-10 - H-14.

Peshastin Creek

During 2009-2011, very few pesticides were detected: 11 detections of four herbicides, three insecticides, one fungicide, and three pesticide degradates. The most frequently detected insecticide was endosulfan with three detections, and the most frequently detected herbicide was simazine with two detections.

Mission Creek

During 2009-2011, Mission Creek had the fewest pesticides detected of the Wenatchee-Entiat sites. There were nine detections of five insecticides, one pesticide degradate, and three detections of a pesticide synergist. The most frequently detected insecticide was carbaryl with two detections. The most frequently detected compound was piperonyl butoxide; a pesticide synergist, with three detections.

Wenatchee River

During 2009-2011, very few pesticides were detected: 11 detections of five insecticides, five herbicides, and one wood preservative. The most frequently detected insecticide was chlorpyrifos with three detections.

Brender Creek

Table 35 presents the most commonly detected pesticides at the Brender Creek site for 2007-2008 and 2009-2011. During both periods, the most commonly detected compounds were pesticide degradates (> 60% legacy DDT degradates) followed by insecticides. During 2009-2011, the most commonly detected compounds were organochlorine insecticide degradates 4,4'-DDE 4,4'-DDD and endosulfan sulfate. The most commonly detected insecticides were the legacy pesticide 4,4'-DDT, the organochlorine insecticides endosulfan I and II, and the organophosphate insecticide chlorpyrifos. Commonly seen herbicides included norflurazon and dichlobenil.

Table 35. Most frequently detected compounds for Brender Creek, 2007-2008 and 2009-2011.

Pesticide	Use	2007-2008 n=58		2009-2011 n=81	
		Number of Detections	% of Sample Events Detected	Number of Detections	% of Sample Events Detected
4,4'-DDT	Insecticide	53	61%	56	69%
Endosulfan I	Insecticide	12	14%	7	9%
Endosulfan II	Insecticide	15	17%	9	11%
Chlorpyrifos	Insecticide	14	16%	15	19%
4,4'-DDE	Degradate	51	59%	59	73%
4,4'-DDD	Degradate	36	41%	33	41%
Endosulfan Sulfate	Degradate	41	47%	57	70%
Norflurazon	Herbicide	20	23%	22	27%
Dichlobenil	Herbicide	1	1%	15	19%

Entiat River

During 2009-2011, very few compounds were detected: 15 detections of eight insecticides, three herbicides, and four detections of a pesticide synergist. The most frequently detected insecticide was carbaryl with four detections. 2,4-D was the only herbicide detected with three detections.

Co-occurrence of Pesticides

Peshastin Creek

Pesticide co-occurrence was rare at the Peshastin Creek site. There were two sample events (one in 2009 and one in 2010) where two pesticides were detected during a sample event.

Mission Creek

Pesticide co-occurrence rarely occurred at the Mission Creek site. There were two sample events (one in 2009 and one in 2011) where two pesticides were detected during a sample event.

Wenatchee River

During 2009-2011, there was one sample event in 2010 when three pesticides co-occurred.

Brender Creek

There was frequent co-occurrence of pesticides at the Brender Creek site. During 2009-2011, there were two or more pesticides detected during 98% of the sample events. The greatest period of co-occurrence varied from mid-April through May (Figure 45). The maximum number of pesticides detected during a sample event for each year was:

- April and May 2009: 8 pesticides
- May and September 2010: 9 pesticides
- 2011: 7 pesticides

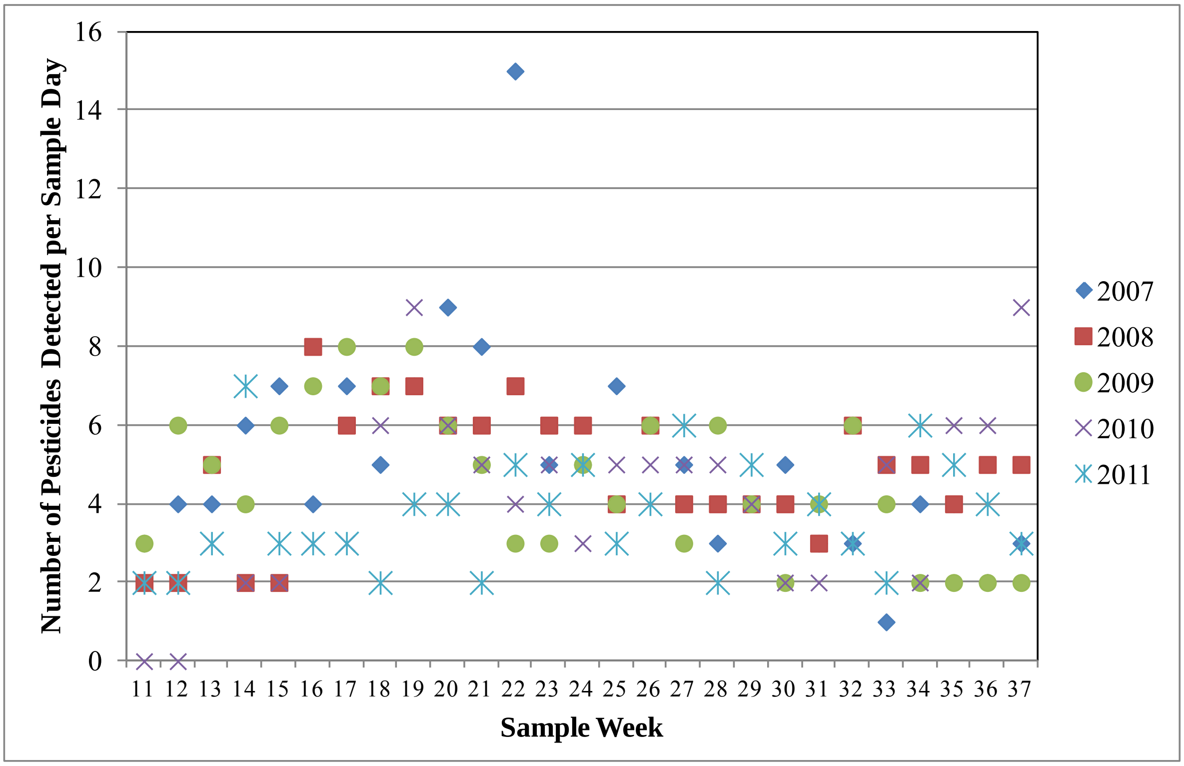


Figure 45. Pesticide co-occurrence at the Brender Creek site, 2007-2011.

Entiat River

Pesticide co-occurrence rarely occurred at the Entiat River site. During 2009-2011, there was one 2009 sample event where two pesticides and a pesticide synergist compound co-occurred.

Pesticide Distribution

Peshastin Creek

Figure 46 presents the distribution of detections by pesticide type for both periods tested, 2007-2008 and 2009-2011. During 2007-08, more insecticides were detected; during 2009-11, herbicides were detected slightly more frequently than insecticides.

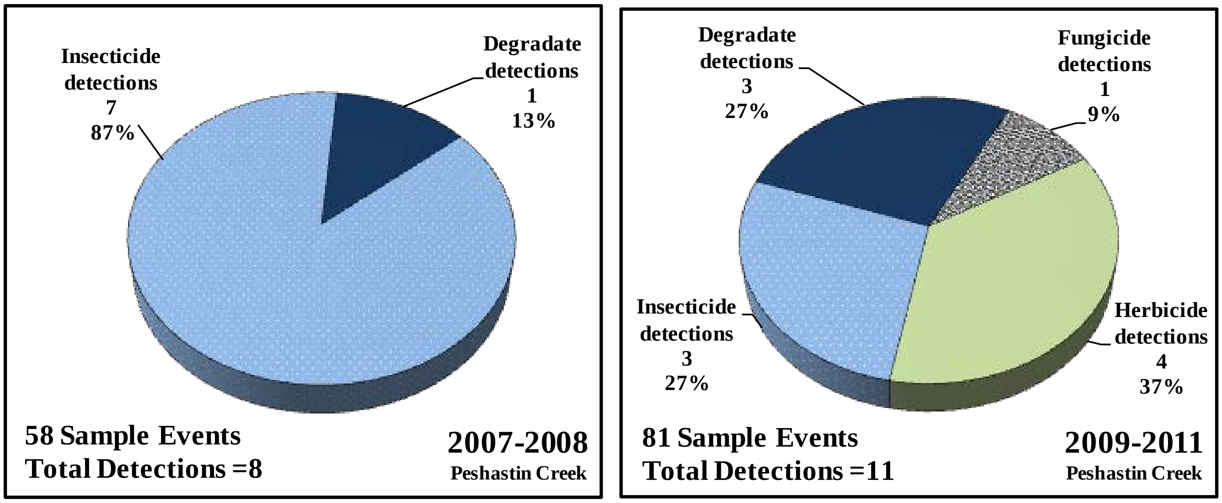


Figure 46. Pesticide distribution Peshastin Creek, 2007-2008 and 2009-2011.

Mission Creek

Figure 47 presents the distribution of detections by pesticide type for both periods tested, 2007-2008 and 2009-2011. During both periods, insecticides were the most frequently detected pesticide. Mission Creek had the least number of pesticide detections of all the Wenatchee-Entiat basin sites during 2009-2011.

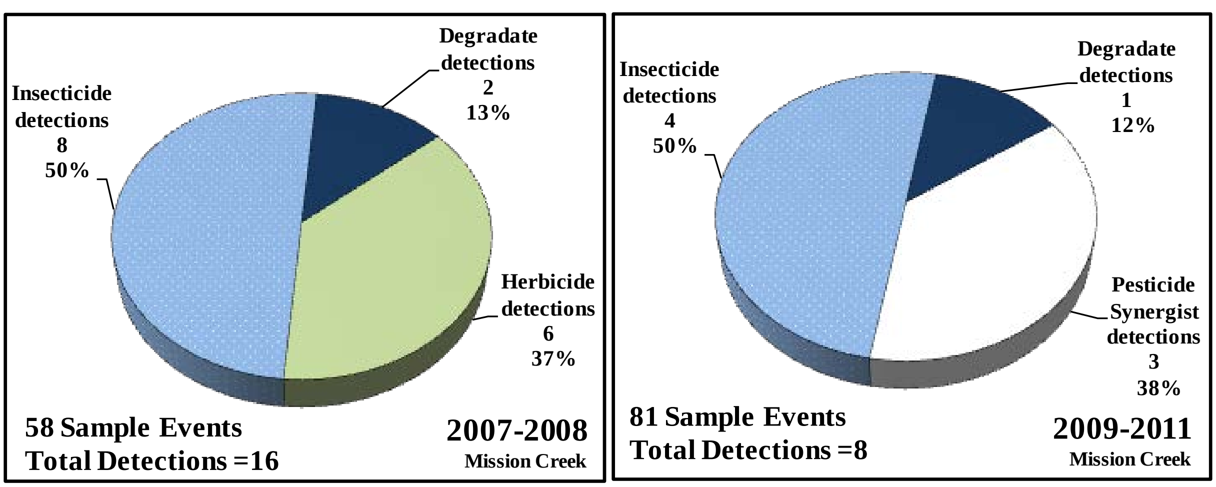


Figure 47. Pesticide distribution for Mission Creek, 2007-2008 and 2009-2011.

Wenatchee River

Figure 48 presents the distribution of detections by pesticide type for both periods tested, 2007-2008 and 2009-2011. During 2007-08, only insecticides were detected; during 2009-11, there were five herbicide and insecticide detections and a wood preservative detection.

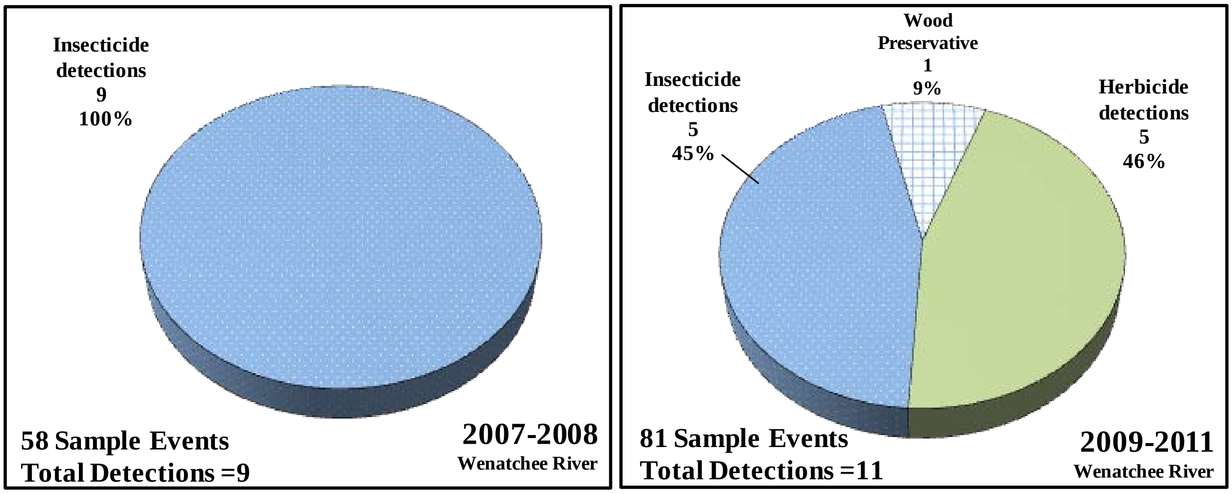


Figure 48. Pesticide distribution for the Wenatchee River, 2007-2008 and 2009-2011.

Brender Creek

Unlike the majority of the Wenatchee-Entiat sample sites, pesticides were consistently detected at the Brender Creek site. Pesticide degradates were the most frequently detected type of pesticide, followed by insecticides. Figure 49 presents the distribution of detections by pesticide type for 2007-2008 and 2009-2011.

The majority of pesticide degradates detected were degradates of the legacy pesticide DDT. During 2007-2008, 68% of the pesticide degradate detections were DDT degradates; in 2009-2011, 62% were DDT degradates.

Endosulfan sulfate, a degradate of the organochlorine insecticide endosulfan, was frequently detected during both periods. During 2007-2008, endosulfan sulfate made up 31% of the pesticide degradate detections. During 2009-2011, endosulfan sulfate made up 37% of the pesticide degradate detections.

Insecticides were detected most frequently after pesticide degradates. The legacy pesticide DDT made up a large percentage of the insecticide detections during both periods, 53% during 2007-2008 and 51% during 2009-2011.

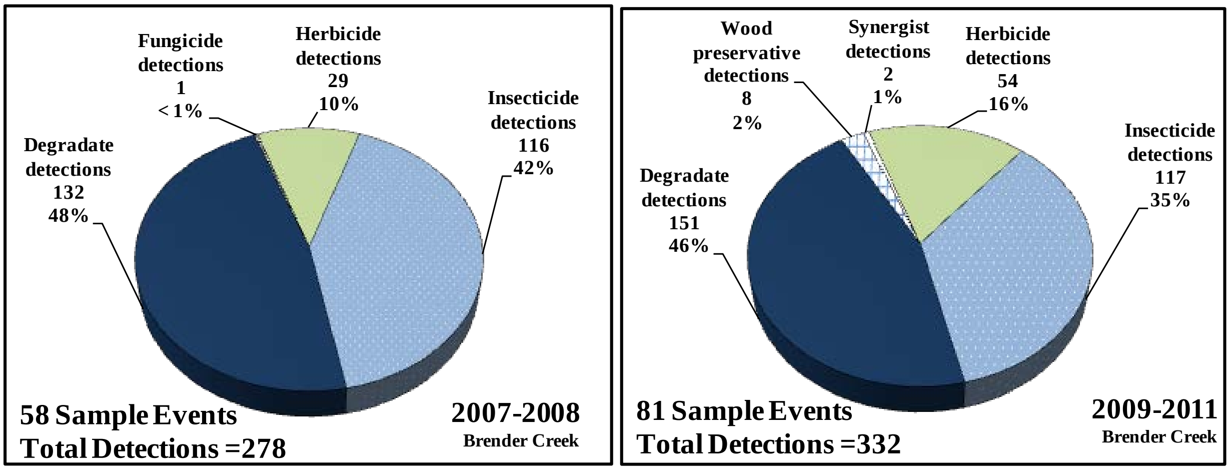


Figure 49. Pesticide distribution for Brender Creek, 2007-2008 and 2009-2011.

Entiat River

Very few pesticides were detected in the Entiat River. Figure 50 presents the distribution of detections by pesticide type. During both periods tested, 2007-2008 and 2009-2011, insecticides were the most commonly detected pesticide.

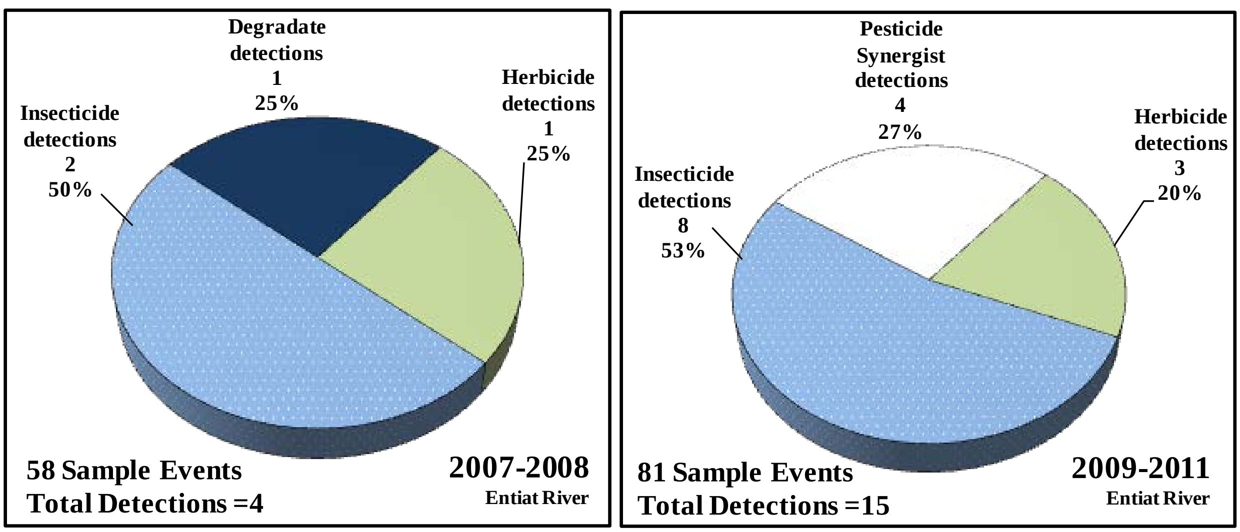


Figure 50. Pesticide distribution for the Entiat River site, 2007-2008 and 2009-2011.

Factors Affecting Pesticide Detections

Environmental and Water Quality Factors

Appendix J, Table J-9, presents the correlation coefficients for the Kendall's tau test for the pesticides where a statistically significant relationship was seen. Brender Creek was the only site with enough pesticide detections to perform the test.

For Brender Creek, there was a positive relationship with flow and total DDT, 4,4'-DDE, 4,4'-DDT, and endosulfan sulfate. There was also a positive relationship between TSS and total DDT, 4,4'-DDE, 4,4'-DDT, and endosulfan sulfate. There was a strong positive relationship between flow and TSS.

Temporal Factors

Pesticide detections in the Wenatchee-Entiat basins followed a slightly different pattern than what was seen at the other project areas (pesticide detections increasing from March through May, then decreasing after May). In Brender Creek, the greatest number of pesticide detections was seen in May and June (Figure 51). Insecticide detections peaked in May, while pesticide degradate and herbicide detections peaked in June.

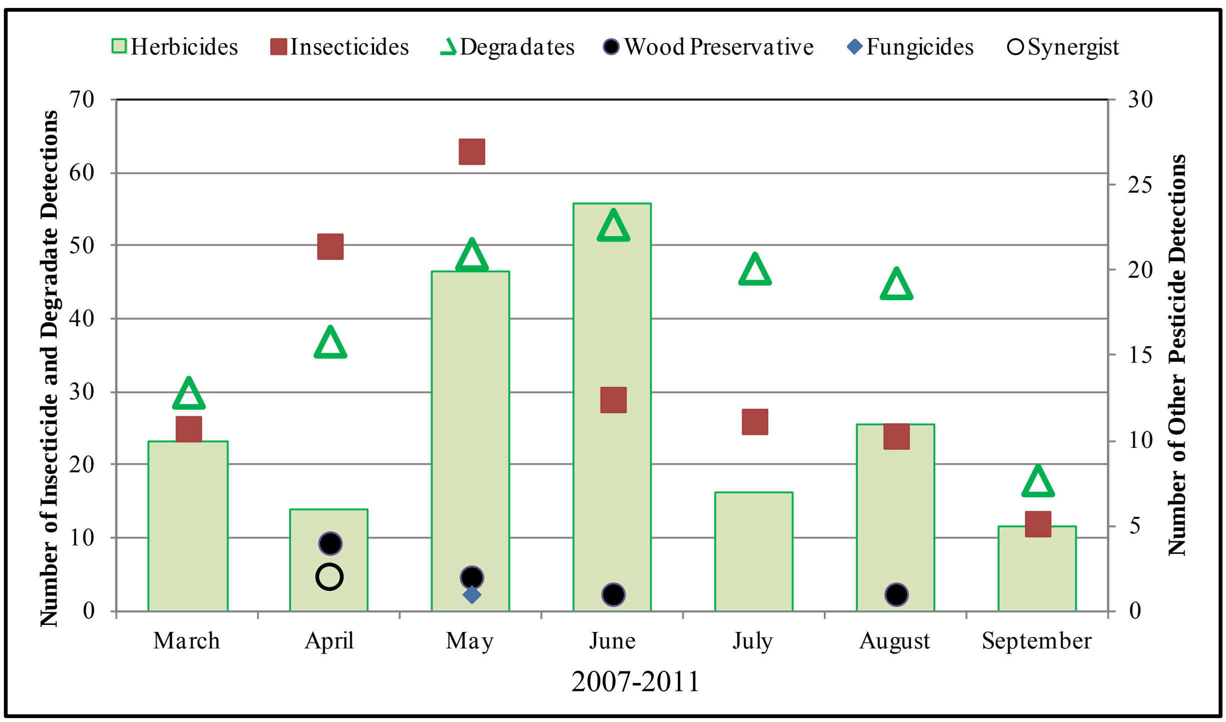


Figure 51. Number of detections by pesticide type for Brender Creek, 2007-2011.

Figure 52 presents the cumulative totals by month and pesticide type for 2007-2011 for the Wenatchee and Entiat Rivers, and Mission and Peshastin Creeks. Insecticides were most frequently seen in April, herbicides in August and September, and the pesticide synergist, piperonyl butoxide, was detected in March and April.

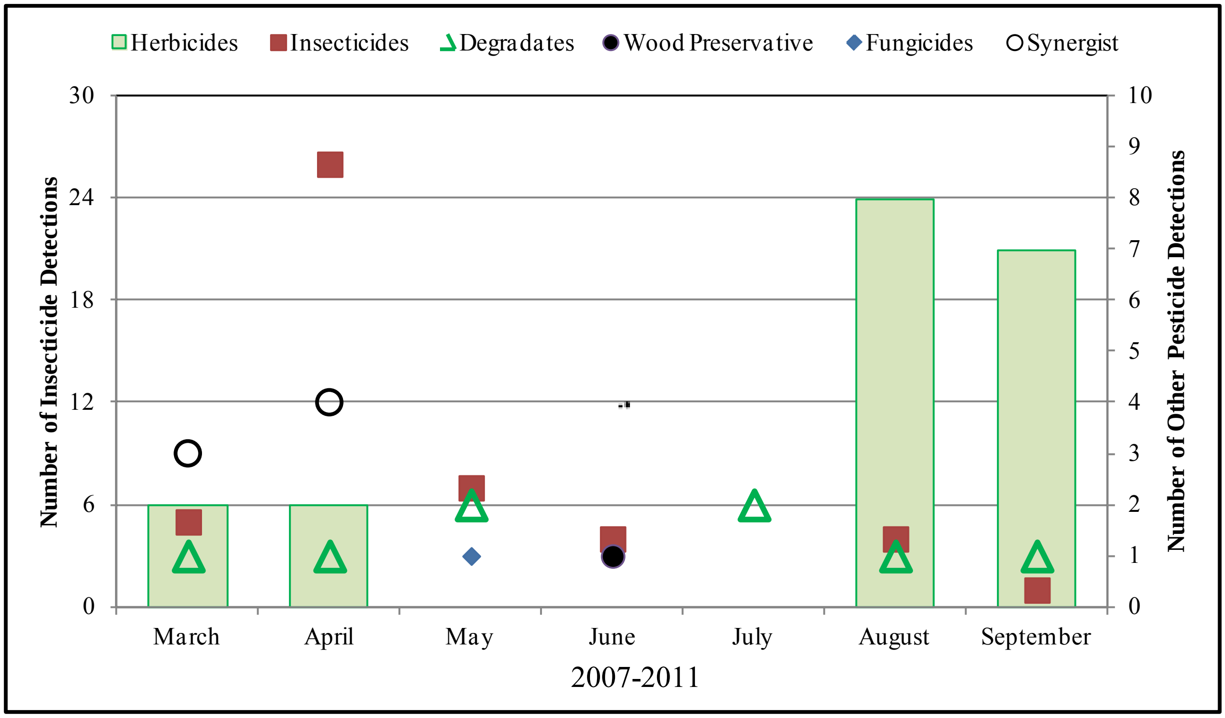


Figure 52. Number of pesticide detections by pesticide type and month for the Wenatchee and Entiat Rivers and Mission and Peshastin Creeks, 2007-2011.

Comparison to Water Quality Standards and Other Assessment Criteria

Comparison to Numeric Criteria

The 2009-2011 pesticide data were compared to water quality standards and assessment criteria. Detailed summaries of the monitoring results can be found in pesticide calendars presented in Appendix I. Pesticide calendars for the Wenatchee-Entiat sites are presented in Appendix I, Tables I-35 – I-49.

In Peshastin Creek, two endosulfan detections did not meet (exceeded) the ESLOC for fish, once in April 2009 and again in March 2010.

In Mission Creek, a single April 2011 detection of chlorpyrifos did not meet the ESLOC for fish, EPA's acute and chronic assessment criteria, the acute and chronic NRWQC, and acute and chronic water quality standards.

At the Wenatchee River site, there was one detection of endosulfan in April 2009 that did not meet the ESLOC for fish.

As in 2007-2008, DDT and DDT degradates were found consistently throughout 2009-2011 in Brender Creek. DDT and DDT degradates were detected in 67 of 81 sample events. All total DDT concentrations did not meet the chronic water quality standard.

Brender Creek also had the following pesticide concentrations not meeting an assessment criteria or water quality standard during 2009-2011:

- In April and May 2009, there were four sample events where total endosulfan did not meet the ESLOC for fish. Detections from three of these four events also exceeded EPA's chronic NRWQC and the chronic water quality standard. In March 2010, there was one total endosulfan detection that did not meet the ESLOC for fish, which also did not meet the chronic NRWQC and the chronic water quality standard.
- In April and May 2009, there were two detections of endosulfan sulfate (degradate of endosulfan) that did not meet the ESLOC for fish. One detection in 2010 and one in 2011 did not meet the ESLOC for fish as well.
- During two consecutive weeks in April 2009, chlorpyrifos did not meet the chronic NRWQC, the chronic invertebrate assessment criteria, and the chronic water quality standard. In April 2010, a chlorpyrifos detection did not meet the acute and chronic NRWQC, the acute and chronic invertebrate assessment criteria, the chronic fisheries assessment criteria, and the acute and chronic water quality standard.
- In September 2010, a single detection of diazinon did not meet the chronic and acute NRWQC and the chronic invertebrate assessment criteria.

At the Entiat River site, there was one detection of a DDT degradate in September 2010 that did not meet the chronic NRWQC and the chronic water quality standard. The chronic water quality standard is based on a 24-hour average concentration.

Toxic Units

Toxic units (TUs) were used to predict toxicity of pesticide mixtures detected at the Wenatchee-Entiat sites. A TU value ≥ 1 means a lethal or sublethal (for chronic criteria) effect may occur with an increasing likelihood, depending on the degree to which TUs exceed 1.0. Lethality measures used include acute and chronic fish assessment endpoints and chronic invertebrate assessment endpoints described in Appendix G.

During 2009-2011, all TU values for Peshastin Creek and the Wenatchee and Entiat Rivers were < 1.0. For Mission Creek, one sample event had a TU value ≥ 1 for the acute (TU value=3.2) and chronic (TU value=8.0) invertebrate assessment endpoints. High TU values on that day were due to a single chlorpyrifos detection, not co-occurrence of multiple pesticides.

Brender Creek had numerous occurrences where the TU value was ≥ 1. A total of 64% of the time, a higher TU value was due to the higher concentration of a single pesticide rather than a mixture of pesticides. During 2009-2011, for 66 out of 81 sample events the TU value was ≥ 1 for the chronic invertebrate assessment endpoint. Of the 66, 41 were primarily due to chronic low level detections of total DDT. Table 36 describes the incidences where TU values were ≥ 1, the assessment endpoint, and the contributing pesticides.

Table 36. Brender Creek dates, assessment endpoints (TU), and contributing pesticides where TU values were ≥ 1, 2009-2011.

Date	Assessment Endpoint			Contributing Pesticides
	Chronic Invertebrate	Acute Invertebrate	Chronic Fish	
3/9/2009	3.4	---	---	Total DDT
3/18/2009	4.3	---	---	Total DDT
3/24/2009	5.2	---	---	Total DDT
3/31/2009	5.4	---	---	Total DDT
4/8/2009	2.6	---	1.8	Total DDT, total endosulfan, chlorpyrifos
4/13/2009	4.2	---	---	Total DDT, total endosulfan, chlorpyrifos
4/21/2009	6.1	---	---	Total DDT, total endosulfan, chlorpyrifos
4/29/2009	6.2	---	2.0	Total DDT, total endosulfan, chlorpyrifos
5/5/2009	4.3	---	1.5	Total DDT, total endosulfan, chlorpyrifos
5/11/2009	3.0	---	---	Total DDT, total endosulfan, chlorpyrifos
5/19/2009	2.4	---	---	Total DDT, total endosulfan
6/8/2009	2.3	---	---	Total DDT, methiocarb
6/16/2009	1.7	---	---	Total DDT
6/24/2009	5.9	---	---	Total DDT
6/29/2009	3.1	---	---	Total DDT
7/7/2009	7.2	---	1.0	Total DDT
7/15/2009	4.9	---	---	Total DDT
7/20/2009	1.0	---	---	Total DDT
7/29/2009	3.5	---	---	Total DDT
8/5/2009	5.7	---	---	Total DDT
8/10/2009	5.3	---	---	Total DDT
8/18/2009	1.3	---	---	Total DDT, 3-hydroxycarbofuran
8/31/2009	2.3	---	---	Total DDT
9/8/2009	3.0	---	---	Total DDT
4/12/2010	3.0	1.2	---	Chlorpyrifos
4/27/2010	3.5	---	---	Total DDT, chlorpyrifos, diazinon, total endosulfan
5/5/2010	5.5	---	1.2	Total DDT, total endosulfan, chlorpyrifos
5/10/2010	3.1	---	---	Total DDT, carbaryl
5/18/2010	1.4	---	---	Total DDT
5/24/2010	1.1	---	---	Total DDT, carbaryl
6/8/2010	1.3	---	---	Total DDT
6/14/2010	7.1	---	1.0	Total DDT
6/23/2010	6.1	---	---	Total DDT
6/29/2010	3.4	---	---	Total DDT
7/7/2010	3.3	---	---	Total DDT
7/13/2010	4.1	---	---	Total DDT
7/19/2010	3.0	---	---	Total DDT
7/28/2010	1.3	---	---	Total DDT
8/2/2010	2.4	---	---	Total DDT
8/11/2010	3.2	---	---	Total DDT
8/24/2010	3.7	---	---	Total DDT, diazinon
9/1/2010	4.5	---	---	Total DDT
9/8/2010	8.7	---	1.4	Total DDT, diazinon
3/22/2011	2.6	---	---	Total DDT, carbaryl
3/30/2011	3.1	---	---	Total DDT, carbaryl, pendimethalin
4/4/2011	2.7	---	---	Total DDT, piperonyl butoxide
4/13/2011	2.2	---	---	Total DDT, chlorpyrifos
4/18/2011	2.9	---	---	Total DDT, chlorpyrifos
5/4/2011	5.7	---	---	Total DDT, chlorpyrifos
5/10/2011	3.5	---	---	Total DDT, chlorpyrifos
5/18/2011	1.8	---	---	Total DDT
5/23/2011	4.6	---	---	Total DDT
5/31/2011	4.4	---	---	Total DDT, carbaryl

Date	Assessment Endpoint			Contributing Pesticides
	Chronic Invertebrate	Acute Invertebrate	Chronic Fish	
6/8/2011	4.3	---	---	Total DDT, carbaryl
6/21/2011	3.2	---	---	Total DDT
6/27/2011	4.9	---	---	Total DDT
7/6/2011	1.8	---	---	Total DDT
7/12/2011	6.3	---	---	Total DDT
7/18/2011	5.9	---	---	Total DDT
7/26/2011	8.5	---	1.2	Total DDT
8/1/2011	4.4	---	---	Total DDT
8/10/2011	2.3	---	---	Total DDT
8/16/2011	6.2	---	---	Total DDT
8/22/2011	5.3	---	---	Total DDT
8/29/2011	4.9	---	---	Total DDT
9/6/2011	5.1	---	---	Total DDT

Trend Analysis

The Sea Wave model (Vecchia et al., 2008) was used to predict trends in pesticide concentrations and peak concentrations. For 2007-2011, all pesticides with ≥ 10 detections that met model assumptions were analyzed using the model. Pesticide trend graphs of sites with significant trend (p≤0.05) are in Appendix F. Of the Wenatchee-Entiat sites, Brender Creek was the only site to have sufficient pesticide detections to run the model.

For Brender Creek the only pesticide with a significant trend in concentrations was total endosulfan. Total endosulfan concentrations are decreasing in Brender Creek (p<0.001) (Figure 53).

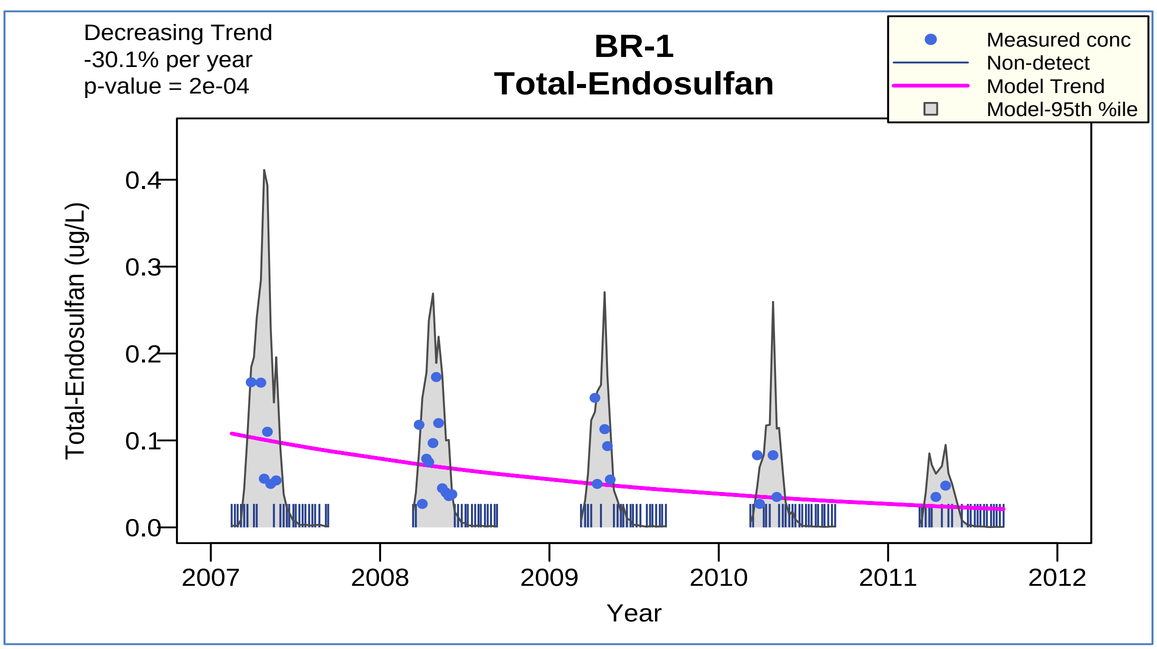


Figure 53. Decreasing trend in total endosulfan concentrations at the Brender Creek site, 2007-2011.

In July 2010, EPA signed an agreement with the registrants of endosulfan that resulted in voluntary cancellation and phase out of all existing endosulfan uses in the United States, with no use of endosulfan after July 31, 2016. Figure 54 presents the number of total endosulfan detections for 2007-2011 in the Wenatchee-Entiat project area. Although the decrease is not statistically significant, cumulative total endosulfan detections decreased after 2008 (Figure 54).

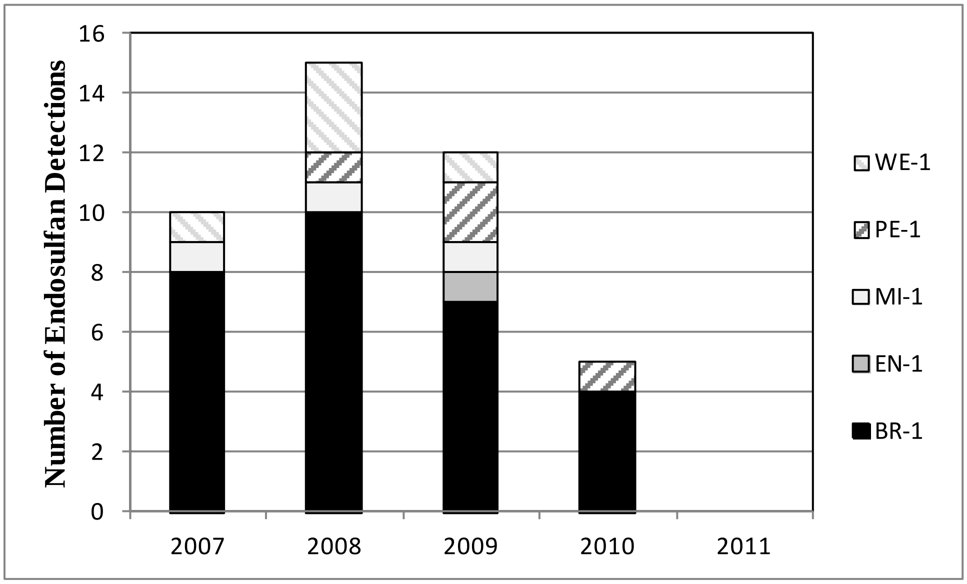


Figure 54. Cumulative total of total endosulfan (endosulfan I and II) detections for all Wenatchee-Entiat sites, 2007-2011.

Conventional Parameters

Conventional water quality parameters were measured at all Wenatchee-Entiat basin sites. Table 37 summarizes results for TSS, flow, pH, conductivity, and DO these sites. All summaries are based on point (discrete) measurements obtained during the time of sampling. All Wenatchee-Entiat sites must meet freshwater water quality standards.

Table 37. Arithmetic mean and range for conventional parameters (grabs) for Wenatchee-Entiat sites, 2009-2011.

Summary Statistics by Site	Total Suspended Solids (mg/)			Flow (cfs)			pH (standard units)			Conductivity (umhos/cm)			Dissolved Oxygen (mg/L)		
	2009	2010	2011	2009	2010	2011	2009	2010	2011	2009	2010	2011	2009	2010	2011
Peshastin Creek															
Number	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27
Mean[1]	9	9	12	214	266.0	342	8.1	8.0	7.9	108	127	132	11.1	11.5	11.3
Minimum	<1	<1	<1	13	18.3	18.2	7.5	7.6	7.4	56	80	78	8.2	9.3	9.1
Maximum	67	55	164	606	887	785	8.6	8.4	8.4	158	199	217	13.5	13.3	14.1
Mission Creek															
Number	27	27	27	27	27	24[2]	27	27	27	27	27	27	27	27	27
Mean[1]	20	202	47	29	24.2	33.8	8.3	8.3	8.1	194	214	222	11.2	11.5	11.4
Minimum	<1	2	<1	0.1	1.5	2.8	7.9	7.9	7.7	110	134	163	9.2	9.7	9.3
Maximum	85	4180	563	101	87.8	86.4	8.7	8.7	8.5	324	270	269	13.2	13.6	13.5
Brender Creek															
Number	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27
Mean[1]	37	52	53	2.2	3.1	3.8	8.2	8.1	7.9	236	256	253	10.5	10.7	10.8
Minimum	7	7	5	0.3	0.5	0.5	7.8	7.7	7.7	151	146	135	9.2	9.5	9.5
Maximum	116	249	109	6.8	9.7	8.5	8.5	8.4	8.3	354	416	412	12.2	12.0	12.4
Wenatchee River															
Number	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27
Mean[1]	8	10	11	3780	4490	5690	8.2	8.2	7.7	51	54	55	11.6	11.9	11.8
Minimum	<1	2	<1	493	766	1090	7.0	7.1	6.8	22	31	31	9.3	9.9	9.9
Maximum	46	70	60	13400	13000	14800	9.1	9.3	9.0	87	84	105	14.8	14.2	14.5
Entiat River															
Number	27	27	27	27	27	26[2]	27	27	27	27	27	27	27	27	27
Mean[1]	6	8	10	607	806	985	8.1	8.1	7.8	61	63	64	10.9	11.4	11.7
Minimum	1	2	1	96	157	191	7.0	7.2	7.0	23	31	31	9.1	9.7	9.9
Maximum	46	31	68	2330	2440	2660	9.0	9.0	9.0	99	111	119	13.8	12.7	13.8

[1]Arithmetic mean.
[2]Some field measurements rejected; did not meet MQOs or meter malfunction.

Comparison to Water Quality Standards

Results for discrete pH and DO measurements, and continuous temperature were compared to water quality standards (Table 7).

pH

All of the sites except Brender Creek did not meet the pH water quality standard range of 6.5 - 8.5 s.u. during 2009-2011. The Wenatchee and Entiat Rivers had multiple exceedances each year. Mission Creek had decreasing exceedances, with none in 2011. Peshastin Creek had two exceedances in 2009, with none in 2010 and 2011.

Dissolved Oxygen

All sites met the DO water quality standard minimum of 8.0 mg/L during all three years.

Temperature

In addition to discrete temperature measurements, continuous (30-minute interval) measurements were collected year-round from 2009-2011. Temperature profiles based on continuous temperature measurements are presented in Appendix K, Figures K-12 – K-16. The temperature standard for the Wenatchee-Entiat basin sites is that the 7-DADMax temperature should not exceed 17.5°C. There is a supplemental spawning and incubation criteria for the Wenatchee River that states the 7-DADMax temperature should not to exceed 13.0 °C from October 1 - May 15. Temperature did not meet standards during the periods described in Table 38.

Table 38. Periods when water temperature did not meet standards for the Wenatchee-Entiat basin sites, 2009-2011.

Site and Standard	2009	2010	2011
Peshastin Creek >17.5°C	7/03-9/04, 9/11-9/16	7/21-8/31	8/04-9/13
Mission Creek >17.5°C	none	7/28-8/12; 8/14-8/23	none
Brender Creek >17.5°C	7/24-8/04	7/29-8/2	none
Wenatchee River >17.5°C	7/09-8/20	7/24-8/08	8/16-9/15
Wenatchee River >13.0 °C	10/02	10/01-10/10	10/01-10/04
Entiat River >17.5°C	7/11-9/04, 9/10-9/26	7/30-8/30	none

Total Suspended Solids

Statistical trends in TSS were examined for the Wenatchee-Entiat sites using a Seasonal-Kendall trend test. TSS concentrations and loading were compared for March through September, 2007-2011.

For Peshastin Creek and the Entiat River, TSS concentrations and loading showed no significant trends over the period tested. For Mission and Brender Creeks and the Wenatchee River, there was no significant trend in TSS concentrations, but TSS loading showed a significant increasing trend during 2007-2011 ($p<0.05$, 2-tailed test). These sites also showed a significant trend toward increasing flows (for instantaneous flow measurements during sampling) during the same period. There was a strong positive correlation between flow and TSS in Mission and Brender Creeks and the Wenatchee River (Table 39). The increasing trend in TSS loading for these three sites is likely due in part to increasing flows measured during sample events.

Table 39. Kendall's tau for Wenatchee-Entiat sites showing a strong positive relationship between flow and TSS.

Site	tau statistic	2-tailed probability
Peshastin Creek	0.77	$p < 0.01$
Mission Creek	0.62	$p < 0.01$
Brender Creek	0.72	$p < 0.01$
Wenatchee River	0.63	$p < 0.01$
Entiat River	0.69	$p < 0.01$

This page is purposely left blank

Discussion

Pesticide Summary by Basin

Urban Basins

Both urban sites, Thornton and Longfellow Creeks, are in heavily urbanized areas. The distribution of pesticide detections for the urban sites, Thornton Creek 2003-2011 and Longfellow Creek 2009-2011, is as follows:

- 78% herbicides (666 detections)
- 10% insecticides (81 detections)
- 9% wood preservative, pentachlorophenol (75 detections)
- 3% pesticide degradates (28 detections)
- <1% fungicides (3 detections)

Figure 55 presents the most commonly detected pesticides for the Thornton Creek sites (2003-2008) and the Thornton and Longfellow Creek sites (2009-2011). The most commonly detected herbicides for the two time periods was similar. Imidacloprid was the most commonly detected insecticide in 2009-2011. In previous triennial periods, diazinon was the most commonly detected insecticide. This is due in part to adding imidacloprid as an analyte in 2008 and reduced imidacloprid detection limits in 2010. In addition, diazinon has not been allowed for homeowner use since 2004.

The most commonly detected pesticide group was the herbicides. The most commonly detected herbicides in 2009-2011 were dichlobenil, 2,4-D, and triclopyr.

Dichlobenil is the active ingredient in the herbicides Casoron and Norosac 4G. Dichlobenil is used to control weeds and grasses in residential, industrial, and agricultural areas including ornamentals, rights-of-way, paved areas, sidewalks, recreational areas, fences, and removing tree roots to prevent growth in sewers (EPA, 1998a; WSDOT, 2006a). A 1997 King County and south Snohomish County survey of pesticides sold at home and garden stores found mecoprop (MCPP), 2,4-D, and dichlobenil were the top three herbicides sold (Voss et al., 1999). Mecoprop was the second most commonly detected herbicide after dichlobenil during 2003-2008 (Figure 58).

2,4-D is the active ingredient in the herbicides Weedar and Amine 4, and it is one of the active ingredients in Curtail (along with clopyralid) and Veteran 720 and Weedmaster (along with dicamba). 2,4-D is used for broadleaf and nuisance weed control in urban (lawn, garden), agricultural, and forestry areas. It is the third most widely used herbicide in the United States and Canada and the most widely used herbicide worldwide (WSDOT, 2003).

In urban areas, triclopyr is used to control broadleaf weeds and brush on a variety of sites: rights-of-way, turf including home lawns, and home and school outdoor use (EPA, 1998b). Triclopyr is the active ingredient in products such as Garlon, Pathfinder; and Crossbow (a combination product of 2,4-D and triclopyr).

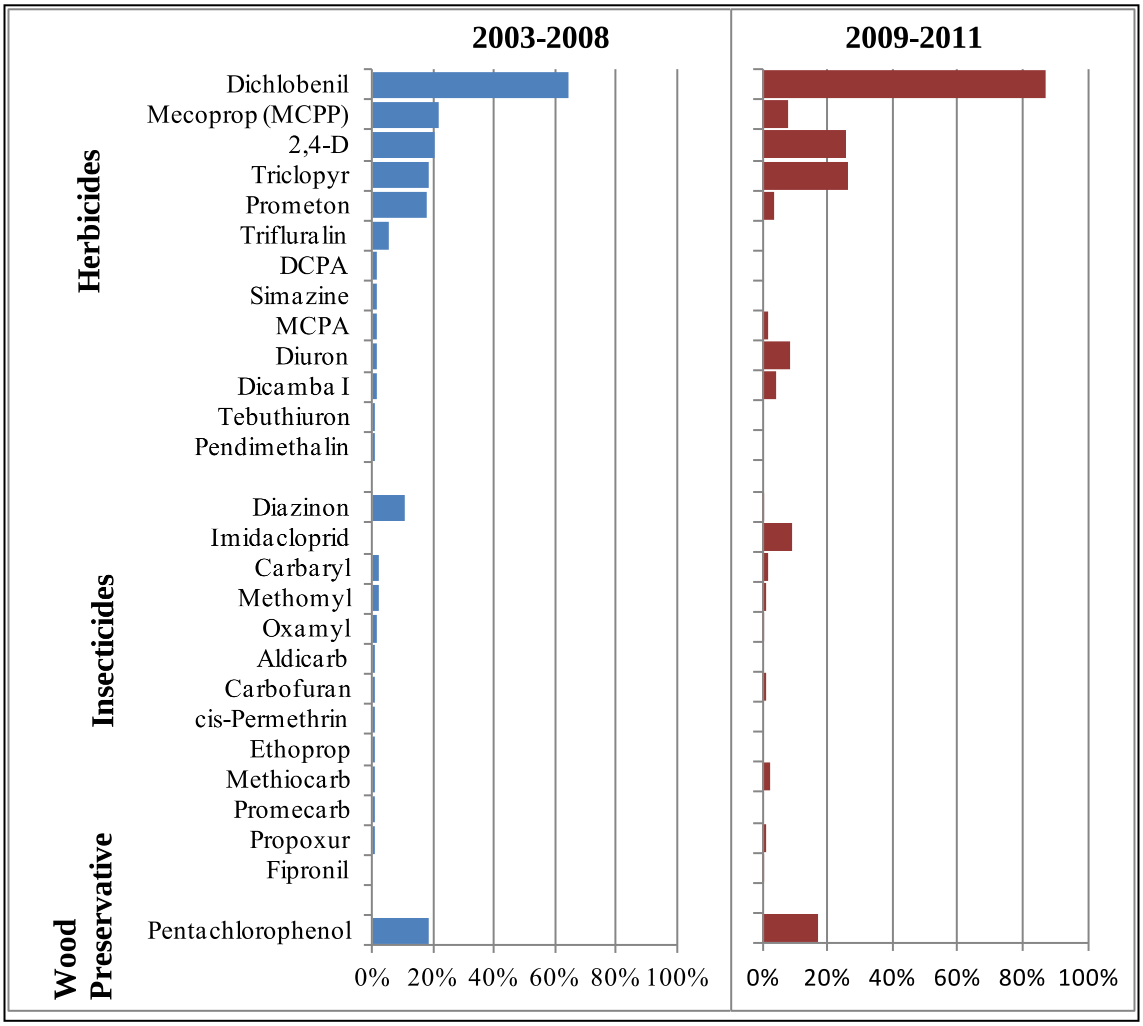


Figure 55. Percentage of pesticide detections for all sample events combined for the Thornton Creek sites, 2003-2008, and the Thornton and Longfellow Creek sites, 2009-2011.

The Longfellow Creek site is located in the West Seattle Golf Course. Fungicides are the primary pesticides used at the golf course; insecticides are rarely used. Herbicides are used sparingly to control broadleaf weeds; ingredients used include 2,4-D, dicamba, triclopyr, and glyphosate (West Seattle Golf Course, 2012).

King County Road Services uses the following herbicides for road right-of-way maintenance: glyphosate, triclopyr, sulfometuron methyl, imazapyr, aminopyralid, metsulfuron methyl (King County Road Services, 2012). Of these, the only herbicide analyzed for was triclopyr.

For insecticides, imidacloprid was most commonly detected during 2009-2011 at the urban sites. Imidacloprid is the active ingredient in numerous insecticides used to control sucking and chewing insects including termites and fleas on pets (Gervais et al., 2010). Major residential uses are (1) for home protection including control of termites, carpenter ants, and cockroaches, (2) on domestic animals for flea control, and (3) on lawns, turf, golf courses, and ornamental plantings.

The wood preservative pentachlorophenol was also detected frequently at the urban sites. Pentachlorophenol is used industrially as a preservative for utility poles, railroad ties, lumber, and wharf pilings. In 1987, use was restricted to certified applicators (NPIC, 2011).

Skagit-Samish Basin

The Skagit-Samish basin sites represent western Washington agriculture. A large variety of vegetable crops are grown in the Skagit-Samish delta. Much of the world's seed production for spinach, beets, brussel sprouts, and radishes are grown in this area. Major crops include potatoes, wheat, corn, grass hay, spinach seed, berries, and vegetable crops. One site (upstream Big Ditch) largely represents commercial/industrial land use.

Distribution of pesticide detections at the Skagit-Samish sites during 2006-2011 is as follows:

- 83% herbicides (2148 detections)
- 9% insecticides (237 detections)
- 3% wood preservative, pentachlorophenol (86 detections)
- 3% fungicides (77 detections)
- 2% pesticide degradates (40 detections)
- <1% pesticide synergist (4 detections)

A higher percentage of herbicide and fungicide detections, and a lower percentage of insecticide detections, occur at the Skagit-Samish basin sites in comparison with the other agricultural areas in this study.

Figure 56 presents the most commonly detected pesticides in the Skagit-Samish basin. The most commonly detected insecticide was imidacloprid. The high percentage of imidacloprid detections was driven by the frequent detections at the upstream Big Ditch site during 2008-2011 (MEL began laboratory analyses for imidacloprid in 2008). Land-use above the upstream Big Ditch site is largely commercial and industrial. Upstream uses of imidacloprid may include control of termites, carpenter ants, and cockroaches, as well as use on lawn or ornamental plantings. Insecticides were rarely detected at the other Skagit-Samish sites.

A wide variety of herbicides were seen in the Skagit-Samish basin. Two of the most commonly detected herbicides, dichlobenil and 2,4-D, were also the most commonly detected at the urban sites. In addition to residential uses, dichlobenil is registered for crops including apples, blueberries, boysenberries, ornamentals, and raspberries; for areas around farm buildings and fencerows, and for road rights-of-way.

2,4-D is registered for crops including apples, barley, corn, grapes, grass-seed, pasture, pears, potatoes, strawberries, triticale, and wheat. 2-4-D can also be used along road and utility rights-of-way, around buildings, and on ditch banks. The Skagit County Roads Department may use 2,4-D and triclopyr for maintenance activities as well as other herbicides not included for laboratory analysis in this sampling study: glyphosate, sulfometuron methyl, flumioxazin, chlorsulfuron, and aminopyralid (Nelson, 2012).

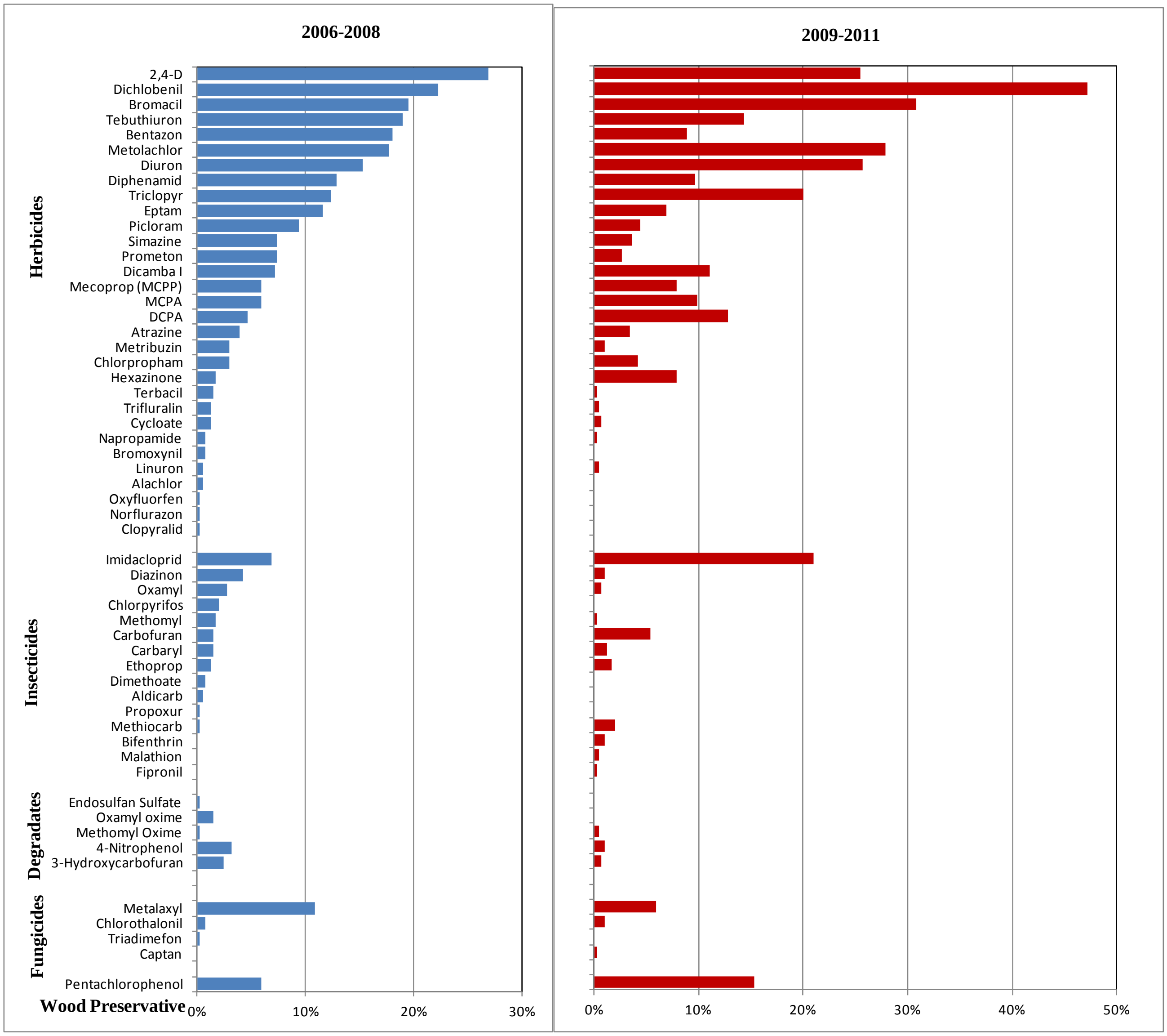


Figure 56. Percentage of pesticide detections for all sample events combined for the Skagit-Samish sites, 2006-2008 and 2009-2011.

During 2009-2011, the herbicides bromacil, metolachlor, and diuron were frequently detected. Bromacil has no registered uses for crops but can be used adjacent to buildings, for fencerows, for industrial sites, and for utility and road rights-of-way. Bromacil is used for weed and brush control on road shoulders. It is used by the Washington State Department of Transportation (WSDOT) alone and in combination with diuron (Krovar) for control of pre-emergent weeds, brush, and grasses (WSDOT, 2006b).

Metolachlor is registered for use on a variety of crops grown in the Skagit-Samish basin including beans, corn, peas, and tomatoes.

Diuron is also registered for a wide variety of crops including apples, artichokes, asparagus, barley, blueberries, boysenberries, corn, grapes, grass, hay, pasture, ornamentals (including bulbs), pears, raspberries, triticale, and wheat. In addition, diuron is registered for use along ditch banks, areas around farm buildings, industrial sites, fencerows, and rights-of-way.

Lower Yakima Basin

The Lower Yakima basin is a large agricultural area that is irrigated by a series of canals and waterways. The Lower Yakima sites represent irrigated agricultural land use. The irrigation period varies slightly from year to year, but it generally begins in early April and ends in mid-October.

An average of 55% of the Lower Yakima basin sampled is in agricultural production. A wide variety of crops are grown in this region. Major crops include grapes, hops, wheat, alfalfa hay, mint, apples, cherries, and a variety of vegetable crops. The distribution of pesticide detections seen at the Lower Yakima sites during 2003-2011 is as follows:

- 79% herbicides (2670 detections)
- 18% insecticides (631 detections)
- 2% pesticide degradates (62 detections)
- 1% wood preservative, pentachlorophenol (25 detections)
- <1% fungicides (6 detections)

The Yakima sites have the greatest number of pesticide detections per sample event. These sites also have the greatest number of acres in agriculture production, compared to the other project areas.

Figure 57 presents the most commonly detected pesticides at the Lower Yakima sites for 2003-2008 and 2009-2011. The greatest variety of insecticides and herbicides was seen at these Lower Yakima sites.

Dicamba, 2,4-D, terbacil, and bromacil were the most commonly detected herbicides during 2009-2011. Dicamba and 2,4-D are similar herbicides, used on a wide spectrum of broadleaf weeds and woody plants. Both are registered for a wide variety of agricultural, commercial, and residential uses. Both can be used for crops such as asparagus, barley, corn, grass, hay, ornamentals, sorghum, rye, sudangrass, timothy, triticale, and wheat, as well as for conservation reserve land, pasture, and rangeland. 2,4-D can also be used on apples, apricots, cherries, grapes, hopes, nectarines, oats, pears, plums, potatoes, and walnuts. Both herbicides have other residential uses including road right-of-way maintenance, around buildings, outdoor school use, recreation areas, canals and ditch banks, fencerows, golf courses, and lawns.

Terbacil is registered for agricultural use on the following crops: alfalfa, apples, asparagus, blueberries, cherries, grass, mint, peaches, plums, and watermelon. Bromacil has no registered uses for crops but can be used around buildings, fencerows, industrial sites, and utility and road rights-of-way.

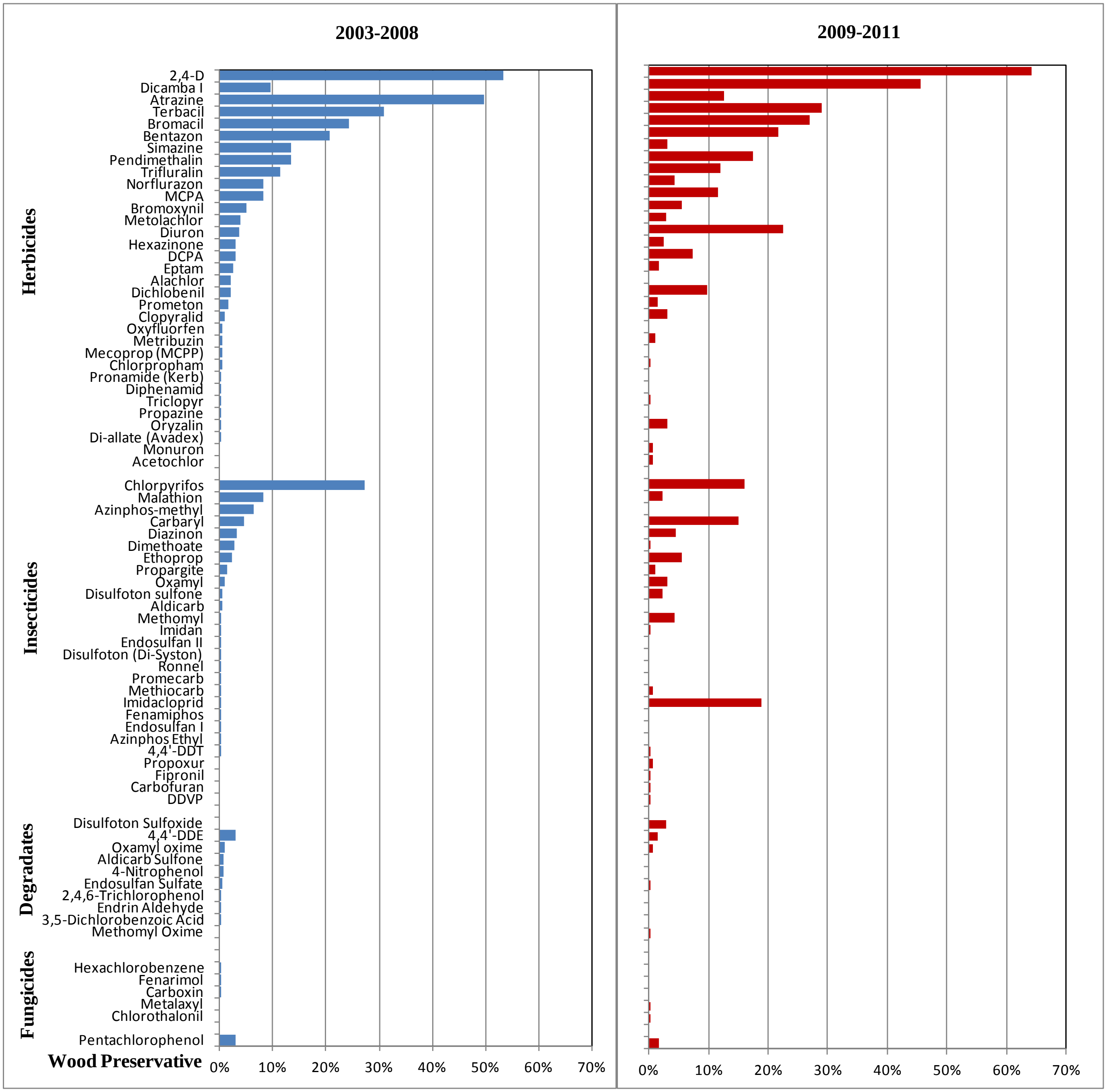


Figure 57. Percentage of pesticide detections for all sample events combined for the Lower Yakima basin sites, 2003-2008 and 2009-2011.

The most common insecticides detected in the Lower Yakima basin include imidacloprid, chlorpyrifos, and carbaryl.

Imidacloprid has a wide variety of agricultural and non-agricultural uses. Registrations for crops include alfalfa, apples, apricots, asparagus, beans, broccoli, cabbage, brussel sprouts, cherries, corn, cucumbers, grass, mint, nectarines, nursery use, onions, ornamentals, peaches, pears, plums, potatoes, pumpkins, sorghum, walnuts, and wheat. In addition, imidacloprid is registered for use around dairy, livestock, and poultry buildings.

Chlorpyrifos also has a wide variety of uses; its agricultural uses are similar to imidacloprid.

Carbaryl has a wide variety of uses for agriculture, turf management, ornamental production, and residential settings. It is used as a mosquito adulticide. For agricultural sites major uses include fruit and nut trees, fruit, vegetables, and grain crops. Yakima basin crop usage could include apples, alfalfa, apricots, artichokes, asparagus, beans, blueberries, cherries, corn, cucumber, currant, grapes, grass hay, nectarines-peach, ornamentals, pasture, pears, peppers, plums, potatoes, pumpkins, sorghum, squash, tobacco, tomato, walnuts, wheat, and watermelon. In addition, carbaryl is registered for use on animals, residential gardens, and turf, as well as outdoors around schools, recreation areas, buildings, and rights-of-way.

Wenatchee-Entiat Basins

The Wenatchee-Entiat basins represent tree fruit agriculture. A large portion of acreage in the uplands is in forest land, and a portion of the lowland area is in agricultural production. Major crops include pears, apples, and cherries. The distribution of pesticide detections at the Wenatchee-Entiat sites for 2007-2011 is as follows:

- 42% pesticide degradates (298 detections)
- 40% insecticides (282 detections)
- 15% herbicides (108 detections)
- 1% wood preservative, pentachlorophenol (9 detections)
- 1% pesticide synergist (9 detections)
- <1% fungicides (2 detections)

Pesticide degradates and insecticides were the most commonly detected compounds. The majority of pesticide degradates were degradates of insecticides. Of the pesticide degradates detected, 63% were degradates of the legacy insecticide DDT, while 34% were endosulfan sulfate, a degradate of the insecticide endosulfan (Figure 58). Of the insecticides detected, 43% were for DDT and 21% were for endosulfan I or II (Figure 58).

EPA cancelled all uses of DDT in 1972. DDT can take more than 15 years to break down in the environment. DDT binds to soils and can be transported to waterways through erosion caused by run-off. In addition, DDT would be resuspended through bank erosion due to increased flows during the irrigation season.

Most DDT breaks down slowly into DDE and DDD, which are also persistent in the environment. Detections of DDT and these degradates are likely a result of past use of DDT.

The insecticide endosulfan is currently registered for use on a number of tree fruit crops and other crops found in the Wenatchee and Entiat basins. These crops include apples, apricots, blueberries, cherries, nectarines, peaches, and pears. Phase out of endosulfan began in July 2010, with no use of endosulfan allowed after July 31, 2016.

Brender Creek had the majority of the pesticide detections, with 88% of the pesticide detections over the five-year sampling period. Brender Creek has the lowest flow of any of the Wenatchee-Entiat sample sites. Table 40 presents the average flow, the number of pesticide detections for the five-year period, and the percentage of the watershed in agricultural production.

Low-flow volume is one reason that Brender Creek has more detections compared to the other sites. Generally, the Wenatchee River has three orders of magnitude greater flow than Brender Creek, the Entiat and Peshastin Rivers have two orders of magnitude greater flow than Bender Creek, and Mission Creek has one order of magnitude greater flow than Brender Creek (Table 40). Dilution is likely a factor in the low number of pesticide detections for Peshastin Creek and the Entiat and Wenatchee Rivers.

Percentage of area in agricultural production could also be a factor in the number of pesticide detections. For example, Mission Creek flow, while low, still has few pesticide detections. Of all the Wenatchee-Entiat sites, Brender Creek has the greatest acreage in production (Table 40). Another factor in pesticide detections could be agricultural pesticide use practices.

Table 40. Average flow and number of pesticide detections for the Wenatchee-Entiat sites, 2007-2011, and percentage of the watershed area in agricultural production, 2011.

Site	Average five-year flow during sampling (cfs)	Number of pesticide detections, 2007-2011	Total agricultural area (2011 crop totals; Appendix C)
Brender Creek	3	625	12.6%
Mission Creek	28	25	1.26%
Peshastin Creek	238	19	0.07%
Entiat River	782	19	0.35%
Wenatchee River	4642	20	1.09%

Figure 58 presents the most commonly detected pesticides in the Wenatchee-Entiat basins for 2007-2008 and 2009-2011.

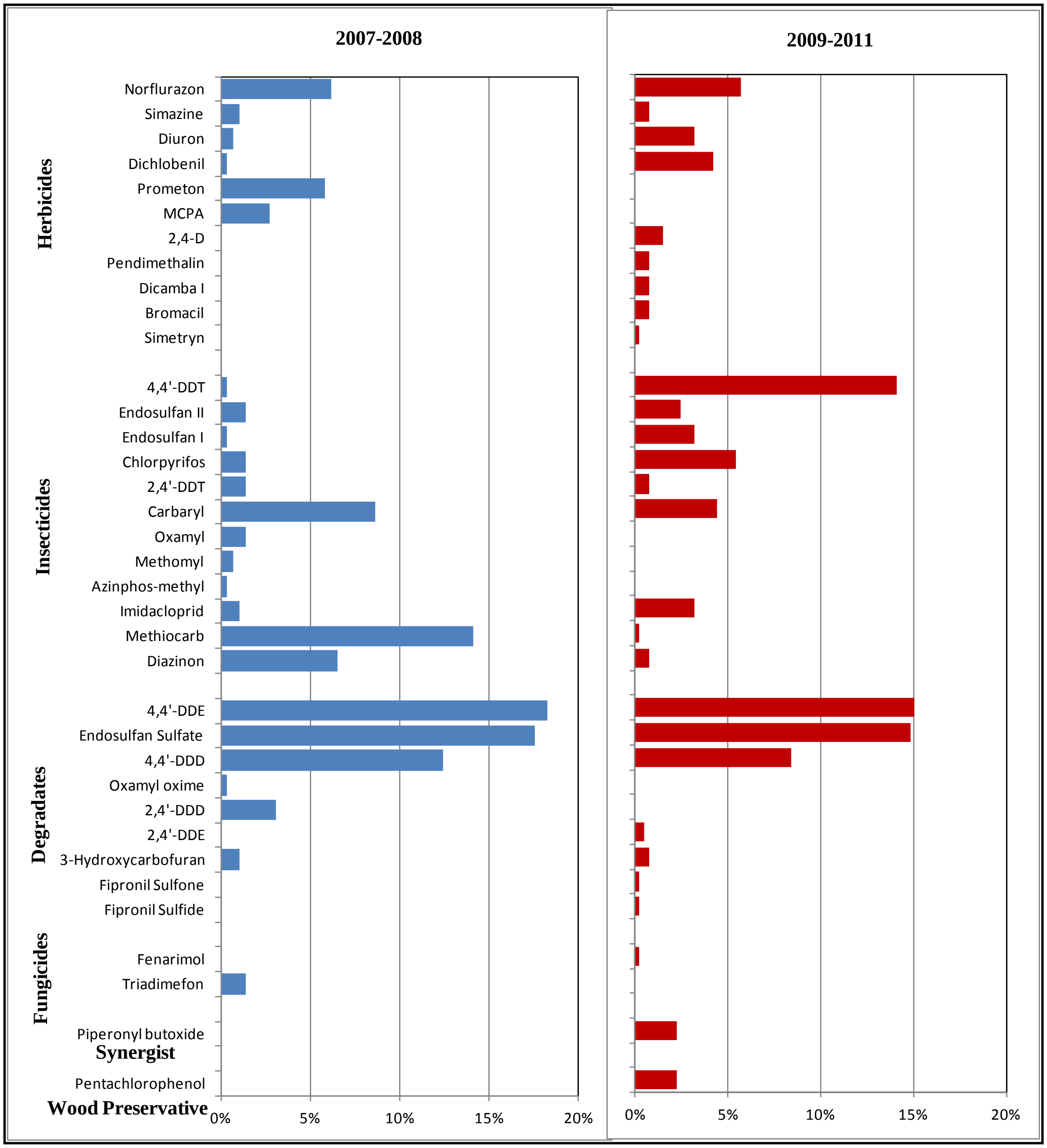


Figure 58. Percentage of pesticide detections for all sample events combined for the Wenatchee-Entiat sites, 2007-2008 and 2009-2011.

Pesticide Trends

A number of trends in pesticide concentrations were seen at sites where the SEAWAVE-Q pesticide analysis was conducted. Figure 62 presents a summary of increasing and decreasing trends, and no change in pesticide concentrations, for the sites where the model was applied. Decreases or increases in pesticide concentrations or use can occur for a variety of reasons.

Decreasing trends:

- Pesticide no longer registered for use (or being phased out).
- New pesticide tools available that are less expensive.
- Pesticide has become less effective against a pest.
- Best management practices decrease pesticide transport to surface water.

Increasing trends:

- New pesticide may allow for faster re-entry of workers to the field.
- Pesticide is found to be more effective against a pest.

Urban Basins

Pesticide trend analysis was not conducted for Longfellow Creek data, as only three years of data are available. In Thornton Creek, trends toward decreasing concentrations were seen for the insecticide diazinon. This is likely due to diazinon not being registered for homeowner use since December 2004. During 2009-2011, diazinon was not detected in Thornton Creek.

Three herbicides also showed decreasing concentrations: diuron, mecoprop, and triclopyr. All are still registered for use. Diuron is a broad spectrum herbicide used for weed, grass, and brush control. Residential uses for diuron include ponds, aquariums, and paints. Commercial uses include ornamental trees, flowers, shrubs, paints and coatings, paved areas, fish ponds, buildings and outdoor structures, recreational areas, rights-of-way, and industrial sites.

Mecoprop is a commonly used herbicide found in many “weed-and-feed” type lawn fertilizers and is primarily used to control broadleaf weeds. The majority of mecoprop use is associated with residential lawns, with smaller usage on other recreational turf and grassy areas. During the 1997 pesticide-sales data survey of King and south Snohomish County, mecoprop had the highest unit sales of the herbicides (Voss et al., 1999). It is often co-formulated with 2,4-D and dicamba (EPA, 2007a).

Triclopyr is also used to control broadleaf weeds and brush on rights-of-way, turf, and home lawns and gardens.

Skagit-Samish Basin

For the Skagit-Samish sites, decreasing trends in concentrations were seen for the herbicides bentazon, diuron, eptam, picloram, simazine, and tebuthiuron. Decreasing trends in concentrations were also seen for the fungicide metalaxyl.

The registration for one form of bentazon was voluntarily cancelled at the end of 2010 (the sodium salt formation is still allowed for use). Bentazon was commonly used in green pea production, which was a major crop in rotation in the Samish-Skagit basin until the closure of a processing facility in 2008. If green pea production restarts, use of this herbicide may increase in the basin.

All the other pesticides with decreasing trends are still registered for use.

Trends toward increasing concentrations for the herbicides chlorpropham, DCPA (dacthal), hexazinone, MCPA, and metolachlor were also seen.

Lower Yakima Basin

Trends toward decreasing concentrations and detections of the organophosphate insecticide azinphos-methyl were seen in Marion Drain and Sulphur Creek Wasteway. Azinphos-methyl is being phased out, with use of existing stocks allowed through September 2013.

Trends toward decreasing concentrations of the organophosphate insecticide chlorpyrifos were seen in Marion Drain, along with increasing concentrations of the organophosphate insecticide ethoprop. It is possible that ethoprop is being used as a substitute for chlorpyrifos on select crops (Washington State University, 2012). In general, ethoprop is less toxic to fish and aquatic life than chlorpyrifos (Appendix G).

Decreasing concentrations were seen for the herbicides atrazine, clopyralid, diuron, norflurazon, and simazine, while increasing concentrations were seen for the herbicides DCPA (dacthal), dicamba I, MCPA, pendimethalin, terbacil, and trifluralin. All of these herbicides are currently registered for use.

Wenatchee-Entiat Basins

Brender Creek was the only site to have sufficient pesticide detections to apply to the model. Decreasing trends in concentrations of the organochlorine insecticide endosulfan were seen in Brender Creek.

In July 2010, EPA signed an agreement with the makers of endosulfan to phase out all uses of endosulfan by July 2016. In addition, EPA required new mitigation measures during the phase-out period, including canceling aerial use and specifying other application methods, extending restricted entry intervals, extending pre-harvest intervals, and reducing maximum single and/or seasonal application rates (EPA, 2010a).

Statewide Trends

In looking at statewide trends across basins (Figure 59), there were increasing concentrations at two or more sites of the herbicides DCPA (dacthal), dicamba I, MCPA, metolachlor, and pendimethalin. There were also decreasing trends in concentrations of diuron and simazine.

WSDA will add five pesticides (dicamba I, hexazinone, metolachlor, terbacil, and trifluralin) with increasing trends to its list of Pesticides of Concern (POC). The other three herbicides listed above with increasing trends (DCPA, MCPA, and pendimethalin) have already been evaluated in WSDA's tracking system and upgraded to POCs. Prior to the analysis of this trend data, only DCPA had been elevated from a Pesticide of Interest to a POC after finding increasing concentrations in Washington groundwater. WSDA uses the Pesticides of Interest Tracking System (POINTS) to identify those pesticides under further review and evaluation for environmental problems. After an initial evaluation, a Pesticide of Interest that shows potential to contaminate surface water or groundwater, or otherwise impact the environment, can be reclassified as a POC, triggering additional analysis by WSDA.

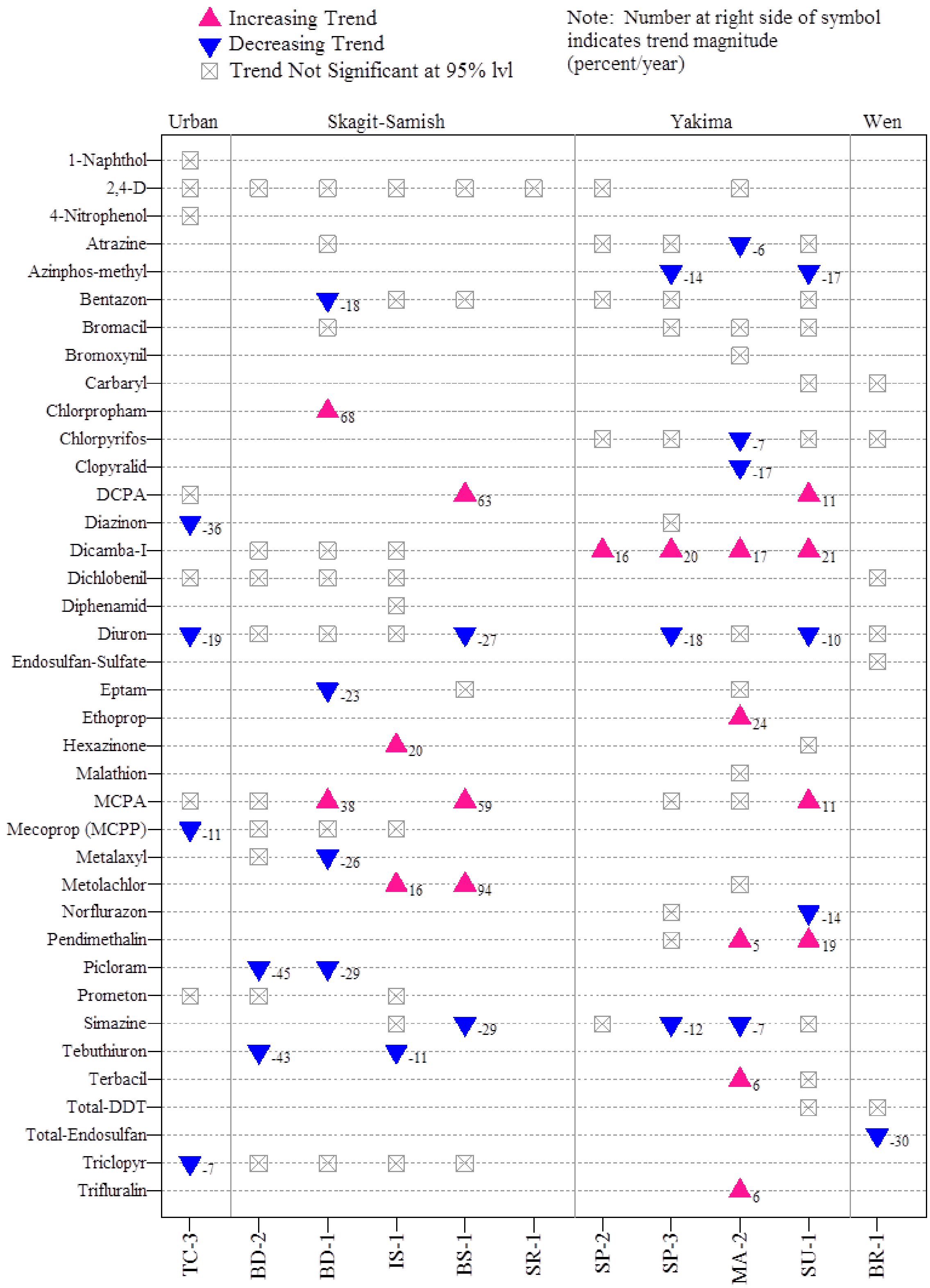


Figure 59. Summary of increasing and decreasing trends in pesticide concentrations for all sites in the pesticide monitoring program.

Comparing the Monitoring Areas

Each project area has a characteristic set of pesticides detected at the sites. Pesticides detected are likely related to usage and each project area was chosen to represent a particular land use (urban, western Washington agriculture, irrigated crop agriculture, and tree-fruit agriculture).

Herbicides were the most commonly detected pesticides at all sites except for the Wenatchee-Entiat sites, where insecticides and insecticide degradates were the most commonly detected compounds.

Comparison among the project areas is complicated by differences in the number of sample events, sites, and monitoring periods. Table 41 presents the ratio of pesticide detections to sample events for each area. Brender Creek has the most pesticide detections of any site, yet the rest of the sites in the Wenatchee-Entiat project area have the least number of pesticide detections per sample event (Table 41). The urban sites, the Skagit-Samish sites, and the Lower Yakima sites had less pesticide detections per sample event in 2006-2008 as compared to 2009-2011. This could be due, in part, to lower detection limits at MEL and also to the addition of pesticides to the analyte list.

Table 41. Ratio of pesticide detections to the number of sample events for the urban, Skagit-Samish, Lower Yakima, and Brender Creek and other Wenatchee-Entiat basin project areas.

Project Area	Period	Number of Detections	Number of Sample Events	Ratio of Detections to One Sample Event	Sites Included
Urban Sites	2003-05	389	128	3.0 : 1	TC-1, TC-1.1, TC-2, TC-3
	2006-08	179	124	1.4 : 1	TC-1.1, TC-3
	2009-11	343	162	2.1 : 1	LC-1, TC-3
Samish-Skagit	2006-08	1179	435	2.7 : 1	BD-1, BD-2, BS-1, IS-1, SR-1, SR-2
	2009-11	1413	405	3.5 : 1	BD-1, BD-2, BS-1, IS-1, SR-1
Lower Yakima	2003-05	1261	319	4.0 : 1	MA-1, MA-2, SP-1, SP-1.1, SP-2, SP-3, SU-1
	2006-08	989	309	3.2 : 1	MA-2, SP-2, SP-3, SU-1
	2009-11	1144	306	3.7 : 1	MA-2, SP-2, SP-3, SU-1
Brender Creek	2007-08	278	57	4.9 : 1	BR-1
	2009-11	347	84	4.1 : 1	BR-0.5, BR-1
Other Wenatchee-Entiat	2007-08	37	230	0.2 : 1	EN-1, MI-1, PE-1, WE-1
	2009-11	46	324	0.1 : 1	EN-1, MI-1, PE-1, WE-1

Note: Excludes special studies (intensive sampling, storm event, DH-81 comparison)

After Brender Creek, the Lower Yakima basin sites had slightly more pesticide detections per sample event than the Skagit-Samish sites for 2009-2011, followed by the urban sites, then the Wenatchee-Entiat sites (with the exception of Brender Creek).

Table 42 compares the number of pesticide detections that did not meet (exceeded) a criteria or standard to the number of sample events. While a pesticide may not meet more than one criterion or standard, Table 42 includes one exceedance per pesticide detection of a criterion or standard. Brender Creek had the most pesticide detections that did not meet a criterion or standard per sample event. This is due to consistent detections of the legacy pesticide DDT and DDT degradates in Brender Creek. After Brender Creek, the Lower Yakima sites had the greatest number of pesticide detections that did not meet a criterion or standard per sample event, followed by the Skagit-Samish sites, then the urban sites.

In 2009-2011, the ratio of pesticides not meeting a criterion or standard to sample events was the same for the Skagit-Samish sites and the urban sites. For the urban sites, a higher ratio of pesticide not meeting standards to sample events is seen for 2009-2011, as compared to previous years. This could be due to the addition of the site at Longfellow Creek. Reductions in pesticides not meeting a criterion or standard were seen for both the Skagit-Samish basin and Lower Yakima basin during 2009-2011.

Table 42. Number of pesticide detections not meeting (exceeding) a criteria or standard for the urban, Skagit-Samish, Lower Yakima, and Brender Creek and other Wenatchee-Entiat basin project areas.

Project Area	Period	Criteria Exceedances				Number of Sampling Events	Ratio of Exceedances above criteria to number of sample events	Sites Included
		ESLOC	WAC/NRWQC and/or Fisheries	Invertebrate	Total			
Urban	2003-05	0	1	0	1	128	1 : 128	TC-1, TC-2, TC-1.1, TC-3
	2006-08	1	0	0	1	124	1 : 124	TC-1.1, TC-3
	2009-11	0	1	3	4	162	1 : 41	LC-1, TC-3
Skagit-Samish	2006-08	0	6	6	12	435	1 : 36	BD-1, BD-2, BS-1, IS-1, SR-1, SR-2
	2009-11	6	0	4	10	405	1 : 41	BD-1, BD-2, BS-1, IS-1, SR-1
Yakima	2003-05	5	52	6	63	320	1 : 5	MA-1, MA-2, SP-1, SP-1.1, SP-2, SP-3, SU-1
	2006-08	2	33	1	36	309	1 : 9	MA-2, SP-2, SP-3, SU-1
	2009-11	2	19	7	28	306	1 : 11	MA-2, SP-2, SP-3, SU-1
Brender Creek	2007-08	23	155	0	178	58	3 : 1	BR-1
	2009-11	11	160	0	171	84	2 : 1	BR-0.5, BR-1
Other Wenatchee-Entiat Basin Sites	2007-08	5	1	0	6	231	1 : 39	EN-1, MI-1, PE-1, WE-1
	2009-11	4	1	0	5	324	1 : 65	EN-1, MI-1, PE-1, WE-1

Note: Excludes special studies (intensive sampling, storm event, DH-81 comparison study)

Water Quality and Salmon Presence

Urban Basins

Fish Presence

In Thornton Creek, salmonid species present include chinook, coho, and sockeye. Thornton Creek is within the Puget Sound Chinook Salmon Evolutionary Significant Unit (ESU) and the Puget Sound Bull Trout Distinct Population Segment (DPS), both designated threatened status (Sargeant et al., 2010).

Historically, Longfellow Creek contained populations of coho salmon, cutthroat trout, and steelhead trout (Kerwin, and Nelson, 2000). During a 1999 spawning survey, Seattle Public Utilities noted the presence of 60 adult coho salmon and juvenile rainbow trout.

Chinook fry emerge during March through April; the greatest number of pesticides detections at both sites occurs in May and June. Coho fry may reside over a year instream.

Pesticides

During 2009-2011, most pesticide detections met (did not exceed) assessment criteria and water quality standards at both Thornton and Longfellow Creeks. When pesticide detections did not meet an assessment criteria and water quality standards, it was for chronic numeric criteria.

In 2011 in Thornton Creek, a legacy DDT degradate was detected that did not meet chronic water quality standards. At both the urban sites, methiocarb, a carbamate insecticide, was detected on March 9 and 16, 2009. Three out of the four detections did not meet the chronic invertebrate assessment criteria for methiocarb. Methiocarb was not detected again on either of the urban creeks during 2009-2011.

During 2009, field and laboratory blank detections of certain carbamate compounds indicated issues with select carbamate parameters: 1-naphthol, aldicarb sulfone, aldicarb sulfoxide, and oxamyl. In 2009, data were not reported for these carbamates, and there was still a possibility of some false positives for other carbamate parameters such as methiocarb (Sargeant et al., 2011).

March 2009 detections of methiocarb could be of chronic concern to aquatic macroinvertebrates, a food source for salmon.

Conventional Parameters

During 2009-2011, Thornton Creek did not consistently meet the temperature and dissolved oxygen (DO) water quality standards. Thornton Creek must meet a stricter DO water quality standard (≥9.5 mg/L) and temperature standard (highest 7-DADMax should not exceed 16°C).

DO levels dropped below 9.5 mg/L occasionally during June through September. But percent DO saturation levels were generally good during sample events and did not drop below 89% saturation.

Longfellow Creek met water quality standards during the majority of sample events. There were a few periods when water temperature did not meet standards during June-August in 2009 and 2010.

Summary

While fish are present during the period of pesticide use, pesticide levels in Thornton and Longfellow Creeks are low. Using the additive model for pesticide toxicity, cumulative concentrations of pesticide mixtures were above the chronic invertebrate assessment criteria once in three years for a degradate of DDT at Thornton Creek, and for two consecutive weeks in early March for methiocarb at both sites (if methiocarb detections are not false positives).

Pesticide concentrations alone do not directly affect salmon in Thornton and Longfellow Creeks. Higher summer temperature levels, as well as occasional lower DO levels in Thornton Creek, may be of concern to fish.

Skagit-Samish Basin

Fish Presence

The Skagit-Samish basin supports several Puget Sound salmonid populations (Table 43). Salmon habitat use is classified according to the highest levels of habitat supported. The greatest value is placed on spawning habitat, followed by rearing, and then documented presence (occupation) of a fish species.

Table 43. Salmonid presence and use for the Skagit-Samish sites.

Species	Big Ditch	Browns Slough	Indian Slough	Samish River
Fall chinook	--	Presence	Presence	Presence
Coho	Rearing	Presence	Presence	Rearing
Fall chum	--	Presence	--	Presence
Pink	--	Presence	--	Presence
Sockeye	--	--	--	Rearing
Bull trout	--	--	--	Presence
Winter steelhead	--	--	--	Rearing

Pesticides

In Browns Slough and the Samish River, all pesticide detections met (did not exceed) assessment criteria or water quality standards during 2009-2011. Using the additive model for pesticide toxicity, co-occurrence of pesticides did not appear to be a concern for aquatic life.

Indian Slough had one pesticide detection (malathion) in three years that did not meet (exceeded) the ESLOC for fish and the chronic water quality standard. Using the additive model for pesticide toxicity, this was the only day that TU values were > 1, and it was due to the single malathion detection. (Table 21).

Both Big Ditch sites had bifenthrin detections that did not meet (exceeded) the ESLOC for fish in April and July. The upstream site had one detection of malathion in May that did not meet the ESLOC for fish. There were other pesticide detections above the chronic invertebrate assessment criteria, but none occurred for two consecutive weeks.

In looking at pesticide mixtures, cumulative concentrations of mixtures were at times of concern to aquatic life; but this was generally due to a high concentration of a single pesticide that was above assessment criteria. Pesticide concentrations of concern did not meet a chronic invertebrate assessment criterion and, for bifenthrin, did not meet a chronic fish assessment criterion (Table 21).

Conventional Parameters

During 2009-2011, none of the sites consistently met temperature standards. Brown and Indian Sloughs, and downstream Big Ditch, had some of the highest temperatures seen throughout the study areas. High water temperatures in Browns Slough could be due to (1) an influx of warm flooding tide from the shallow Skagit tidal flats and (2) warm upstream water.

Dissolved oxygen levels fell below the standard numerous times at both sites on Big Ditch, Indian Slough, and Browns Slough. Some of the lowest DO levels were seen on Browns Slough, as well as some of the highest DO levels. It is likely that actual instream minimum DO levels are lower than values obtained during this study. This is because DO and temperature fluctuate during a 24-hour period. The lowest DO levels are found in the early morning hours before plant photosynthesis begins. Generally sampling does not occur early enough in the morning to capture the lowest values.

Summary

While fish are present during the period of pesticide use, pesticide levels in Indian and Browns Slough and the Samish River are low. Using the additive model for pesticide toxicity, high cumulative concentrations of pesticide mixtures rarely occur at these three sites.

Coho salmon rearing occurs in Big Ditch. At the upstream Big Ditch site, bifenthrin detections may be of acute and chronic concern for aquatic invertebrates. This may impact salmon indirectly due to impact to their food source. At the downstream site, metolachlor levels may be of chronic concern for aquatic invertebrates, but levels of chronic concern were not observed for two consecutive sampling weeks.

The greatest concerns for fish at the majority of the Skagit-Samish sites are higher temperatures and lower DO levels during the summer months.

Elevated water temperature lowers the availability of DO by reducing the water's solubility. It also increases salmon vulnerability to disease, and the toxicity of many substances to salmonids intensifies as temperature rises (Ecology, 2000). Oxygen levels affect the growth rates of salmonids as well as their swimming ability, susceptibility to disease, and their relative ability to endure other environmental stressors and pollutants, such as pesticides (Ecology 2000 and 2002; Carter, 2008).

Lower Yakima Basin

Fish Presence

The three monitored drainages (Marion Drain, Sulphur Creek Wasteway, and Spring Creek) in the Lower Yakima basin support a diverse assortment of salmonid species including fall chinook, spring chinook, coho, and summer steelhead. Of the fisheries, Mid-Columbia steelhead are designated threatened and have been documented in all three drainages. The Yakima River supports ESA-listed Upper Columbia River summer/fall chinook (river-type), Mid-Columbia River spring chinook (ocean-type), and Mid-Columbia River bull trout (Burke et al., 2006).

The majority of summer discharge in the three drainages is comprised of irrigation return flows. Upstream migration of adult salmonids generally requires an environmental cue in the form of an "attraction flow" which provides a chemical or other type of signal to the fish that upstream conditions are suitable for migration and spawning. Therefore, bypasses and water diversions can present false migration pathways, which interfere with spawning and limit the success of salmonid populations.

For example, Marion Drain is a constructed conveyance which intercepts a portion of historical groundwater flow to Toppenish Creek. As a result, Marion Drain steelhead are likely ancestral Toppenish Creek fish. Marion Drain provides spawning habitat for fall chinook, summer steelhead, and resident fish. Coho have also been observed in the drain (Burke et al., 2006).

Fish distribution in Sulphur Creek Wasteway includes spawning coho; however, suitable spawning gravels and low velocity habitat for emerging fry are rare. Salmonids are attracted to Sulphur Creek Wasteway by the high volume of irrigation return flows. Summer steelhead and fall and spring chinook presence have been documented in the Sulphur Creek Wasteway (Burke et al., 2006).

In November 2007, construction began on a fish barrier designed to prevent adult salmonids from entering Sulphur Creek Wasteway. Construction was completed in March 2008. The barrier was a cooperative project between the Yakama Nation, Rosa-Sunnyside Board of Joint Control, and Washington Department of Fish and Wildlife.

Fish distribution in the lower reach of Spring Creek includes spawning coho and rearing spring chinook. Coho, spring and fall chinook, and summer steelhead presence have been documented in the lower reach (Burke et al., 2006).

Pesticides

In March and April, there were several chlorpyrifos detections in Spring Creek that did not meet chronic water quality standards, and one detection did not meet the acute standard. During 2009 and 2011, there were two or three weeks of consecutive detections of chlorpyrifos that did not meet chronic water quality standards. In looking at pesticide mixtures, cumulative concentrations of mixtures were at times of concern to aquatic life, but this was generally due to a high concentration of a single pesticide that did not meet an assessment criterion.

In Marion Drain, there were detections of chlorpyrifos, malathion, ethoprop, and methomyl that were above the chronic invertebrate assessment criteria. One detection of malathion also did not meet the ESLOC for fish. Consecutive weeks of detections for these insecticides did not occur. In looking at pesticide mixtures using the additive model for pesticide toxicity, cumulative concentrations of mixtures occasionally were above a chronic invertebrate assessment criterion.

Sulphur Creek Wasteway also had several March and April detections of chlorpyrifos that did not meet (exceeded) the chronic water quality standard and chronic invertebrate assessment criteria and occasionally did not meet the acute water quality standard. During 2009-2011, there were two to three consecutive weeks when chlorpyrifos detections did not meet the chronic water quality standard and chronic invertebrate assessment criteria.

The DDT degradate, 4,4’-DDE, was detected above the chronic water quality standard. One detection of DDVP and methiocarb were above the chronic invertebrate assessment criteria.

In looking at pesticide mixtures using the additive model for pesticide toxicity, cumulative concentrations of mixtures were occasionally above an acute or chronic invertebrate assessment criteria, the majority due to detections of a single pesticide that did not meet criteria or standards.

Conventional Parameters

During 2009-2011, none of the sites met temperature standards. During most years, there were temperature exceedances during late-May through early September. Elevated spring temperatures in the downstream Lower Yakima River tributaries restrict juvenile rearing habitat (Freudenthal et al., 2005). Yet, these tributaries often have lower maximum temperatures than the mainstem, and struggling juveniles and kelts may use these tributaries as temporary thermal refuge.

Most of the sites met the DO water quality standard. Upstream Spring Creek had two sample events during 2009-2011 that did not meet standards.

While the upstream Spring Creek site rarely exceeded the pH standard, all of the other sites had periods when pH exceeded the 8.5 standard.

Summary

Fish are present during the period of highest pesticide use, and there are occasional pesticide detections that do not meet (exceed) an ESLOC for fish. In addition to direct effects to fish, fish are indirectly impacted by pesticide concentrations. Pesticide levels are of chronic concern to aquatic invertebrates, a food source for salmon.

Of concern are downstream Spring Creek and Sulphur Creek chlorpyrifos concentrations that do not meet (exceed) chronic assessment criteria and water quality standards, meeting the temporal component of the criteria.

Elevated temperatures are also of concern in the summer months. Elevated temperature lowers the availability of DO by reducing its solubility. It also increases salmon vulnerability to disease, and the toxicity of many substances to salmon intensifies as temperature rises (Ecology, 2000).

Wenatchee-Entiat Basins

Fish Presence

Salmonid presence and use of the Wenatchee-Entiat sites is described in Table 44. Salmon habitat use is classified according to the highest level of habitat supported. The greatest value is placed on spawning habitat, followed by rearing, and then documented presence (occupation) of a fish species. Greatest use, as might be expected, is in the Wenatchee and Entiat Rivers.

Table 44. Salmonid presence and use for the Wenatchee-Entiat sites.

Species	Wenatchee River	Mission Creek	Brender Creek	Peshastin Creek	Entiat River
Spring chinook	Rearing	Rearing	--	Rearing	Rearing
Summer chinook	Spawning	Spawning	Presence	--	Presence
Coho	--	--	--	--	Spawning
Sockeye	Rearing	--	--	--	Presence
Bull trout	Rearing	--	--	--	Presence
Summer steelhead	Rearing	Spawning	Presence	Rearing	Spawning

Pesticides

Pesticide detections at the Wenatchee and Entiat River sites and the Peshastin and Mission Creek sites were rare, and pesticide co-occurrence was seldom observed.

During 2009-2011, Mission Creek had one pesticide detection of chlorpyrifos that did not meet (exceeded) the ESLOC for fish and the acute and chronic water quality standard. The Entiat River had one detection of a legacy DDT degradate that did not meet the chronic water quality standard. In the Wenatchee River and Peshastin Creek, there were endosulfan detections that did not meet the ESLOC for fish.

During 2009-2011, endosulfan was detected in the Wenatchee River once and Peshastin Creek twice, exceeding the ESLOC for fish. Phase out, including label changes, of endosulfan began in 2010, with no use of endosulfan after July 2016. Endosulfan detections at the Wenatchee-Entiat sites have decreased since 2008, with no detections in 2011 (Figure 54). Endosulfan detections in higher volume rivers such as the Wenatchee River mean that endosulfan loading is high. This indicates there are smaller tributaries upstream, or upstream inputs along the Wenatchee River, that are contributing endosulfan to the downstream Wenatchee River site (Sargeant et al., 2011).

Conventional Parameters

During 2009-2011, none of the sites consistently met temperature standards. Peshastin Creek and the Wenatchee River had longer periods during summer months when temperature standards were not met.

All sites met the DO water quality standard minimum of 8.0 mg/L during all three years. For all sites, occasionally there were pH values that exceeded the water quality standard range.

Summary

The greatest concern for fish at the majority of the Wenatchee-Entiat sites is higher temperatures during the summer months. Brender Creek pesticide detections are of chronic concern for aquatic invertebrates. This impacts salmon indirectly due to impacts to their food source. Brender Creek pesticide detections may also be of chronic concern for fish, but it is unknown if the temporal component of the pesticide assessment criteria was exceeded.

Pesticides Not Meeting (Exceeding) a Criteria or Standards

Bifenthrin

In 2011 in the Skagit-Samish basin, three detections of bifenthrin did not meet (exceeded) the ESLOC for fish and are of chronic concern to aquatic invertebrates at upstream Big Ditch. One 2011 detection of bifenthrin did not meet the ESLOC for fish at downstream Big Ditch.

Bifenthrin is a pyrethroid insecticide used against a wide range of insects and mites. It has low solubility and correspondingly strong tendency to bind to soil. Bifenthrin is virtually stable to aqueous hydrolysis and photolysis. Because of its high octanol water partitioning coefficient and ability to adsorb to soils, bifenthrin has a low potential to contaminate groundwater, but sediment-bound bifenthrin could contaminate surface water sources during runoff events. (Fecko, 1999).

Bifenthrin is considered highly toxic to fish on an acute and chronic basis and is very highly toxic to freshwater aquatic invertebrates (EPA, 2010b). The strong adsorption of bifenthrin to soil can limit its availability to certain aquatic organisms, mitigating toxicity (Johnson et al., 2010).

Bifenthrin is registered for a variety of agricultural, non-agricultural, and residential uses. Non-agricultural use can include use on garden vegetables, lawns, ornamentals, buildings, turf, firewood, fencerows, and recreational and outdoor school areas. The primary agricultural use of bifenthrin is on corn, with over 60% of pounds applied annually for agricultural use (EPA, 2010b). It is also registered for use on apples, beans, beets, blueberries, cabbage, carrots, cucumbers, dairy buildings, farm buildings, grapes, greenhouses, ornamentals (including greenhouse), pears, potatoes, spinach, and strawberries (Washington State University, 2012).

Chlorpyrifos

During 2009-2011, there were numerous detections of chlorpyrifos that did not meet (exceeded) the chronic water quality standard at the Yakima sites. Sulphur Creek and downstream Spring Creek did not meet the acute water quality standard for chlorpyrifos at times. In addition, Sulphur Creek Wasteway and Spring Creek had two to three consecutive weeks where chlorpyrifos detections did not meet the chronic water quality standard, indicating a chronic concern for aquatic life.

In Mission Creek and Brender Creek, a single detection of chlorpyrifos did not meet the ESLOC for fish, as well as the acute and chronic water quality standards. In Brender Creek, there were also two consecutive sample weeks where chlorpyrifos did not meet the chronic water quality standard, indicating a chronic concern for aquatic life.

Chlorpyrifos is a broad-spectrum, organophosphate insecticide. Chlorpyrifos is used on agricultural food, feed crops, cattle ear tags, golf course turf, industrial plants, and wood treatments. Chlorpyrifos is considered very highly toxic to aquatic invertebrates and freshwater fish (Christensen et al., 2009).

Chlorpyrifos is registered for a number of agricultural uses in the Yakima basin including on alfalfa, apples, apricots, asparagus, beans, cherries, corn, cucumbers, grapes, mint, nectarines, onions, pears, plums, pumpkins, sorghum, tobacco, walnuts, and wheat, as well as on cattle, nursery ornamental, agricultural buildings and fencerows.

Agricultural uses of chlorpyrifos in the Wenatchee basin include use on alfalfa, apples, cherries, grapes, pears, Christmas trees, and well as on agricultural buildings and fencerows,

DDT and degradates

During April 2009 in Sulphur Creek Wasteway in the Yakima basin, there were two consecutive weeks where total DDT did not meet the chronic water quality standard for aquatic life.

Total DDT (including its degradates DDE and DDD) did not meet the chronic water quality standard consistently in Brender Creek.

EPA cancelled all uses of DDT in 1972. DDT can take more than 15 years to break down in the environment. Most DDT breaks down slowly into DDE and DDD, which are also persistent in the environment. Detections of DDT and its degradates are likely a result of past use of DDT.

Diazinon

In Brender Creek, one detection of diazinon did not meet acute NRWQC and the chronic invertebrate assessment criteria.

Diazinon was one of the most widely used insecticides for household and agricultural pest control. All residential uses were cancelled in 2004. Currently, agricultural uses of diazinon are limited to select crops, and diazinon products (other than cattle ear tags) are regulated as restricted use pesticides (Harper et al., 2009). Possible agricultural crop uses in Brender Creek include use on apples, cherries, and pears.

Endosulfan

During 2009-2010, all of the Wenatchee basin sites except Mission Creek had at least one detection of endosulfan that did not meet (exceeded) the ESLOC for fish. There were no detections of endosulfan in 2011. During 2009-2011 in Brender Creek, detections of endosulfan sulfate (endosulfan degradate) did not meet the ESLOC for fish.

In July 2010, EPA signed an agreement with the makers of endosulfan to phase out all uses of endosulfan by July 2016. In addition, EPA requires new mitigation measures during the phase-out period, including canceling aerial use and specifying other application methods, extending restricted entry intervals, extending pre-harvest intervals, and reducing maximum single and/or seasonal application rates (EPA, 2010a).

Endosulfan is a broad-spectrum contact insecticide and acaricide registered for use on a wide variety of vegetables, fruits, cereal grains, ornamental shrubs, and trees. Agricultural uses in the Wenatchee-Entiat basins include use on apples, apricots, blueberries, cherries, Christmas trees, grapes, nectarines, peaches, and pears.

During 2007-2011, significant decreases in total endosulfan concentrations were seen in Brender Creek (Figure 53).

Malathion

During 2009 in the Skagit-Samish basin, two detections of malathion did not meet (exceeded) the ESLOC for fish, one at upstream Big Ditch and one in Indian Slough.

During 2011 in Marion Drain in the Yakima basin, one malathion detection did not meet the ESLOC for fish.

Malathion is a broad-spectrum organophosphate insecticide used widely in agriculture and regional pest eradication programs. Non-agricultural use includes use on ornamentals, vegetable gardens, fruit trees, turf, ornamentals, domestic and commercial structures, pastures, golf courses, rights-of-way, and rangeland.

Possible agricultural use in the Skagit-Samish basin includes use on barley, beets, blueberries, corn, cucumbers, grass hay, ornamentals, potatoes, pumpkins, spinach, strawberries, wheat, pasture, as well as around farm buildings.

Possible agricultural use in the Marion Drain sub-basin includes use on alfalfa, apricots, asparagus, barley, beans, blueberries, cantaloupe, cherries, corn, cucumbers, grapes, hops, mint, nectarines, nursery, oats, onions, pasture, pears, peppers, potatoes, pumpkin, squash, timothy, tomatoes, watermelon, and wheat, as well as around animal quarters and agricultural buildings.

Methiocarb

During March 2009 in Longfellow Creek, methiocarb detections could be of chronic concern to aquatic invertebrates. Methiocarb is not registered for homeowner use (Washington State University, 2012). Applicable registered uses in this basin include commercial use in nurseries, greenhouses, and ornamental use, as well as for insect control around buildings.

Conclusions

Results of this 2009-2011 study support the following conclusions:

- The majority of detected pesticides met (did not exceed) water quality assessment criteria or standards.
- When pesticide mixtures were of concern to aquatic life, it was generally due to a high concentration of a single pesticide (68% of the time) in the mixture that did not meet a water quality assessment criterion or standard.
- The major factors that influence the number and type of pesticides detected were season and timing of pesticide application for specific crops. Rainfall and flow were significant but less influential.
- Each of the four project areas has a characteristic set of pesticides detected, and pesticide detections are likely related to pesticide usage. Each project area was chosen to represent a particular land use (urban, western Washington agriculture, irrigated crop agriculture, and tree-fruit agriculture).
- Herbicides were the most frequently detected pesticides in all areas except the Wenatchee-Entiat basins where insecticides and insecticide degradates were the most frequently detected pesticides.
- For the urban sites, May 2009 methiocarb detections in Longfellow Creek may have been of chronic concern to aquatic invertebrates, a food source for salmon.
- In the Skagit-Samish basin, July 2011 concentrations of bifenthrin at the upstream Big Ditch site were of chronic concern for fish and aquatic invertebrates (prey base for salmon).
- The Lower Yakima basin sites had the greatest number of current-use pesticide detections that did not meet water quality standards or assessment criteria. The greatest concern is for acute and chronic risk to aquatic invertebrates in Spring Creek and Sulphur Creek Wasteway (especially for chlorpyrifos), and for chronic risk to aquatic invertebrates in Marion Drain.
- Endosulfan levels at the Wenatchee basin sites (especially Brender Creek) indicate chronic aquatic health concerns. But endosulfan detections in the Wenatchee basin and concentrations of endosulfan in Brender Creek appear to be decreasing.
- Consistent detections of total DDT indicate chronic health concerns for aquatic life (e.g., fish and aquatic invertebrates) in Brender Creek. There is a moderately strong relationship between total DDT and total suspended solids (TSS); therefore, reductions in TSS would likely lead to lower DDT concentrations.
- Brender Creek chlorpyrifos concentrations were at times of acute and chronic concern for aquatic life.
- Brender Creek had the most pesticide detections per sample event and the greatest number of pesticides detections not meeting criteria or standards.

- Significant decreasing trends in pesticide concentrations were seen at the following sites:
  - Thornton Creek: diazinon, diuron, mecoprop (MCPP), triclopyr.
  - Upstream Big Ditch: picloram, tebuthiuron.
  - Downstream Big Ditch: bentazon, eptam, metalaxyl, picloram.
  - Indian Slough: tebuthiuron.
  - Browns Slough: diuron, simazine.
  - Downstream Spring Creek: azinphos-methyl, diuron, simazine.
  - Marion Drain: atrazine, chlorpyrifos, clopyralid, simazine.
  - Sulphur Creek Wasteway: azinphos-methyl, diuron, norflurazon.
  - Brender Creek: total endosulfan.
- Significant increasing trends in pesticide concentrations were seen at the following sites:
  - Downstream Big Ditch: chlorpropham, MCPA.
  - Indian Slough: hexazinone, metolachlor.
  - Browns Slough: DCPA, MCPA, metolachlor.
  - Upstream and downstream Spring Creek: dicamba I.
  - Marion Drain: dicamba I, ethoprop, pendimethalin, terbacil, trifluralin.
  - Sulphur Creek Wasteway: DCPA, dicamba I, MCPA, pendimethalin.
- None of the project area sites consistently met standards for water temperature.
- In the Skagit-Samish basin, high water temperatures and low dissolved oxygen levels are of concern for the fisheries resource in Indian Slough, Browns Slough, and Big Ditch.
- In the Lower Yakima basin, an increase in TSS was observed at the upstream Spring Creek site, while the downstream site showed a decreasing trend in TSS.
- Per the 2006-2008 report recommendations, the field and laboratory blank detection issue with the carbamate laboratory analysis was resolved in 2010. New laboratory instrumentation allowed for greater detection accuracy by providing confirmation of detected analytes.
- Per the 2006-2008 report recommendations, toxic units were used to evaluate toxicity of pesticide mixtures on aquatic invertebrates and salmonids. This method used an additive toxicity model to determine toxic unit values. Toxic unit values were compared to acute and chronic assessment criteria and standards for invertebrates and fish in order to determine toxicity of pesticide mixtures.
- The surface water monitoring data collected annually during 2003-2011 allow WSDA to investigate pesticide-use trends as part of its pesticide management strategy. The trend analysis and annual monitoring will continue to aid WSDA in tracking pesticide-use trends and addressing potential water quality issues related to pesticides.
- These data also allow WSDA to continue to meet its obligations to EPA and NMFS (per the State Initiated Plan for ESA protection under FIFRA) by providing pesticide data and data analysis products.

Recommendations

Results of this 2009-2011 study support the following recommendations and actions:

- WSDA will add five pesticides with increasing trends to its list of Pesticides of Concern: dicamba I, hexazinone, metolachlor, terbacil, and trifluralin. WSDA uses the Pesticides of Interest Tracking System (POINTS) to identify those pesticides under further review and evaluation for environmental problems. After an initial evaluation, a Pesticide of Interest that shows potential to contaminate surface water or groundwater, or otherwise impact the environment can be reclassified as a Pesticide of Concern, triggering additional analysis by WSDA.
- While DCPA (dacthal), MCPA, and pendimethalin have already been evaluated by POINTS; these pesticides will be included in WSDA's Pesticide of Concern category due to increasing trends.
- Ecology and WSDA should evaluate the need for:
    - Adding new pesticides to the monitoring program. Usage data for sampling areas should be reviewed to better align with the list of analytes.
    - Discontinuing sampling at the high-flow Wenatchee-Entiat sites and replacing these sites with lower flow sites in tree-fruit agricultural areas.
    - Shortening the sampling season for select pesticides in Marion Drain by two weeks. No pesticides were detected in Marion Drain the last two weeks in October during 2009-2011.

This page is purposely left blank

References

Anderson, P., D. Dugger, and C. Burke, 2007. Surface Water Monitoring Program for Pesticides in Salmonid-Bearing Streams, 2006 Monitoring Data Summary. Washington State Department of Ecology, Olympia, WA. Publication No. 07-03-016. https://fortress.wa.gov/ecy/publications/SummaryPages/0703016.html

Anderson, P. and D. Dugger, 2008. Surface Water Monitoring Program for Pesticides in Salmonid-Bearing Streams, 2007 Data Summary. Washington State Department of Ecology, Olympia, WA. Publication No. 08-03-009. https://fortress.wa.gov/ecy/publications/SummaryPages/0803009.html

Anderson, P. and D. Sargeant, 2009. Addendum 3 to Quality Assurance Project Plan: Washington State Surface Water Monitoring Program for Pesticides in Salmonid Habitat for Two Index Watersheds. Washington State Department of Ecology, Olympia, WA. Publication No. 03-03-104ADD3. https://fortress.wa.gov/ecy/publications/summarypages/0303104add3.html

Anderson, P and D. Sargeant, 2010. Environmental Assessment Program Standard Operating Procedures for Sampling of Pesticides in Surface Waters Version 2.0 Revised: April 21, 2010. Washington State Department of Ecology, Olympia, WA. SOP Number EAP003. www.ecy.wa.gov/programs/eap/quality.html.

APHA, 2005. Standard Methods for the Analysis of Water and Wastewater, 21st Edition. Joint publication of the American Public Health Association, American Water Works Association, and Water Environment Federation. www.standardmethods.org.

Aroner, E., 2012. WQHydro-Water Quality/ Hydrology/ Graphics/ Analysis Package. Version 2012. Aug. 11; Portland, OR.

Brouillard, E., 2012. Electronic communication. October 2012. From Elaine Brouillard, Water Quality Specialist for Roza Irrigation District and Sunnyside Valley Irrigation District, Roza-Sunnyside Board of Joint Control, Sunnyside, WA.

Burke, C. and P. Anderson, 2006. Addendum to the Quality Assurance Project Plan for Surface Water Monitoring Program for Pesticides in Salmonid-Bearing Streams, Addition of the Skagit-Samish Watersheds and Extension of the Program Through June 2009. Washington State Department of Ecology, Olympia, WA. Publication No. 03-03-104ADD. https://fortress.wa.gov/ecy/publications/summarypages/0303104add.html

Burke, C., P. Anderson, D. Dugger, and J. Cowles, 2006. Surface Water Monitoring Program for Pesticides in Salmonid-Bearing Streams, 2003-2005: A Cooperative Study by the Washington State Departments of Ecology and Agriculture. Washington State Departments of Agriculture and Ecology, Olympia, WA. Publication No. 06-03-036. https://fortress.wa.gov/ecy/publications/summarypages/0603036.html

Carter, K., 2008. Effects of Temperature, Dissolved Oxygen/Total Dissolved Gas, Ammonia, and pH on Salmonids, Implications for California's North Coast TMDLs. California Regional Water Quality Control Board, North Coast Region.

Christensen, K.; Harper, B.; Luukinen, B.; Buhl, K.; Stone, D., 2009. Chlorpyrifos Technical *Fact Sheet*; National Pesticide Information Center, Oregon State University Extension Services. http://npic.orst.edu/factsheets/chlorptech.pdf.

Dugger, D., P. Anderson, and C. Burke, 2007. Addendum to Quality Assurance Project Plan: Surface Water Monitoring Program for Pesticides in Salmonid-Bearing Streams: Addition of Wenatchee and Entiat Watersheds in the Upper Columbia Basin. Washington State Department of Ecology, Olympia, WA. Publication No. 03-03-104ADD#2. https://fortress.wa.gov/ecy/publications/summarypages/0303104add2.html

Ecology, 2000. Focus Sheet entitled Effects of Elevated Water Temperatures on Salmonids, July 2000. Water Quality Program. Washington State Department of Ecology, Olympia, WA. Publication No. 00-10-046. https://fortress.wa.gov/ecy/publications/SummaryPages/0010046.html

Ecology, 2002. Focus Sheet entitled Dissolved Oxygen and the Water Quality Standards, January 2002. Water Quality Program. Washington State Department of Ecology, Olympia, WA. Publication No. 02-10-001. https://fortress.wa.gov/ecy/publications/SummaryPages/0210001.html

Ecology, 2008. Excel spreadsheet entitled Guidance for Calculating "Total" Values of Selected Analytes for the EAP Toxics Studies Unit and EIM Parameters to Use. Dated November 3, 2008. Toxics Studies Unit SharePoint site, Environmental Assessment Program, Washington State Department of Ecology, Olympia, WA.

Ecology, 2012. Water Quality Program Policy 1-11, Revised: July 2012, Assessment of Water Quality for the Clean Water Act Sections 303(d) and 305(b) Integrated Report. Water Quality Program, Washington State Department of Ecology, Olympia, WA. www.ecy.wa.gov/programs/wq/303d/WQpolicy1-11ch1.pdf.

Embrey, S.S. and L.M. Frans, 2003. Surface-Water Quality of the Skokomish, Nooksack, and Green-Duwamish Rivers and Thornton Creek, Puget Sound Basin, Washington, 1995-1998. U.S. Geological Survey, Water Resources Investigations Report 02-4190.

EPA, 1990. Specifications and Guidance for Obtaining Contaminant-Free Sample Containers. U.S. Environmental Protection Agency. OSWER Directive #93240.0-05.

EPA, 1998a. Registration Eligibility Determination (RED) Facts Dichlobenil. U.S. Environmental Protection Agency. Offices of Prevention, Pesticides and Toxic Substances. EPA-738-F-98-005, October 1998.

EPA, 1998b. R.E.D. FACTS Triclopyr. U.S. Environmental Protection Agency. Offices of Prevention, Pesticides and Toxic Substances. EPA-738-F-98-007, October 1998. www.epa.gov/oppsrrd1/REDs/factsheets/2710fact.pdf.

EPA, 1999. Contract Laboratory Program National Functional Guidelines for Organic Data Review. U.S. Environmental Protection Agency. EPA 540/R-99/008. www.epa.gov/superfund/programs/clp/download/fgorg.pdf.

EPA, 2002. Atrazine, Bensulide, Diphenamid; Imazalil, 6-Methyl-1,3-dithiolo[4,5-b] quinoxalin-2-one, Phosphamidon S-Propyl dipropylthiocarbamate, and Trimethacarb; Tolerance Revocations. U. S. Environmental Protection Agency docket ID: EPA-HQ-OPP-2002-0085-0001. http://pmep.cce.cornell.edu/profiles/herb-growthreg/dalapon-ethephon/diphenamid/diphenamid_tol_602.html.

EPA, 2006a. National Recommended Water Quality Criteria listings. U.S. Environmental Protection Agency. Accessed May 2008. www.epa.gov/waterscience/criteria/wqcriteria.html.

EPA, 2006b. Final Decisions for the Remaining Uses of Azinphos-methyl, November 16, 2006. U.S. Environmental Protection Agency. Offices of Prevention, Pesticides and Toxic Substances, D.C. Document ID: EPA-HQ-OPP-2005-0061-0207 Docket ID: EPA-HQ-OPP-2005-0061. www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2005-0061-0207

EPA, 2007a. Registration Eligibility Decision (RED) for Mecoprop-p (mcpp). U.S. Environmental Protection Agency. Offices of Prevention, Pesticides and Toxic Substances. EPA-738-R-07-009. www.epa.gov/oppsrrd1/REDs/mcpp_red.pdf.

EPA, 2007b. USEPA Contract Laboratory Program. National Functional Guidelines for Superfund Organic Methods Data Review. U.S. Environmental Protection Agency. EPA-540-R-04-009. www.epa.gov/superfund/programs/clp/download/somnfg.pdf.

EPA, 2010a. Pesticides: Reregistration, Endosulfan Phase-out. U.S. Environmental Protection Agency. Office of Pesticide Programs website. Accessed October 2012 at www.epa.gov/pesticides/reregistration/endosulfan/endosulfan-agreement.html

EPA, 2010b. Bifenthrin Summary Document Registration Review: Initial Docket June 2010. U.S. Environmental Protection Agency. Prevention, Pesticide Re-evaluation Division. Docket number EPA-HQ-OPP-2010-0384. Document ID: EPA-HQ-OPP-2010-0384-0003. www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2010-0384-0003.

Fecko, A., 1999. Environmental Fate of Bifenthrin. Environmental Monitoring and Pest Management Branch, Department of Pesticide Regulation, Sacramento, CA. December 1999. www.pw.ucr.edu/textfiles/bifentn.pdf.

Freudenthal, J., D. Lind, R. Visser, and P. Mess, 2005. Yakima Subbasin Salmon Recovery Plan, Draft October 19, 2005. Prepared for the Yakima Subbasin Fish and Wildlife Planning Board. www.co.benton.wa.us/docview.aspx?docid=10303.

Gervais, J.A., B. Luukinen, K. Buhl, and D. Stone, 2010. Imidacloprid Technical Fact Sheet; National Pesticide Information Center, Oregon State University Extension Services. http://npic.orst.edu/factsheets/imidacloprid.pdf.

Harper, B.; Luukinen, B.; Gervais, J. A.; Buhl, K.; Stone, D., 2009. Diazinon Technical Fact *Sheet*; National Pesticide Information Center, Oregon State University Extension Services. http://npic.orst.edu/factsheets/diazinontech.pdf.

Johnson, A. and J. Cowles, 2003. Quality Assurance Project Plan: Washington State Surface Water Monitoring Program for Pesticides in Salmonid Habitat for Two Index Watersheds: A Study for the Washington State Department of Agriculture Conducted by the Washington State Department of Ecology. Washington State Department of Ecology, Olympia, WA. Publication No. 03-03-104. https://fortress.wa.gov/ecy/publications/SummaryPages/0303104.html.

Johnson, M.; Luukinen, B.; Gervais, J.; Buhl, K.; Stone, D., 2010. Bifenthrin Technical Fact *Sheet*; National Pesticide Information Center, Oregon State University Extension Services. http://npic.orst.edu/factsheets/biftech.pdf.

Kerwin, John and Nelson, Tom S. (Eds.). December 2000. Habitat Limiting Factors and Reconnaissance Assessment Report, Green/Duwamish and Central Puget Sound Watersheds (WRIA 9 and Vashon Island). Washington Conservation Commission and the King County Department of Natural Resources.

King County Road Services, 2012. Electronic communication from Glenn Bagley, Vegetation Crew Chief, King County Road Services, Seattle, WA. October 2012.

Laetz, C., D. Baldwin, T. Collier, V. Hebert, J. Stark, and N. Scholz, 2009. The Synergistic Toxicity of Pesticide Mixtures; Implications for Risk Assessment and the Conservation of Endangered Pacific Salmon. Environmental Health Perspectives, Volume 117/Number 3/ March 2009.

Lydy, M., J. Belden, C. Wheelock, B. Hammock, and D. Denton, 2004. Challenges in Regulating Pesticide Mixtures. Ecology and Society 9(6): 1. www.ecologyandsociety.org/vol9/iss6/art1.

Mathieu, N., 2006. Replicate Precision for 12 TMDL Studies and Recommendations for Precision Measurement Quality Objectives for Water Quality Parameters. Washington State Department of Ecology, Olympia, WA. Publication No. 06-03-044. https://fortress.wa.gov/ecy/publications/summarypages/0603044.html.

MEL, 2000. Standard Operating Procedure for Pesticides Screening and Compound Independent Elemental Quantitation by Gas Chromatography with Atomic Emission Detection (AED), Method 8085, version 2.0. Manchester Environmental Laboratory, Washington State Department of Ecology, Manchester, WA.

MEL, 2012. Manchester Environmental Laboratory Quality Assurance Manual. Manchester Environmental Laboratory, Washington State Department of Ecology, Manchester, WA.

Microsoft Corporation, 2007. Microsoft Office XP Professional, Version 10.0. Microsoft Corporation.

Nelson, R., 2012. Personal communication from Randy Nelson, Skagit County Public Works, Mount Vernon, WA. February 24, 2012.

NPIC, 2011. National Pesticide Information Center website on Pentachlorophenol Wood Preservatives, May 2011. http://npic.orst.edu/ingred/ptype/treatwood/penta.html

R Foundation for Statistical Computing, 2010. The R Project for Statistical Computing, at www.r-project.org.

Rantz et al., 1983. Measurement and Computation of Streamflow. Volume 1: Measurement of Stage and Discharge. Volume 2: Computation of Discharge. Water Supply Paper 2175. http://pubs.er.usgs.gov/usgspubs/wsp/wsp2175.

Sargeant, D., D. Dugger, E. Newell, P. Anderson, and J. Cowles, 2010. Surface Water Monitoring Program for Pesticides in Salmonid-Bearing Streams, 2006-2008 Triennial Report. Washington State Departments of Agriculture and Ecology, Olympia, WA. Publication No. 10-03-008. https://fortress.wa.gov/ecy/publications/summarypages/1003008.html.

Sargeant, D., 2011. Surface Water Monitoring Program for Pesticides in Salmon-Bearing Streams: DH-81 and Grab Sample Comparison Study. Washington State Departments of Agriculture and Ecology, Olympia, WA. Publication No. 11-03-066. https://fortress.wa.gov/ecy/publications/SummaryPages/1103066.html.

Sargeant, D., D. Dugger, P. Anderson, and E. Newell, 2011. Surface Water Monitoring Program for Pesticides in Salmonid-Bearing Streams, 2009 Data Summary. Washington State Departments of Agriculture and Ecology, Olympia, WA. Publication No. 11-03-004. https://fortress.wa.gov/ecy/publications/SummaryPages/1103004.html.

Swanson, T., 2010. Standard Operating Procedure (SOP) for Hydrolab® DataSonde® and MiniSonde® Multiprobes, Version 1.0. Washington State Department of Ecology, Olympia, WA. SOP Number EAP033. www.ecy.wa.gov/programs/eap/quality.html.

Vecchia, A.V., J.D. Martin, and R.J. Gilliom, 2008. Modeling Variability and Trends in Pesticide Concentrations in Streams. Journal of the American Water Resources Association, vol. 44, no. 5.

Voss, F.D, S. Embrey, and J. Ebbert, 1999. Pesticides Detected in Urban Streams During Rainstorms and Relations to Retail Sales of Pesticides in King County, Washington. U.S. Geological Survey Fact Sheet 097-99, Tacoma, WA.

Wagner, R.J., H.C. Mattraw, G.F. Ritz, and B.A. Smith, 2000. Guidelines and standard procedures for continuous water-quality monitors: site selection, field operation, calibration, record computation, and reporting. U.S. Geological Survey Water Resources Investigations Report 00-4252.

Ward, W., 2007. Standard Operating Procedures (SOP) for the Collection and Analysis of Dissolved Oxygen (Winkler Method). Washington State Department of Ecology, Olympia, WA. www.ecy.wa.gov/programs/eap/qa/docs/ECY_EAP_SOP_CollectionandAnalysisofDOWinklerMethod_v2_1EAP023.pdf.

Washington State Department of Agriculture (WSDA), 2011. Washington State Department of Agriculture, 2008 Cropland Geodatabase. Accessed by Kelly McLain, Pesticide Use and Water Quality Specialist, Office of the Director-Natural Resource Assessment, WSDA, Olympia, WA.

Washington State University, 2012. PICOL database accessed October 2012. Washington State University's label database. Puyallup Research and Extension Center, 2606 West Pioneer, Puyallup, WA. http://cru66.cahe.wsu.edu/LabelTolerance.html.

West Seattle Golf Course, 2012. Personal communication with John Price, West Seattle Golf Course, Seattle, WA. October 2012.

WSDOT, 2003. 2,4-D Roadside Vegetation management Fact Sheet developed by Oregon State University and Intertox, Inc. July 2003. Washington State Department of Transportation, Olympia, WA. www.wsdot.wa.gov/NR/rdonlyres/C6CBCC5B-64F8-4017-A209-9C6116EB36DB/0/2_4D.pdf.

WSDOT, 2006a. Dichlobenil Roadside Vegetation Management Fact Sheet developed by Oregon State university and Intertox, Inc. February 2006. Washington State Department of Transportation, Olympia, WA. www.wsdot.wa.gov/NR/rdonlyres/37DC03D2-3E93-4A36-AF6A-F08066A3A6BB/0/dichlobenil.pdf.

WSDOT, 2006b. Bromacil Roadside Vegetation Management Fact Sheet developed by Oregon State University and Intertox, Inc. February 2006. Washington State Department of Transportation, Olympia, WA. www.wsdot.wa.gov/NR/rdonlyres/7004073D-DBAD-4BBA-B32D-04082C699136/0/bromacil.pdf.

Appendices

Appendix A. Glossary, Acronyms, and Abbreviations

Glossary

Analyte: Water quality constituent being measured (parameter).

Assessment criteria: Assessment criteria in this report are numeric criteria included in the EPA Federal Insecticide Fungicide and Rodenticide Act (FIFRA) Pesticide Registration Toxicity Criteria and endpoints; and the EPA National Recommended Water Quality Criteria (NRWQC).

Basin: Watershed. A drainage area in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

Bioaccumulation: Progressive increase in the amount of a substance in an organism or part of an organism which occurs because the rate of intake exceeds the organism's ability to remove the substance from the body.

Carbamate insecticide: N-methyl carbamate insecticides are similar to organophosphate insecticides in that they are nerve agents that inhibit cholinesterase enzymes. However they differ in action from the organophosphate compounds in that the inhibitory effect on cholinesterase is brief.

Clean Water Act: A federal act passed in 1972 that contains provisions to restore and maintain the quality of the nation's waters. Section 303(d) of the Clean Water Act establishes the TMDL program.

Conductivity: A measure of water's ability to conduct an electrical current. Conductivity is related to the concentration and charge of dissolved ions in water.

Degradate: Pesticide breakdown product.

Dissolved oxygen (DO): A measure of the amount of oxygen dissolved in water.

Endosulfan: An organochlorine insecticide that is registered for use on a number of agricultural commodities. In 2010, EPA signed an agreement with the registrants of endosulfan that will result in voluntary cancellation and phase out of all existing endosulfan uses in the United States. Under this agreement, all endosulfan uses will be phased out by July 2016. EPA is terminating uses of endosulfan to address its unacceptable risks to agricultural workers and wildlife (EPA, 2010).

Endpoint: Criteria.

Exceeded criteria: Did not meet criteria.

Grab sample: A discrete sample from a single point in the water column or sediment surface.

Herbicide: A substance used to kill plants or inhibit their growth.

Legacy pesticide: A pesticide that is no longer registered for use but persists in the environment.

Loading: The input of pollutants into a waterbody.

Marine water (seawater): Salt water.

Organophosphate pesticide: Pesticide derived from phosphoric acid and are highly neurotoxic, typically inhibiting cholinesterase.

Parameter: Water quality constituent being measured (analyte). A physical, chemical, or biological property whose values determine environmental characteristics or behavior.

Pesticide: Any substance or mixture of substances intended for killing, repelling or mitigating any pest. Pests include nuisance microbes, plants, fungus, and animals.

Pesticide Synergist: A natural or synthetic chemical which increases the lethality and effectiveness of currently available pesticides.

pH: A measure of the acidity or alkalinity of water. A low pH value (0 to 7) indicates that an acidic condition is present, while a high pH (7 to 14) indicates a basic or alkaline condition. A pH of 7 is considered to be neutral. Since the pH scale is logarithmic, a water sample with a pH of 8 is ten times more basic than one with a pH of 7.

Point source: Sources of pollution that discharge at a specific location from pipes, outfalls, and conveyance channels to a surface water. Examples of point source discharges include municipal wastewater treatment plants, municipal stormwater systems, industrial waste treatment facilities, and construction sites that clear more than 5 acres of land.

Pollution: Contamination or other alteration of the physical, chemical, or biological properties of any waters of the state. This includes change in temperature, taste, color, turbidity, or odor of the waters. It also includes discharge of any liquid, gaseous, solid, radioactive, or other substance into any waters of the state. This definition assumes that these changes will, or are likely to, create a nuisance or render such waters harmful, detrimental, or injurious to (1) public health, safety, or welfare, or (2) domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or (3) livestock, wild animals, birds, fish, or other aquatic life.

Salmonid: Fish that belong to the family *Salmonidae*. Basically, any species of salmon, trout, or char. www.fws.gov/le/ImpExp/FactSheetSalmonids.htm

Suspended sediment: Solid fragmented material (soil and organic matter) in the water column.

Synergistic effects: An effect which occurs when the combined effects of two chemicals are greater than the predicted sum of each chemical’s effects.

Total Maximum Daily Load (TMDL): Water cleanup plan. A distribution of a substance in a waterbody designed to protect it from exceeding water quality standards. A TMDL is equal to the sum of all of the following: (1) individual wasteload allocations for point sources, (2) the load allocations for nonpoint sources, (3) the contribution of natural sources, and (4) a Margin of Safety to allow for uncertainty in the wasteload determination. A reserve for future growth is also generally provided.

Total suspended solids (TSS): The suspended particulate matter in a water sample as retained by a filter.

Water quality standards: Washington State water quality standards.

Watershed: Basin. A drainage area in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

303(d) list: Section 303(d) of the federal Clean Water Act requires Washington State periodically to prepare a list of all surface waters in the state for which beneficial uses of the water – such as for drinking, recreation, aquatic habitat, and industrial use – are impaired by pollutants. These are water quality limited estuaries, lakes, and streams that fall short of Washington State surface water quality standards and are not expected to improve within the next two years.

7-DADMax or 7-day average of the daily maximum temperatures: The arithmetic average of seven consecutive measures of daily maximum temperatures. The 7-DADMax for any individual day is calculated by averaging that day's daily maximum temperature with the daily maximum temperatures of the three days prior and the three days after that date.

Acronyms and Abbreviations

7-DADMax	7-day average of the daily maximum temperatures
AChE	Acetylcholinesterase
DCPA	Dacthal
DDD	Dichloro-diphenyl-dichloroethane (a degradate of DDT)
DDE	Dichloro-diphenyl-dichloroethylene (a degradate of DDT)
DDT	Dichloro-diphenyl-trichloroethane
DO	(See Glossary above)
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management (Ecology)
EPA	United States Environmental Protection Agency
ESLOC	Endangered Species Level of Concern (EPA)
FIFRA	Federal Insecticide Fungicide and Rodenticide Act
GCMS	Gas chromatograph coupled with mass spectrometer
LC_{50}	Lethal concentration to cause mortality in 50% of test species
LCMS	Liquid chromatograph coupled with mass spectrometer
LCMS/MS	Liquid chromatograph coupled with tandem mass spectrometer
LCS	Laboratory control sample
LOC	Level of concern
LOEC	Lowest observed effects concentration
LPQL	Lower practical quantitation limit
MCPA	2-methyl-4-chlorophenoxyacetic acid
MCPP	Mecoprop-p
MEL	Manchester Environmental Laboratory
MLE	Maximum likelihood estimation
MQO	Measurement quality objective
MS	Mass spectrometer
MS/MSD	Matrix spike/matrix spike duplicate
MQO	Measurement quality objective
NAD	North American Datum

n	Number
NRWQC	National Recommended Water Quality Criteria (EPA)
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NOEC	No observable effect concentration
QA	Quality assurance
QC	Quality control
RPD	Relative percent difference
RQ	Risk quotient
RSD	Relative standard deviation
SOP	Standard operation procedures
TMDL	(See Glossary above)
TSS	(See Glossary above)
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WAC	Washington Administrative Code
WRIA	Water Resource Inventory Area
WSDA	Washington State Department of Agriculture

Units of Measurement

°C	degrees centigrade
cfs	cubic feet per second
m	meter
mg/L	milligrams per liter (parts per million)
s.u.	standard units
TU	toxic unit
µg/L	micrograms per liter (parts per billion)
umhos/cm	micromhos per centimeter

Appendix B. Monitoring Sites and Duration of Sampling

Table B-1. Site names, monitoring periods, and site descriptions for 2009-2011.

Site	Duration	Latitude	Longitude	Location Description
Cedar-Sammamish Watershed				
TC-3	March– September	47.6958	122.2757	Downstream of pedestrian footbridge near Matthews Beach Park.
Green-Duwamish Watershed				
LC-1	March– September	47.5625	122.367	Upstream of the culvert under the 12th fairway on the West Seattle Golf Course.
Skagit-Samish Watershed				
BD-1	March– September	48.3086	122.3473	Upstream side of bridge at Milltown Road.
BD-2	March– September	48.3887	122.3329	Upstream side of bridge at Eleanor Lane.
BS-1	March– September	48.3406	122.4140	Downstream of tidegate on Fir Island Road.
IS-1	March– September	48.4506	122.4651	Inside upstream side of tidegate at Bayview-Edison Road.
SR-1	March– September	48.5209	122.4113	Upstream side of bridge at Thomas Road.
Lower Yakima Watershed				
MA-2	March– October	46.3306	120.1989	Approximately 15 meters upstream of bridge at Indian Church Road.
SP-2	March– September	46.2583	119.7101	Downstream side of culvert on McCreadie Road.
SP-3	March– September	46.2344	119.6845	Approximately 3 meters downstream of Chandler Canal overpass.
SU-1	March– September	46.2509	120.0202	Downstream side of bridge at Holaday Road.
Wenatchee Watershed				
WE-1	March– September	47.4721	120.3710	Upstream side of Sleepy Hollow bridge.
MI-1	March– September	47.4893	120.4815	Mission Creek Road off of Trip Canyon Road.
PE-1	March– September	47.5570	120.5825	Approximately 30 meters downstream of bridge at Saunders Road.
BR-1	March– September	47.5211	120.4862	Upstream side of culvert at Evergreen Drive.
Entiat Watershed				
EN-1	March– September	47.6633	120.2506	Upstream side of bridge at Keystone Road.

Datum in North American Datum (NAD) 83.

Appendix C. Land Use Area Estimates and Crop Totals for Agricultural Sites

Reference: Crop totals based on the 2011 crop geodatabase. Washington State Department of Agriculture, Olympia Washington.

Table C-1. Land use estimates and crop totals for Lower Skagit-Samish WRIA 3.

Site and Land Use	Area (acres)	Watershed Percent Area
Big Ditch		
Apple	1.2	0.01%
Bean, Green	4.2	0.05%
Beet Seed	70.5	0.88%
Blueberry	8.2	0.10%
Cabbage Seed	16.7	0.21%
Caneberry	42.1	0.53%
Carrot	115	1.43%
Corn, Field	587	7.32%
Corn, Sweet	20.4	0.25%
Cucumber	84.7	1.06%
Developed	30.8	0.38%
Fallow	113	1.41%
Fescue Seed	34.9	0.44%
Golf Course	48.2	0.60%
Grape, Wine	4.8	0.06%
Grass Hay	773	9.65%
Nursery, Greenhouse	16.2	0.20%
Nursery, Ornamental	67.5	0.84%
Pasture	70.8	0.88%
Pear	0.6	0.01%
Potato	1012	12.63%
Ryegrass Seed	47.1	0.59%
Spinach Seed	83.9	1.05%
Strawberry	31.4	0.39%
Triticale	44.2	0.55%
Wheat	797	9.94%
Wildlife Feed	35.0	0.44%
Total Agricultural Area	4160	51.92%
Watershed Area	8012	
Indian Slough		
Barley	27.3	0.54%
Beet Seed	1.4	0.03%
Blueberry	202	4.02%

Site and Land Use	Area (acres)	Watershed Percent Area
Caneberry	32.9	0.66%
Corn, Field	16.1	0.32%
Cucumber	1.9	0.04%
Fallow	65.5	1.30%
Golf Course	74.4	1.48%
Grass Hay	533	10.61%
Market Crops	20.2	0.40%
Nursery, Ornamental	103	2.05%
Pasture	140	2.79%
Potato	923	18.36%
Pumpkin	8.6	0.17%
Ryegrass Seed	49.2	0.98%
Sod Farm	38.4	0.77%
Spinach Seed	95.7	1.90%
Strawberry	84.4	1.68%
Tulip	22.6	0.45%
Wheat	217	4.32%
Total Agricultural Area	2657	52.87%
Watershed Area	5025	
Browns Slough		
Barley	57.8	1.68%
Beet Seed	31.9	0.93%
Broccoli	62.5	1.82%
Caneberry	15.5	0.45%
Clover Hay	26.2	0.76%
Corn, Field	627	18.20%
Cucumber	76.5	2.22%
Fallow	77.5	2.25%
Grass Hay	227	6.60%
Market Crops	8.5	0.25%
Nursery, Ornamental	21.6	0.63%
Poplar	2.3	0.07%
Potato	1167	33.88%
Spinach Seed	183	5.32%
Strawberry	5.3	0.15%
Triticale	7.3	0.21%
Wheat	560	16.28%
Total Agricultural Area	3158	91.70%
Watershed Area	3443	
Samish River		
Apple	8.3	0.01%
Barley	107	0.16%
Blueberry	38.3	0.06%

Site and Land Use	Area (acres)	Watershed Percent Area
Broccoli	30.0	0.05%
Caneberry	170	0.26%
Corn, Field	947	1.45%
Corn, Sweet	5.7	0.01%
CRP/Conservation	11.5	0.02%
Fallow	124	0.19%
Golf Course	132	0.20%
Grass Hay	1581	2.43%
Market Crops	7.0	0.01%
Nursery, Ornamental	48.6	0.07%
Oat	68.9	0.11%
Pasture	1188	1.83%
Potato	1281	1.97%
Pumpkin	33.4	0.05%
Sod Farm	130	0.20%
Spinach Seed	53.4	0.08%
Strawberry	22.8	0.04%
Tea	6.8	0.01%
Wheat	260	0.40%
Total Agricultural Area	6256	9.61%
Watershed Area	65075	

Table C-2. Land use estimates and crop totals for Lower Yakima WRIA 37.

Site and Land Use	Area (acres)	Watershed Percent Area
Marion Drain		
Alfalfa Hay	3983	4.95%
Alfalfa/Grass Hay	1268	1.58%
Apple	7341	9.12%
Apricot	71.7	0.09%
Artichoke	16.3	0.02%
Asparagus	1091	1.36%
Barley	91.8	0.11%
Bean, Dry	233	0.29%
Bean, Green	16.2	0.02%
Blueberry	12.9	0.02%
Cantaloupe	14.6	0.02%
Cherry	373	0.46%
Corn, Field	13352	16.59%
Corn, Sweet	626	0.78%
Cucumber	55.6	0.07%
Developed	251	0.31%
Dill	160	0.20%
Driving Range	2.3	0.00%
Fallow	2057	2.56%
Golf Course	82.8	0.10%
Grape, Juice	2888	3.59%
Grape, Wine	9.1	0.01%
Grass Hay	722	0.90%
Green Manure	1.6	0.00%
Hops	8122	10.09%
Market Crops	863	1.07%
Mint	4249	5.28%
Nectarine/Peach	382	0.47%
Nursery, Orchard/Vineyard	127	0.16%
Nursery, Ornamental	33.3	0.04%
Oat	48.4	0.06%
Onion	449	0.56%
Pasture	4060	5.04%
Pear	606	0.75%
Pepper	165	0.21%
Plum	76.4	0.09%
Potato	1140	1.42%
Pumpkin	52.8	0.07%
Squash	143	0.18%
Sudangrass	39.9	0.05%
Timothy	457	0.57%

Site and Land Use	Area (acres)	Watershed Percent Area
Tobacco	156	0.19%
Tomato	42.7	0.05%
Watermelon	4.8	0.01%
Wheat	5542	6.89%
Wildlife Feed	71.4	0.09%
Total Agricultural Area	61553	76.47%
Watershed Area	80489	
Sulphur Creek Wasteway		
Alfalfa Hay	2592	2.52%
Alfalfa/Grass Hay	315	0.31%
Apple	5500	5.34%
Apricot	11.8	0.01%
Asparagus	678	0.66%
Barley	107	0.10%
Blueberry	9.2	0.01%
Caneberry	1.0	0.00%
Cherry	1304	1.27%
Corn Seed	101	0.10%
Corn, Field	8370	8.13%
Corn, Sweet	22.1	0.02%
CRP/Conservation	3674	3.57%
Developed	189	0.18%
Fallow	687	0.67%
Golf Course	101	0.10%
Grape, Juice	7041	6.83%
Grape, Wine	4104	3.98%
Grass Hay	470	0.46%
Green Manure	24.6	0.02%
Hops	1785	1.73%
Market Crops	90.3	0.09%
Mint	823	0.80%
Nectarine/Peach	141	0.14%
Nursery, Orchard/Vineyard	43.3	0.04%
Nursery, Ornamental	108	0.11%
Oat	9.0	0.01%
Pasture	1566	1.52%
Pear	172	0.17%
Plum	32.1	0.03%
Pumpkin	23.4	0.02%
Rye	101	0.10%
Sorghum	39.5	0.04%
Squash	124	0.12%
Sudangrass	525	0.51%

Site and Land Use	Area (acres)	Watershed Percent Area
Tomato	1.7	0.00%
Triticale	23.7	0.02%
Walnut	6.0	0.01%
Wheat	1680	1.63%
Wheat Fallow	1023	0.99%
Total Agricultural Area	43619	42.34%
Watershed Area	103010	
Spring Creek		
Alfalfa Hay	151	0.55%
Apple	970	3.54%
Asparagus	3.8	0.01%
Blueberry	62.7	0.23%
Cherry	506	1.85%
Corn, Field	90.5	0.33%
Corn, Sweet	2.4	0.01%
CRP/Conservation	6542	23.90%
Currant	40.5	0.15%
Developed	12.3	0.04%
Fallow	313	1.14%
Grape, Juice	1527	5.58%
Grape, Wine	2704	9.88%
Grass Hay	41.8	0.15%
Hops	1303	4.76%
Nursery, Orchard/Vineyard	61.1	0.22%
Pasture	746	2.73%
Research Station	444	1.62%
Triticale	13.2	0.05%
Wheat	1909	6.97%
Wheat Fallow	2068	7.56%
Total Agricultural Area	19512	71.28%
Watershed Area	27373	

Table C-3. Land use estimates and crop totals for Wenatchee-Entiat WRIAs 45 and 46.

Site and Land Use	Area (acres)	Watershed Percent Area
Peshastin Creek		
Apple	44.9	0.05%
Cherry	8.5	0.01%
Developed	56.5	0.07%
Fallow	11.8	0.01%
Grass Hay	5.0	0.01%
Pasture	9.2	0.01%
Pear	596	0.69%
Total Agricultural Area	731	0.85%
Watershed Area	86244	
Mission Creek		
Alfalfa/Grass Hay	16.9	0.03%
Apple	36.0	0.07%
Cherry	18.7	0.04%
Christmas Tree	4.4	0.01%
Fallow	48.9	0.09%
Grass Hay	5.4	0.01%
Pasture	10.1	0.02%
Pear	542	1.03%
Total Agricultural Area	682	1.30%
Watershed Area	52387	
Brender Creek		
Apple	121	1.76%
Cherry	74.4	1.08%
Developed	7.9	0.12%
Fallow	32.6	0.48%
Golf Course	34.4	0.50%
Grape, Wine	2.1	0.03%
Pasture	13.3	0.19%
Pear	629	9.16%
Total Agricultural Area	914	13.32%
Watershed Area	6864	
Wenatchee River		
Alfalfa/Grass Hay	82.8	0.01%
Apple	885	0.10%
Apricot	1.9	<0.01%
Blueberry	6.3	<0.01%
Caneberry	1.2	<0.01%
Cherry	574	0.07%
Christmas Tree	4.4	<0.01%
Developed	573	0.07%

Site and Land Use	Area (acres)	Watershed Percent Area
Fallow	438	0.05%
Golf Course	105	0.01%
Grape, Wine	18.0	<0.01%
Grass Hay	122	0.01%
Nectarine/Peach	11.9	<0.01%
Nursery, Lavender	0.8	<0.01%
Nursery, Ornamental	8.3	<0.01%
Pasture	184	0.02%
Pear	6292.7	0.74%
Total Agricultural Area	9310	1.10%
Watershed Area	849910	
Entiat River		
Apple	153	0.06%
Cherry	26.9	0.01%
Christmas Tree	6.1	<0.01%
Developed	69.8	0.03%
Fallow	57.0	0.02%
Grape, Wine	1.1	<0.01%
Grass Hay	14.4	0.01%
Pasture	66.9	0.03%
Pear	535	0.20%
Total Agricultural Area	929	0.35%
Watershed Area	265426	

Appendix D. Monitoring Program Changes, 2003-2011

During the course of the 2003-2011 monitoring program, changes have occurred to the monitoring period and sites to better capture the pesticide application period and pesticide use with the resources available.

Changes have also occurred in laboratory methods and instrumentation and to the suite of laboratory analytes. These laboratory changes have been made to improve data quality with regards to sensitivity and detection limits.

Changes in field and laboratory sampling and analysis are summarized below

Field

2003

In 2003 sampling was exploratory. Nine sites were sampled: three sites in Thornton Creek in the Cedar-Sammamish basin and six sites in the Yakima basin (two on Marion Drain, three on Spring Creek, one on Sulphur Creek Wasteway) (Burke et al., 2006). Sample frequency included 18 sample events with emphasis on spring pesticide use and fall storm events. Samples were analyzed for a wide spectrum of pesticides, TSS, and semivolatile organic compounds. Field measurements were obtained for pH, conductivity, temperature, and flow discharge.

2004

In 2004 six sites were sampled: one site each on Marion Drain and Sulphur Creek Wasteway and two sites on Spring Creek in the Yakima basin; and two sites on Thornton Creek in the Cedar-Sammamish basin. Sample frequency included approximately 31 sample events at the mouth sites with weekly sampling from the end of March through September. Samples were analyzed for a wide spectrum of pesticides and TSS. Field measurements were obtained for pH, conductivity, temperature, and flow discharge.

2005

In 2005 the same six sites in the Yakima and Cedar-Sammamish basins were sampled as in 2004. Sample frequency included approximately 29 sample events at the mouth sites with weekly sampling from March through mid-September; Marion Drain sampling continued for organophosphate pesticides through October. Samples were analyzed for pesticides and TSS. Field measurements were obtained for pH, conductivity, temperature, and flow discharge.

2006

In 2006 the same Yakima and Cedar-Sammamish basin sites were sampled as in 2005. Sites in the Skagit-Samish basin were added to incorporate sampling of western Washington agricultural sites. Five Skagit-Samish basin sites were sampled: one site each on Indian Slough, Browns Slough, and Big Ditch; and two sites on the Samish River. Sample frequency included approximately 24 sample events at the mouth sites with weekly sampling from April through mid-September; Marion Drain sampling continued for organophosphate pesticides through October. Samples were analyzed for pesticides and TSS. Field measurements were obtained for pH, conductivity, temperature, and flow discharge.

2007
In 2007 the same Yakima, Cedar-Sammamish, and Skagit-Samish basin sites were sampled as in 2008, except the upstream site on the Samish River was discontinued due to infrequent pesticide detections. An upstream site on Big Ditch was added in place of the upstream Samish River site. Sites in the Wenatchee-Entiat basin were added to incorporate tree-fruit agricultural sites. There were five Wenatchee-Entiat basin sites: one site each on Brender Creek, Peshastin Creek, Mission Creek, the Wenatchee River, and the Entiat River.

Sample frequency included approximately 31 sample events at the mouth sites with weekly sampling from February through the second week in September; Marion Drain sampling continued for organophosphate pesticides through October. Samples were analyzed for pesticides and TSS. Field measurements were obtained for pH, conductivity, temperature, and flow discharge.

2008
In 2008 sample sites remained the same as in 2007. Sample frequency included approximately 27 sample events at the mouth sites with weekly sampling from the second week in March through the second week in September, Marion Drain sampling continue for organophosphate pesticides through October. Samples were analyzed for a wide spectrum of pesticides and TSS. Field measurements were obtained for pH, conductivity, temperature, DO, and flow discharge.

2009
In 2009 sample sites remained the same as in 2008 except the upstream site on Thornton Creek in the Green-Sammamish basin was discontinued. In its place, a sample site on Longfellow Creek in the Green-Duwamish basin was added to represent an urban area.

Sample frequency included approximately 27 sample events at the mouth sites with weekly sampling from the second week in March through the second week in September; Marion Drain sampling continue for organophosphate pesticides through October. Samples were analyzed for pesticides and TSS. Field measurements were obtained for pH, conductivity, temperature, DO, and flow discharge.

2010
In 2010 sample sites remained the same as in 2009. Sample frequency remained the same with 27 weekly sample events from the second week in March through the second week in September. Marion Drain sampling continued for organophosphate pesticides through October. Samples were analyzed for pesticides and TSS. Field measurements were obtained for pH, conductivity, temperature, DO, and flow discharge.

2011
In 2011 sample sites remained the same as in 2010. Sample frequency remained the same with 27 weekly sample events from the second week in March through the second week in September; Marion Drain sampling continued for organophosphate pesticides through October. Samples were analyzed for a wide spectrum of pesticides and TSS. Field measurements were obtained for pH, conductivity, temperature, DO, and flow discharge.

Laboratory

From 2003-2011, a number of pesticides and degradates were added and a few were discontinued to better reflect current use pesticides. Table D-1 describes changes to the analyte list.

Table D-1. Pesticide analyte additions and discontinuations for 2003-2011.

Analytes Added	Analytes Discontinued
2004 Changes in Analytes from 2003	
Bensulide H	DDVP I-OP
Methidathion I– OP	Mevinphos I-OP
Naled I-OP	Tetrachlorvinphos (Gardona) I-OP
2005 Changes in Analytes from 2004	
Aldicarb Sulfone D-C	1-Naphthol D-C
Fenvalerate I-Py	Dioxocarb I-C
Phenothrin I-Py	
Resmethrin I-Py	
2006 Changes in Analytes from 2005	
1-Naphthol D-C	Butachlor H
Methomyl Oxime D-C	Bendiocarb I-C
Oxamyl oxime D-C	Bolstar (Sulprofos) I-OP
	Carbophenothion I-OP
	Fenitrothion I-OP
	Fensulfothion I-OP
	Fenthion I-OP
	Ronnel I-OP
2007 Changes in Analytes from 2006	
Methyl Paraoxon D-OP	
Clopyralid H	
Oryzalin H	
Simetryn H	
Thiobencarb H-C	
DDVP I-OP	
Disulfoton sulfone I-OP	
Mevinphos I-OP	
Monocrotophos I-OP	
Tetrachlorvinphos (Gardona) I-OP	
Tokuthion I-OP	
Trichloronate I-OP	
cis-Permethrin I-Py	
Deltamethrin I-Py	
Tralomethrin I-Py	

Analytes Added	Analytes Discontinued
2008 Changes in Analytes from 2007	
Imidacloprid I-N	
Bolstar (Sulprofos) I-OP	
Fensulfothion I-OP	
Fenthion I-OP	
2009 Changes in Analytes from 2008	
4,4'-Dichlorobenzophenone D	Bensulide H
Chlorpyrifos O.A. D-OP	Bolstar (Sulprofos) I-OP
Diazoxon D-OP	
Disulfoton Sulfoxide D-OP	
Fenamiphos Sulfone D-OP	
Phosmetoxon D-OP	
Phorate O.A. D-OP	
Fipronil Disulfinyl D-Py	
Fipronil Sulfide D-Py	
Fipronil Sulfone D-Py	
Tricyclazole F	
Acetochlor H	
Butachlor H	
beta-Cypermethrin I-Py	
Bifenthrin I-Py	
Fipronil I-Py	
lambda-Cyhalothrin I-Py	
trans-Permethrin I-Py	
Piperonyl butoxide Sy	
2010 Changes in Analytes from 2009	
Bolstar (Sulprofos) I-OP	
Fensulfothion I-OP	
Ronnel I-OP	
2011 Changes in Analytes from 2010	
Monuron H	
Neburon H	

C: Carbamate, D: Degradate, F: Fungicide, I: Insecticide, H: Herbicide, N: Neonicotinoid, OC: Organochlorine, OP: Organophosphate, Py: Pyrethroid, Pyra: Pyrazole, SE: Sulfite Ester, Sy: Synergist, WP: Wood Preservative.

Laboratory methods have stayed fairly consistent over the years with the exception of the analytical method for carbamate pesticides. Changes in laboratory methodology, instrumentation, and reporting are described below.

2003

In 2003 samples were analyzed for semivolatile organic compounds as well as pesticides and TSS. The 2003 analytical methods are described in Table D-2.

Table D-2. Summary of 2003 Laboratory Methods.

Analysis	Analytical Method[1]		Reference	Laboratory
	Extraction	Analysis		
AED pesticides	3510	GC/AED	8085	MEL
Carbamate pesticides	8318	HPLC	8318	PSC
Semivolatiles	3510	GC/MS	8270	MEL
TSS	n/a	Gravimetric	EPA 160.2	MEL

[1]All analytical methods refer to EPA SW 846, unless otherwise noted.
n/a: not applicable
TSS: total suspended solids
GC/AED: gas chromatography/atomic emission detection
GC/MS: gas chromatography/mass spectrometry
HPLC: high performance liquid chromatography
PSC: Philip Services Corporation
MEL: Manchester Environmental Laboratory

2004

Analytical methods for 2004 are described in Table D-3. In 2004 samples were no longer analyzed for semivolatile organic compounds. Samples were analyzed for pesticides and TSS. Analytical methods for carbamate pesticides and TSS remained the same as 2003. During 2004 MEL continued to use the GC/AED method for most of the pesticide analysis, but the chlorophenoxy herbicides and pentachlorophenol samples were analyzed using the GC/MS, EPA SW 846 extraction method 8151, and analytical method 8270.

Table D-3. Summary of 2004 Laboratory Methods.

Analyte	Analytical Method[1]		EPA Reference	Laboratory
	Extraction	Analysis		
Pesticides	3510	GC/AED	8085	MEL
Herbicides	3510/8151	GC/MS	8270	MEL
Carbamates	8318	HPLC	8318	PSC
TSS	n/a	Gravimetric	EPA 160.2	MEL

[1]All analytical methods refer to EPA SW 846, unless otherwise noted.
n/a: not applicable
TSS: total suspended solids
GC/MS: gas chromatography/mass spectrometry
GC/AED: gas chromatography/atomic emission detection
HPLC: high performance liquid chromatography
PSC: Philip Services Corporation
MEL: Manchester Environmental Laboratory

2005

MEL methods for 2005 are described in Table D-4. MEL conducted all of the laboratory analysis including the carbamate pesticide analysis. In addition, the pesticide analysis method changed from AED to GC/MS. These changes in laboratory methods resulted in improvements of detection limits and/or pesticide residue identification (Burke et al., 2006).

Table D-4. Summary of 2005 Laboratory Methods.

Analyte	Analytical Method[1]		Reference
	Extraction	Analysis	
Pesticides	3510	GC/MS	8270
Herbicide Analysis	3510/8151	GC/MS	8270
Carbamates	n/a	HPLC	EPA 531.1M
TSS	n/a	Gravimetric	EPA 160.2

[1]All analytical methods refer to EPA SW 846, unless otherwise noted.
n/a: not applicable
TSS: total suspended solids
GC/MS: gas chromatography/mass spectrometry
HPLC: high performance liquid chromatography

2006

MEL methods for all pesticides except carbamates in 2006 were the same as in 2005 (Table D-5). In 2006 the analytical method for carbamates changed to include extraction using SW846 method 3535M Solid Phase Extraction (SPE), analysis with LC/MS. In addition, the herbicides diuron and linuron were confirmed using LC/MS. The extraction methods for pesticides and herbicides by GC/MS were also changed to method 3535M to utilize SPE.

Table D-5. Summary of 2006 Laboratory Methods.

Analyte	Analytical Method[1]		Reference
	Extraction	Analysis	
Pesticides	3535	GC/MS	8270
Herbicide Analysis	3535/8151	GC/MS	8270
Carbamates	3535	HPLC/MS	8321
TSS	n/a	Gravimetric	EPA 160.2

[1]All analytical methods refer to EPA SW 846, unless otherwise noted.
n/a: not applicable
TSS: total suspended solids
GC/MS: gas chromatography/mass spectrometry
HPLC/MS: high performance liquid chromatography/mass spectrometry

From 2006-2009, there were likely some false positive results using the LC/MS for select carbamate analytes: 1-naphthol, aldicarb sulfone, and aldicarb sulfoxide. All results above the reporting limit were reported and qualified NJ (tentatively identified as the estimated concentration), and all results below the reporting limit as UJ (Sargeant, 2010).

2007

MEL methods in 2007 remained the same as in 2006 (Table D-5). Newer instrumentation was used for the herbicide analysis in 2007. Also, MEL increased the reporting limits for carbamates during week 18 (April 30-May 4, 2007). MEL determined that reporting limits had been too low, which increased the chance of false positive (Sargeant et al., 2010).

Beginning in 2007, MEL did not report NJ qualified results below the maximum detection limit (MDL; Weakland, 2008). In previous years, detections of some analytes that were below the reporting limit had been reported and qualified with an NJ. An NJ means the analyte was tentatively identified and the associated numeric value represents its approximate concentration.

In 2007, significantly fewer NJs were reported than in previous years, especially for the wood preservative, pentachlorophenol.

2008

MEL methods in 2008 remained the same as in 2007, with the exception of herbicide analysis. MEL changed the solvent used for extracting herbicide samples in 2008 to reduce background interference and improve recoveries (Weakland, 2008). September 2008 herbicide analyses were switched from a quadrupole MS (Agilent 5975 or Agilent 5973) to the ion trap MS (Thermo Scientific PolarisITQ) which continues to today. Prior to that change, herbicides were analyzed from 2006 to 2008 either on the Agilent 5973 or the Agilent 5975 GC/MS with the bulk of the samples being analyzed on the 5975.

2009

MEL methods in 2009 remained the same as in 2008. In addition to NJ qualification of 1-naphthol, aldicarb sulfone, and aldicarb sulfoxide, all oxamyl detections for 2009 were qualified as UJ due to concerns regarding false positives.

2010

MEL methods in 2010 remained the same as in previous years with the exception of carbamates (Table D-6). In 2010, EPA Method 8321 AM, modified using electrospray ionization with jet stream technology and triple quadrupole mass spectrometry, was used for carbamate analysis. This allowed for greater detection accuracy by providing confirmation of detected analytes. In addition, the new instrumentation allowed for lower carbamate detection limits (Sargeant et al., 2011).

Table D-6. Summary of 2010 Laboratory Methods.

Analyte	Analytical Method[1]		Reference
	Extraction	Analysis	
Pesticides	3535	GC/MS	8270
Herbicide Analysis	3535/8151	GC/MS	8270
Carbamates	3535	HPLC/MS/MS	8321B
TSS	n/a	Gravimetric	EPA 160.2

[1]All analytical methods refer to EPA SW 846, unless otherwise noted.
n/a: not applicable
TSS: total suspended solids
GC/MS: gas chromatography/mass spectrometry
HPLC/MS/MS: high performance liquid chromatography/triple quadrupole mass spectrometry

2011

MEL methods in 2011 remained the same as in previous years with the exception of carbamates (Table D-7). In 2011 the sample extraction step for carbamates was eliminated. MEL went to a direct injection method continuing to use the LC/MS/MS for carbamate analysis. The benefit of direct injection included higher recoveries for some analytes and less qualified and rejected data.

Table D-7. Summary of 2011 Laboratory Methods.

Analyte	Analytical Method[1]		Reference
	Extraction	Analysis	
Pesticides	3535	GC/MS	8270
Herbicide Analysis	3535/8151	GC/MS	8270
Carbamates	n/a	HPLC/MS/MS	8321B
TSS	n/a	Gravimetric	EPA 160.2

[1]All analytical methods refer to EPA SW 846, unless otherwise noted.
n/a: not applicable
TSS: total suspended solids
GC/MS: gas chromatography/mass spectrometry
HPLC/MS/MS: high performance liquid chromatography/triple quadrupole mass spectrometry

References for Appendix D

Burke, C., P. Anderson, D. Dugger, and J. Cowles, 2006. Surface Water Monitoring Program for Pesticides in Salmonid-Bearing Streams, 2003-2005. Washington State Departments of Agriculture and Ecology. Ecology Publication No. 06-03-036. https://fortress.wa.gov/ecy/publications/SummaryPages/0603036.html

Sargeant, D., D. Dugger, E. Newell, P. Anderson, and J. Cowles, 2010. Surface Water Monitoring Program for Pesticides in Salmonid-Bearing Streams, 2006-2008 Triennial Report. Washington State Departments of Agriculture and Ecology. Ecology Publication No. 10-03-008. https://fortress.wa.gov/ecy/publications/SummaryPages/1003008.html

Sargeant, D., 2010. Memorandum to Jim Cowles, WSDA, dated September 8, 2010. Subject: Manchester Environmental Laboratory Data Quality for Carbamate Pesticides, 2006-2009. Washington State Department of Ecology.

Weakland, J., 2008. Memorandum to Jim Cowles, WSDA, and Debby Sargeant, Ecology, dated March 7, 2008. Subject: Herbicide extractions and NJ qualification of herbicide results. Manchester Environmental Laboratory, Washington State Department of Ecology.

Weakland, J., 2008. Memorandum to Debby Sargeant, Ecology, dated March 10, 2008. Subject: Herbicide extraction solvent changes to the standard operating procedure (SOP) for the Washington State Department of Agriculture CY 2008 sampling. Manchester Environmental Laboratory, Washington State Department of Ecology.

Appendix E. Quality Assurance

Laboratory Data Quality

Data may be qualified if one or more analytical factors affect confidence in the prescribed data value. Manchester Environmental Laboratory (MEL) qualifies data according to the National Functional Guidelines for Organic Data Review (EPA, 1999, 2007). Definitions of data qualifiers are presented in Table E-1.

Table E-1. Data qualification.

Qualifier	Definition
(No qualifier)	The analyte was detected at the reported concentration. Data are not qualified.
E	Reported result is an estimate because it exceeds the calibration range.
J	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
NJ	The analysis indicates the presence of an analyte that has been “tentatively identified,” and the associated numerical value represents its approximate concentration.
NAF	Not analyzed for.
NC	Not calculated.
REJ	The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control (QC)criteria. The presence or absence of the analyte cannot be verified.
U	The analyte was not detected at or above the reported sample quantitation limit.
UJ	The analyte was not detected at or above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately measure the analyte in the sample.

MEL, 2000, 2012; EPA, 1999, 2007.

Performance measures for quality assurance (QA) and quality control (QC) are presented in Table E-2. Lowest concentrations of interest for surface-water grab samples are below reporting limits. Detections quantified below reporting limits are qualified as estimates.

Table E-2. Performance measures for quality assurance and quality control.

Analysis Method[1]	Analysis[2]	Field/Lab Replicates, MS/MSD[3], and Lab Control Samples	MS/MSD[3], Surrogates, and Lab Control Samples
		RPD[4]	% Recovery
GCMS	Pesticide-C-l	±40	30-130
	Pesticide-N	±40	30-130
	Pesticide-OP	±40	30-130
	Pesticide-Py	±40	30-130
GCMS-H	Herbicides	±50	40-130
LCMS/MS	Pesticide-C	±40	50-150
TSS	TSS	±20	80-120

[1] GCMS: Gas chromatography/mass spectroscopy, EPA method (modified) SW 846 3535M/8270M.
GCMS-H: Derivitizable acid herbicides by GCMS, EPA method (modified) SW 846 3535M/8270M.
LCMS/MS: Liquid chromatography/mass spectroscopy, EPA method (modified) SW 846 3535M/8321AM.
TSS: Total suspended solids, EPA method 2540D.
[2]C-l: chlorinated, N: nitrogen containing, OP: organophosphate, Py: pyrethroid, C: carbamate.
[3]MS/MSD: Matrix spike and matrix spike duplicate.
[4]RPD: Relative percent difference.

Lower Practical Quantitation Limits

Lower practical quantitation limits (LPQLs) are the limits at which laboratories may report data without classifying the concentration as an estimate below the lowest calibration standard. The LPQL is determined by averaging the lower reporting values, per analyte, for all batches over each study period. LPQL data are presented in Table E-3.

Table E-3. Mean performance lower practical quantitation limits (LPQL) in ug/L unless otherwise noted.

Chemical	[1]Use	Parent	[2]Analysis Method	LPQL[3]		
				2009	2010	2011
1-Naphthol	D-C		LCMS\MS	0.050	0.049	0.191
2,3,4,5-Tetrachlorophenol	D-M		GCMS-H	0.063	0.063	0.063
2,3,4,6-Tetrachlorophenol	D-M		GCMS-H	0.063	0.063	0.063
2,4,5-T	H		GCMS-H	0.063	0.063	0.063
2,4,5-TP (Silvex)	H		GCMS-H	0.063	0.063	0.063
2,4,5-Trichlorophenol	D-M		GCMS-H	0.063	0.063	0.063
2,4,6-Trichlorophenol	D-M		GCMS-H	0.063	0.063	0.063
2,4-D	H		GCMS-H	0.063	0.063	0.063
2,4-DB	H		GCMS-H	0.063	0.063	0.063
2,4'-DDD	D-OC	DDT	GCMS	0.033	0.033	0.034
2,4'-DDE	D-OC	DDT	GCMS	0.033	0.033	0.034
2,4'-DDT	D-OC	DDT	GCMS	0.033	0.033	0.034
3,5-Dichlorobenzoic Acid	D-M		GCMS-H	0.063	0.063	0.063
3-Hydroxycarbofuran	D-C	Carbofuran	LCMS\MS	0.050	0.049	0.010
4,4'-DDD	D-OC	DDT	GCMS	0.034	0.033	0.034
4,4'-DDE	D-OC	DDT	GCMS	0.034	0.033	0.034
4,4'-DDT	I-OC		GCMS	0.034	0.033	0.034
4,4'-Dichlorobenzophenone	D		GCMS	0.101	0.100	0.101
4-Nitrophenol	D-H		GCMS-H	0.063	0.063	0.063
Acetochlor	H		GCMS	0.101	0.100	0.101
Acifluorfen	H		GCMS-H	0.063	0.063	0.063
Alachlor	H		GCMS	0.033	0.033	0.034
Aldicarb	I-C		LCMS\MS	0.100	0.096	0.033
Aldicarb Sulfone	D-C	Aldicarb	LCMS\MS	0.053	0.049	0.023
Aldicarb Sulfoxide	D-C	Aldicarb	LCMS\MS	0.054	0.020	0.010
Aldrin	I-OC		GCMS	0.033	0.033	0.034
Alpha-BHC	I-OC		GCMS	0.033	0.033	0.034
Atrazine	H		GCMS	0.034	0.033	0.034
Azinphos Ethyl	I-OP		GCMS	0.033	0.033	0.034
Azinphos Methyl	I-OP		GCMS	0.050	0.043	0.034
Benefin	H		GCMS	0.033	0.033	0.034
Bentazon	H		GCMS-H	0.063	0.063	0.063
Benthiocarb	H-C		GCMS	0.101	0.100	0.101
Beta-BHC	I-OC		GCMS	0.033	0.033	0.034
beta-Cypermethrin	I-Py		GCMS	0.101	0.100	0.101

Chemical	[1]Use	Parent	[2]Analysis Method	LPQL[3]		
				2009	2010	2011
Bifenthrin	I-Py		GCMS	0.101	0.100	0.101
Bromacil	H		GCMS	0.033	0.033	0.034
Bromoxynil	H		GCMS-H	0.063	0.063	0.063
Butachlor	H		GCMS	0.304	0.303	0.305
Butylate	H		GCMS	0.033	0.033	0.034
Captan	F		GCMS	0.033	0.033	0.034
Carbaryl	I-C		LCMS/MS	0.020	0.020	0.010
Carbofuran	I-C		LCMS/MS	0.020	0.020	0.010
Carboxin	F		GCMS	0.044	0.051	0.034
Chlorothalonil	F		GCMS	0.033	0.033	0.034
Chlorpropham	H		GCMS	0.033	0.033	0.034
Chlorpyrifos	I-OP		GCMS	0.034	0.033	0.034
Chlorpyrifos O.A.	D-OP		GCMS	0.101	0.100	0.101
Cis-Chlordane	I-OC		GCMS	0.033	0.033	0.034
Cis-Nonachlor	I-OC		GCMS	0.051	0.051	0.051
Cis-Permethrin	I-Py		GCMS	0.051	0.051	0.051
Clopyralid	H		GCMS-H	0.063	0.063	0.063
Coumaphos	I-OP		GCMS	0.051	0.051	0.051
Cyanazine	H		GCMS	0.033	0.033	0.034
Cycloate	H		GCMS	0.033	0.033	0.034
DCPA	H		GCMS-H	0.063	0.063	0.063
DDVP	I-OP		GCMS	0.051	0.051	0.051
Delta-BHC	I-OC		GCMS	0.033	0.033	0.034
Deltamethrin	I-Py		GCMS	0.101	0.100	0.101
Diallate	H		GCMS	0.033	0.033	0.034
Diazinon	I-OP		GCMS	0.033	0.033	0.034
Diazoxon	D-OP	Diazinon	GCMS	0.101	0.100	0.101
Dicamba I	H		GCMS-H	0.063	0.063	0.063
Dichlobenil	H		GCMS	0.033	0.033	0.034
Dichlorprop	H		GCMS-H	0.063	0.063	0.063
Diclofop-Methyl	H		GCMS-H	0.063	0.063	0.063
Dieldrin	I-OC		GCMS	0.051	0.051	0.051
Dimethoate	I-OP		GCMS	0.033	0.033	0.034
Dinoseb	H		GCMS-H	0.063	0.063	0.063
Diphenamid	H		GCMS	0.033	0.033	0.034
Disulfoton	I-OP		GCMS	0.112	0.065	0.053
Disulfoton Sulfone	I-OP		GCMS	0.101	0.100	0.101
Disulfoton Sulfoxide	D-OP		GCMS	0.135	0.100	0.101
Diuron	H		GCMS LCMS\MS[4]	0.058	0.051	0.020
Endosulfan I	I-OC		GCMS	0.051	0.051	0.051
Endosulfan II	I-OC		GCMS	0.051	0.051	0.051
Endosulfan Sulfate	D-OC	Endosulfan	GCMS	0.034	0.033	0.034
Endrin	I-OC		GCMS	0.051	0.051	0.051
Endrin Aldehyde	D-OC	Endrin	GCMS	0.051	0.051	0.051

Chemical	Use[1]	Parent	Analysis Method[2]	LPQL[3]		
				2009	2010	2011
Endrin Ketone	D-OC	Endrin	GCMS	0.033	0.033	0.034
EPN	I-OP		GCMS	0.033	0.033	0.034
Eptam	H		GCMS	0.033	0.033	0.034
Ethalfluralin	H		GCMS	0.033	0.036	0.034
Ethion	I-OP		GCMS	0.033	0.033	0.034
Ethoprop	I-OP		GCMS	0.033	0.033	0.034
Fenamiphos	I-OP		GCMS	0.038	0.042	0.034
Fenamiphos Sulfone	D-OP		GCMS	0.101	0.100	0.101
Fenarimol	F		GCMS	0.033	0.033	0.034
Fenitrothion	I-OP		GCMS		0.050	0.050
Fensulfothion	I-OP		GCMS	0.033	0.033	0.033
Fenthion	I-OP		GCMS	0.033	0.033	0.033
Fenvalerate (2 isomers)	I-Py		GCMS	0.033	0.038	0.034
Fipronil	I-Pyra		GCMS	0.101	0.100	0.101
Fipronil Disulfinyl	D-Pyra		GCMS	0.101	0.100	0.101
Fipronil Sulfide	D-Pyra		GCMS	0.101	0.100	0.101
Fipronil Sulfone	D-Pyra		GCMS	0.101	0.100	0.101
Fluridone	H		GCMS	0.101	0.100	0.101
Fonofos	I-OP		GCMS	0.033	0.033	0.034
Heptachlor	I-OC		GCMS	0.033	0.033	0.034
Heptachlor Epoxide	D-OC	Heptachlor	GCMS	0.033	0.033	0.034
Hexachlorobenzene	F		GCMS	0.033	0.033	0.034
Hexazinone	H		GCMS	0.051	0.051	0.051
Imidacloprid	I-N		LCMS\MS	0.020	0.020	0.017
Imidan	I-OP		GCMS	0.068	0.038	0.034
Ioxynil	H		GCMS-H	0.063	0.063	0.063
Kelthane	I-OC		GCMS	0.304	0.303	0.305
lambda-Cyhalothrin	I-Py		GCMS	0.101	0.100	0.101
Lindane (gamma-BHC)	I-OC		GCMS	0.033	0.033	0.034
Linuron	H		GCMS LCMS\MS[4]	0.051	0.051	0.048
Malathion	I-OP		GCMS	0.033	0.033	0.034
MCPA	H		GCMS-H	0.063	0.063	0.063
MCPP	H		GCMS-H	0.063	0.063	0.063
Metalaxyl	F		GCMS	0.033	0.033	0.034
Methidathion	I-OP		GCMS	0.304	0.303	0.305
Methiocarb	I-C		LCMS\MS	0.021	0.020	0.021
Methomyl	I-C		LCMS\MS	0.050	0.049	0.010
Methomyl Oxime	D-C	Thiodicarb	LCMS\MS	0.020	0.020	0.068
Methoxychlor	I-OC		GCMS	0.051	0.051	0.051
Methyl Chlorpyrifos	I-OP		GCMS	0.033	0.033	0.034
Methyl Paraoxon	D-OP	Methyl parathion	GCMS	0.101	0.100	0.101
Methyl Parathion	I-OP		GCMS	0.033	0.033	0.034
Metolachlor	H		GCMS	0.033	0.033	0.034
Metribuzin	H		GCMS	0.033	0.033	0.034

Chemical	[1]Use	Parent	[2]Analysis Method	LPQL[3]		
				2009	2010	2011
Mevinphos	I-OP		GCMS	0.051	0.051	0.051
MGK-264	Sy		GCMS	0.051	0.051	0.051
Mirex	I-OC		GCMS	0.035	0.033	0.034
Monocrotophos	I-OP		GCMS	0.051	0.051	0.051
Monuron	H		LCMS\MS			0.010
Naled	I-OP		GCMS	0.035	0.034	0.034
Napropamide	H		GCMS	0.051	0.051	0.051
Neburon	H		LCMS\MS			0.043
Norflurazon	H		GCMS	0.034	0.033	0.034
Oryzalin	H		GCMS	0.114	0.133	0.101
Oxamyl	I-C		LCMS\MS	0.052	0.049	0.010
Oxamyl oxime	D-C	Oxamyl	LCMS\MS	0.020	0.020	0.025
Oxychlordane	D-OC	Chlordane	GCMS	0.033	0.033	0.034
Oxyfluorfen	H		GCMS	0.101	0.100	0.101
Parathion	I-OP		GCMS	0.033	0.033	0.034
Pebulate	H		GCMS	0.033	0.033	0.034
Pendimethalin	H		GCMS	0.034	0.033	0.034
Pentachlorophenol	WP		GCMS-H	0.063	0.063	0.063
Phenothrin	I-Py		GCMS	0.033	0.033	0.034
Phorate	I-OP		GCMS	0.291	0.303	0.305
Phorate O.A.	D-OP		GCMS	0.193	0.137	0.101
Phosmet O.A.	D-OP		GCMS		0.100	0.101
Picloram	H		GCMS-H	0.063	0.063	0.063
Piperonyl Butoxide	Sy		GCMS	0.101	0.100	0.101
Promecarb	I-C		LCMS\MS	0.020	0.020	0.010
Prometon	H		GCMS	0.033	0.033	0.034
Prometryn	H		GCMS	0.033	0.033	0.034
Pronamide	H		GCMS	0.033	0.033	0.034
Propachlor	H		GCMS	0.033	0.033	0.034
Propargite	I-SE		GCMS	0.051	0.051	0.051
Propazine	H		GCMS	0.033	0.033	0.034
Propoxur (Baygon)	I-C		LCMS\MS	0.050	0.049	0.010
Prothiofos (Tokuthion)	I-OP		GCMS	0.101	0.100	0.101
Resmethrin	I-Py		GCMS	0.036	0.033	0.034
Ronnel	I-OP		GCMS		0.050	0.050
Simazine	H		GCMS	0.033	0.033	0.034
Simetryn	H		GCMS	0.101	0.100	0.101
Sulfotepp	I-OP		GCMS	0.033	0.033	0.034
Sulprofos	I-OP		GCMS		0.050	0.015
Tebuthiuron	H		GCMS	0.033	0.033	0.034
Terbacil	H		GCMS	0.034	0.033	0.034
Tetrachlorvinphos	I-OP		GCMS	0.051	0.051	0.051
Total Suspended Solids	N/A		TSS	1 mg/L	2 mg/L	2 mg/L
Tralomethrin	I-Py		GCMS	0.101	0.100	0.101
Trans-Chlordane	I-OP		GCMS	0.033	0.033	0.034

Chemical	Use[1]	Parent	Analysis Method[2]	LPQL[3]		
				2009	2010	2011
Trans-Nonachlor	I-OC		GCMS	0.051	0.051	0.051
trans-Permethrin	I-Py		GCMS	0.101	0.100	0.101
Triadimefon	F		GCMS	0.033	0.033	0.034
Triallate	H		GCMS	0.033	0.033	0.034
Trichloronat	I-OP		GCMS	0.051	0.051	0.051
Triclopyr	H		GCMS-H	0.063	0.063	0.063
Tricyclazole	F		GCMS	0.101	0.100	0.101
Trifluralin	H		GCMS	0.034	0.033	0.034

[1] C: Carbamate, D: Degradate, F: Fungicide, I: Insecticide, H: Herbicide, OC: Organochlorine, OP: Organophosphate, Py: Pyrethroid, Pyra: Pyrazole, SE: Sulfite Ester, Sy: Synergist, WP: Wood Preservative.
[2] GCMS: Gas chromatography/mass spectroscopy, EPA method (modified) SW 846 3535M/8270M.
GCMS-H: Derivitizable acid herbicides by GCMS, EPA method (modified) SW 846 3535M/8270M.
LCMS\MS: Liquid chromatography/mass spectroscopy, EPA method (modified) SW 846 3535M/8321AM.
[3] Blank cells indicate no analysis for the compound in that year.
[4] In 2011, analysis method for diuron and linuron changed from GCMS to LCMS\MS.

Quality Assurance Samples

QA samples were collected each year to assure consistency and accuracy of sample analysis.

For this project, QA samples included field replicates, field blanks, and matrix spike and matrix spike duplicates (MS/MSD). QA samples for the laboratory included split sample duplicates, laboratory control samples (LCS), surrogate spikes, and method blanks.

Table E-4 describes the percentage of field replicates, field blanks, and MS/MSD samples that were obtained during 2009-2011. During each field season, QA included 32-33 field replicates for carbamates, herbicides, pesticide GCMS, and TSS. QA also included 16 field blanks and MS/MSD samples for carbamates, herbicides, pesticide GCMS, and TSS.

Table E-4. Percentage of field QA samples obtained as a percentage of field samples, 2009-2011.

Field QA	2009	2010	2011
Field Replicates	7.9	7.7	7.6
Field Blanks	4.1	3.8	3.8
MS/MSD samples	3.8	3.8	3.8

Results for QA sampling are outlined in the sections below.

Field Replicates

Pooled results for pesticide field replicates by analysis type and year are presented in Table E-5. Precision between replicate pairs was calculated using relative percent difference (RPD). The RPD is calculated by dividing the absolute value of the difference between the replicates by their mean, then multiplying by 100 for a percent value.

Table E-5. Pooled average RPD of consistent field replicate pairs by analysis type and year, 2009-2011.

Year	Herbicides		Carbamates		Pesticide GCMS		TSS	
	Pooled Average RPD	Number of Replicate Pairs	Pooled Average RPD	Number of Replicate Pairs	Pooled Average RPD	Number of Replicate Pairs	Pooled Average RPD	Number of Replicate Pairs
2009	10.9	34	6.3	4	9.1	65	13.1	32
2010	9.2	36	3.3	16	9.7	49	9.5	33
2011	11.5	34	10.7	16	8.9	37	10.3	33

Table E-6 presents the data value, data qualification (if assigned), and RPD between the results for pesticide compounds which were consistently identified in both the grab sample and replicate.

Consistent identification refers to compounds which were identified in both the original sample and field replicate. Inconsistently identified replicate pairs are those in which the compound was identified in one sample but not the other. Inconsistently identified grab sample replicates are presented in Table E-7.

The average RPD for each of the analytical methods was good (Table E-5). During 2009-11, of the consistently identified replicate pairs, seven of the 87 pairs did not meet the 40% RPD criterion (Table E-6). One of these replicate pairs (dichlobenil) had a RPD of 100%. This difference is likely because the results were very low and the RPD statistic has limited effectiveness in assessing variability at low levels (Mathieu, 2006). Results of the other replicate pairs ranged from 44.4 - 65.5% RPD; in addition, most of the results were near or below the reporting limit.

Table E-6. Detected pairs with field replicate results (ug/L), 2009-2011.

Year	Parameter	Sample	Q	Replicate	Q	RPD
2009		0.079		0.078		1.3
2009		0.99		0.91		8.4
2009		0.15		0.1		40.0
2009		0.02	J	0.02	J	0.0
2009		0.098		0.096		2.1
2009		0.023	J	0.025	NJ	8.3
2009		0.11		0.09		20.0
2009		0.051	J	0.053	J	3.8
2009		0.079		0.078		1.3
2009		0.019	J	0.022	J	14.6
2009		0.024	J	0.028	NJ	15.4
2009		0.036	J	0.034	J	5.7
2010		0.041	J	0.041	J	0.0
2010		0.18		0.32		56.0
2010	2,4-D	0.04	J	0.039	J	2.5
2010		0.026	NJ	0.031	NJ	17.5
2010		0.04	J	0.054	J	29.8
2010		0.027	J	0.026	J	3.8
2010		0.032	NJ	0.038	NJ	17.1
2010		0.24	J	0.23	J	4.3
2010		0.038	J	0.045	J	16.9
2010		0.023	J	0.024	J	4.3
2011		0.19		0.17		11.1
2011		0.063	J	0.087		32.0
2011		0.066	J	0.08		19.2
2011		0.08		0.089		10.7
2011		0.066		0.051	J	25.6
2011		0.051	J	0.051	J	0.0
2011		0.058	J	0.051	J	12.8
2011		0.046	J	0.045	J	2.2
				Mean		**12.9**
2009		0.019	J	0.019	J	0.0
2009	4,4'-DDD	0.015	J	0.013	J	14.3
				Mean		**7.1**
2009		0.022	J	0.02	J	9.5
2009		0.016	J	0.016	J	0.0
2009		0.026	J	0.014	J	60.0
2009	4,4'-DDE	0.044		0.042		4.7
2010		0.038		0.037		2.7
2011		0.041		0.033	J	21.6
				Mean		**16.4**
2009		0.022	J	0.023	J	4.4
2009		0.027	J	0.022	J	20.4
2009	4,4'-DDT	0.036		0.035		2.8
2010		0.016	J	0.017	J	6.1
2011		0.031	J	0.026	J	17.5
				Mean		**10.3**
2009		0.022	J	0.023	J	4.4
2009		0.027	J	0.022	J	20.4
2009	4,4'-DDT	0.036		0.035		2.8
2010		0.016	J	0.017	J	6.1
2011		0.031	J	0.026	J	17.5
				Mean		**10.3**
2009		0.016	NJ	0.015	J	6.5
2009		0.049		0.055	NJ	11.5
2010		0.05	NJ	0.04	NJ	22.2
2010	Atrazine	0.013	NJ	0.015	NJ	14.3
2011		0.025	NJ	0.025	NJ	0.0
2011		0.021	J	0.022	J	4.7
2011		0.016	J	0.013	J	20.7
				Mean		**11.4**
2009		0.025	J	0.024	J	4.1
2009		0.13		0.15		14.3
2010		0.052	J	0.044	NJ	16.7
2010		0.045	J	0.049	J	8.5
2010		0.12	NJ	0.13	NJ	8.0
2010	Bentazon	0.063		0.082		26.2
2011		0.073		0.068		7.1
2011		0.036	J	0.031	J	14.9
2011		0.026	J	0.027	J	3.8
2011		0.048	NJ	0.054	NJ	11.8
2011		0.18		0.19		5.4
2011		0.063	J	0.057	NJ	10.0
				Mean		**10.9**
2011	Bifenthrin	0.057	J	0.056	J	1.8
2009		0.019	J	0.027	J	34.8
2009		0.074		0.068		8.5
2009		0.046		0.042		9.1
2009		0.07		0.069		1.4
2009		0.045		0.047		4.3
2009	Bromacil	0.14		0.15		6.9
2009		0.058		0.059		1.7
2010		0.036		0.038		5.4
2010		0.19	J	0.22	J	14.6
2010		0.07		0.066		5.9
2010		0.032	J	0.036		11.8
2011		0.029	J	0.033	J	12.9
				Mean		**9.8**
2009	Bromoxynil	0.072		0.073		1.4
2009		0.021		0.022		4.7
2010		0.015	J	0.014	J	6.9
2011	Carbaryl	0.03		0.026		14.3
2011		0.018		0.022		20.0
				Mean		**11.5**
2009		0.099		0.105		5.9
2010		0.005	J	0.005	J	0.0
2010	Carbofuran	0.1		0.094		6.2
2010		0.004	J	0.004	J	0.0
2010		0.006	J	0.006	J	0.0
				Mean		**2.4**
2010	Chlorpropham	0.025	J	0.023	J	8.3
2009		0.041		0.048		15.7
2009		0.03	J	0.028	J	6.9
2009		0.053		0.056		5.5
2009	Chlorpyrifos	0.037		0.039		5.3
2009		0.08		0.086		7.2
2009		0.023	J	0.021	J	9.1
2011		0.027	J	0.025	J	7.7
				Mean		**8.2**

Year	Parameter	Sample	Q	Replicate	Q	RPD	Year	Parameter	Sample	Q	Replicate	Q	RPD
2011	Clopyralid	0.02	J	0.017	J	16.2	2009		0.038		0.043		12.3
2009		0.12		0.064	J	60.9	2009		0.092		0.09		2.2
2009	DCPA	0.017	J	0.012	J	34.5	2010		0.362		0.411		12.7
2010	(Dacthal)	0.063	J	0.072		13.3	2010		0.005	J	0.005	J	0.0
2011		0.059	J	0.069		15.6	2010		0.024		0.024		0.0
2011		0.077		0.039	J	65.5	2010		0.02		0.019	J	5.1
				Mean		**38.0**	2010		0.007	J	0.007	J	0.0
2010	DDVP	0.07		0.067		4.4	2010	Imidacloprid	0.005	J	0.005	J	0.0
2010		0.23	J	0.2	NJ	14.0	2010		0.004	J	0.004	J	0.0
2010		0.15		0.17	NJ	12.5	2010		0.005	J	0.005	J	0.0
2010		0.11	J	0.12	J	8.7	2010		0.924		0.833		10.4
2010		0.017	J	0.015	J	12.5	2010		0.009	J	0.008	J	11.8
2010		0.025	J	0.028	NJ	11.3	2011		0.067	J	0.061	J	9.4
2010		3.6	E	3.6	E	0.0	2011		0.19	J	0.19	J	0.0
2010		0.067	J	0.059	NJ	12.7					**Mean**		**4.6**
2011	Diuron	0.127	J	0.132	J	3.9	2009		0.022	NJ	0.026	J	16.7
2011		0.038		0.038		0.0	2009		0.16		0.15		6.5
2011		0.027		0.022		20.4	2009		0.09		0.079		13.0
2011		0.338		0.33		2.4	2009		0.091		0.086		5.6
2011		0.028	J	0.034		19.4	2010	MCPA	0.023	NJ	0.024	J	4.3
2011		0.023	J	0.021	J	9.1	2010		0.061	J	0.059	J	3.3
2011		0.013	J	0.013	J	0.0	2011		0.059	J	0.07		17.1
2011		0.01	J	0.011	J	9.5	2011		0.043	J	0.041	J	4.8
2011		0.01	J	0.007	J	35.3					**Mean**		**8.9**
				Mean		**10.7**	2009		0.089		0.077		14.5
2009		0.024	J	0.03	J	22.2	2010		0.019	NJ	0.02	NJ	5.1
2009	Endosulfan I	0.018	J	0.017	J	5.7	2011	MCPP	0.076		0.094		21.2
2009		0.044	J	0.028	J	44.4	2011		0.026	NJ	0.026	NJ	0.0
				Mean		**24.1**					**Mean**		**10.2**
2009	Endosulfan II	0.063	J	0.052	J	19.1	2009	Metalaxyl	0.05		0.051		2.0
2009		0.041	J	0.046	J	11.5	2010		0.004	J	0.004	J	0.0
2009		0.043		0.044		2.3	2011	Methomyl	0.006	J	0.007	J	15.4
2009		0.092	J	0.076	J	19.0	2011		0.009	J	0.008	J	11.8
2009	Endosulfan	0.03	J	0.032	J	6.5					**Mean**		**9.0**
2010	Sulfate	0.036		0.038		5.4	2009		0.086		0.083		3.6
2011		0.034	J	0.036		5.7	2009		0.061		0.056		8.5
2011		0.024	J	0.04		50.0	2009		0.029	J	0.028	J	3.5
				Mean		**14.3**	2010		0.054	J	0.056		3.6
2010		0.2		0.22		9.5	2010		0.039		0.044		12.0
2010		0.027	J	0.028	J	3.6	2010	Metolachlor	0.008	J	0.008	J	0.0
2010		0.03	J	0.029	J	3.4	2010		0.19		0.2		5.1
2010	Eptam	0.063		0.074		16.1	2011		0.2		0.22		9.5
2011		0.051		0.05		2.0	2011		0.31		0.31		0.0
2011		0.042	NJ	0.034	NJ	21.1	2011		0.07		0.065		7.4
2011		0.14		0.14		0.0	2011		0.1		0.093		7.3
				Mean		**7.9**					**Mean**		**5.5**
2010		0.28		0.3		6.9	2009		0.045		0.053		16.3
2011	Ethoprop	0.44		0.43		2.3	2010	Metribuzin	0.21		0.21		0.0
				Mean		**4.6**					**Mean**		**8.2**
2009	Hexazinone	0.056		0.057		1.8	2010	Napropamide	0.48		0.4		18.2

Year	Parameter	Sample	Q	Replicate	Q	RPD
2009		0.03	J	0.027	NJ	10.5
2010		0.02	NJ	0.021	NJ	4.9
2010	Norflurazon	0.025	NJ	0.025	NJ	0.0
2011		0.041	NJ	0.043	NJ	4.8
2011		0.048		0.058		18.9
				Mean		**7.8**
2011	Oxamyl	0.03		0.03		0.0
2009		0.06		0.063		4.9
2009		0.029	NJ	0.028	J	3.5
2010	Pendimethalin	0.076		0.074		2.7
2011		0.049		0.048		2.1
2011		0.044	NJ	0.042	NJ	4.7
				Mean		**3.6**
2009		0.053	J	0.051	J	3.8
2009		0.018	NJ	0.02	J	10.5
2010		0.021	NJ	0.024	NJ	13.3
2010		0.015	NJ	0.015	J	0.0
2010		0.02	J	0.021	NJ	4.9
2010		0.016	J	0.016	J	0.0
2010	Pentachlorophenol	0.016	NJ	0.016	NJ	0.0
2011		0.026	J	0.025	J	3.9
2011		0.03	NJ	0.038	NJ	23.5
2011		0.014	NJ	0.011	NJ	24.0
2011		0.023	NJ	0.023	NJ	0.0
2011		0.017	NJ	0.016	NJ	6.1
				Mean		**7.5**
2010	Picloram	0.09	NJ	0.076	NJ	16.9
2009		0.072		0.077		6.7
2011	Prometon	0.033	J	0.03	J	9.5
				Mean		**8.1**

Year	Parameter	Sample	Q	Replicate	Q	RPD
2009		0.034	NJ	0.037		8.5
2009		0.027	J	0.03	J	10.5
2009	Tebuthiuron	0.047		0.041		13.6
2011		0.035		0.035	NJ	0.0
2011		0.045	J	0.035	J	25.0
				Mean		**11.5**
2009		0.11		0.12		8.7
2009		0.11		0.13		16.7
2010		0.098		0.095		3.1
2010		0.035	J	0.036	J	2.8
2010	Terbacil	0.09		0.1		10.5
2010		0.5		0.51		2.0
2011		0.15	J	0.15	J	0.0
2011		0.05		0.049		2.0
2011		0.49		0.48		2.1
				Mean		**5.3**
2009		0.5		0.46		8.3
2009		0.06	J	0.057	J	5.1
2009		0.076		0.071		6.8
2010		0.16		0.19		17.1
2010		0.033	NJ	0.031	NJ	6.3
2010	Triclopyr	0.035	J	0.035	NJ	0.0
2010		0.042	J	0.043	J	2.4
2010		0.089		0.083		7.0
2010		0.03	J	0.032	J	6.5
2010		0.028	NJ	0.027	NJ	3.6
				Mean		**6.3**
2009		0.025	J	0.026	J	3.9
2009	Trifluralin	0.017	J	0.017	J	0.0
2010	(Treflan)	0.022	J	0.023	J	4.4
2011		0.016	J	0.016	J	0.0
				Mean		**2.1**

For inconsistently identified pairs, 54 of the 65 pairs (83%) had a less than reporting limit value (U or UJ qualifier) paired with an estimated value that was less than the reporting limit. For the 11 inconsistently identified pairs where a result was above the reporting limit, the result was a tentative detection or a result close to the reporting limit (Table E-7).

TSS was consistently detected in 97 replicate pairs. For one inconsistent detection, the result was qualified as less than the reporting limit of 17 mg/L. The paired result was an uncensored value of 17 mg/L. For TSS, the average RPD over the 2009-2011 period was 10.9%. Table E-5 describes the average RPD by year for TSS. A total of 92% of the replicates were within the 20% RPD criterion. Pairs with > 20% RPD were close to the detection limit, and the RPD statistic has limited effectiveness in assessing variability at low levels (Mathieu, 2006).

Table E-7. Inconsistent field replicate pair detections (µg/L), 2009-2011.

Year	Parameter	Sample	Q	Replicate	Q	Year	Parameter	Sample	Q	Replicate	Q
2010	2,4-D	0.024	NJ	0.064	U	2011	Diuron	0.010	U	0.018	
2011	2,4-D	0.064	U	0.031	NJ	2011	Diuron	0.030	U	0.007	J
2011	2,4-D	0.032	NJ	0.061	U	2009	Endosulfan II	0.023	J	0.051	UJ
2011	2,4-D	0.031	NJ	0.062	U	2010	Hexazinone	0.052	U	0.079	
2011	2,4-D	0.065	U	0.042	NJ	2010	Hexazinone	0.052	U	0.110	
2009	2,4'-DDE	0.009	J	0.033	U	2009	Imidacloprid	0.020	U	0.023	
2011	2,4'-DDT	0.006	J	0.033	U	2010	Imidacloprid	0.005	J	0.020	U
2011	4,4'-DDD	0.031	J	0.033	U	2010	Imidacloprid	0.005	J	0.020	U
2011	4,4'-DDE	0.024	U	0.030	J	2011	Imidacloprid	0.020	UJ	0.014	J
2009	4,4'-DDT	0.020	J	0.033	U	2010	MCPA	0.027	NJ	0.064	U
2011	4,4'-DDT	0.028	J	0.033	U	2010	MCPA	0.023	NJ	0.064	U
2011	4-Nitrophenol	0.110	NJ	0.063	U	2010	MCPA	0.024	NJ	0.064	U
2009	Atrazine	0.032	U	0.022	J	2011	MCPA	0.017	NJ	0.064	U
2010	Atrazine	0.033	U	0.020	NJ	2011	MCPP	0.064	U	0.026	NJ
2010	Atrazine	0.032	U	0.014	NJ	2009	Methiocarb	0.020	U	0.033	
2010	Bentazon	0.034	NJ	0.065	U	2011	Methiocarb	0.030	U	0.015	J
2010	Bentazon	0.064	U	0.037	NJ	2011	Methiocarb	0.010	U	0.003	J
2011	Bentazon	0.063	U	0.048	J	2011	Methomyl oxime	0.070	U	0.034	J
2009	Bromacil	0.033	U	0.021	J	2011	Norflurazon	0.013	U	0.037	NJ
2010	Bromacil	0.037		0.034	U	2010	Pentachlorophenol	0.062	U	0.016	NJ
2011	Bromacil	0.014	J	0.035	U	2010	Pentachlorophenol	0.020	NJ	0.065	U
2011	Bromacil	0.012	J	0.033	U	2010	Pentachlorophenol	0.065	U	0.018	NJ
2010	Carbaryl	0.020	UJ	0.016	J	2010	Pentachlorophenol	0.061	U	0.016	NJ
2010	Carbaryl	0.020	U	0.005	J	2010	Pentachlorophenol	0.020	NJ	0.064	U
2011	Carbaryl	0.010	U	0.008	J	2010	Pentachlorophenol	0.021	J	0.068	U
2010	Carbofuran	0.006	J	0.020	U	2010	Pentachlorophenol	0.017	NJ	0.064	U
2010	DCPA	0.026	NJ	0.064	U	2011	Pentachlorophenol	0.064	U	0.013	NJ
2010	DCPA	0.062	U	0.025	NJ	2011	Pentachlorophenol	0.066	U	0.014	J
2010	DCPA	0.064	U	0.098		2009	Picloram	0.064	U	0.180	
2011	DCPA	0.031	J	0.065	UJ	2009	Simazine	0.034	U	0.015	J
2010	Dicamba I	0.015	NJ	0.064	U	2011	Terbacil	0.016		0.035	U
2010	Dichlobenil	0.009	J	0.034	U	2010	Trifluralin	0.015	J	0.034	U
2010	Diphenamid	0.035	U	0.023	NJ						

Laboratory Duplicates

MEL used laboratory split sample duplicates to ensure consistency of TSS analyses. Table E-8 presents the average RPD for laboratory duplicates by year. During 2009-2011, 5-8% of the replicate pairs exceeded the 20% RPD criteria. For these duplicates, results were low, and the RPD statistic has limited effectiveness in assessing variability at low levels (Mathieu, 2006).

Table E-8. Average RPD by year for TSS laboratory duplicates, 2009-2011.

Year	n	Average RPD
2009	121	9.4%
2010	142	6.1%
2011	106	4.3%

Field Blanks

Field blank detections indicate the potential for sample contamination in the field and laboratory and the potential for false detections due to analytical error.

In 2009, there were two field blank detections, both for the pesticide GCMS analysis. On March 11, 2009, dichlobenil was found in a field blank for Longfellow Creek (LC-1). Dichlobenil was not found in the associated sample for LC-1, but it was detected at other western Washington sites on the same day. None of these detections were greater than five times the blank concentration, so dichlobenil was qualified as tentatively undetected (UJ) for these samples.

On April 8, 2009, tricyclazole was detected in a field blank for Brender Creek (BR-1) but was not detected in any associated samples. No data qualification was needed.

In 2010, there were no field blank detections for the pesticide analysis. On July 20, 2010, there was a TSS field blank detection of 3 mg/L at the Samish River site. The reporting limit for TSS was 1 mg/L. All TSS values analyzed that day (July 20, 2010) that are less than 9 mg/L were qualified as estimates.

In 2011, there were no field blank detections for the pesticide or TSS analyses.

Laboratory Blanks

MEL uses laboratory blanks to assess the precision of equipment and the potential for internal laboratory contamination. If lab blank detections occur, the sample LPQL may be increased, and detections may be qualified as estimates.

Laboratory blank detections for 2009-2010 are presented in Table E-9. In 2011, there were no laboratory blank detections. For all laboratory blank detections, any analytes found in associated samples below 5 times the lab blank detection were reported at the level detected but qualified as not detected at an estimated detection limit (UJ).

Table E-9. Laboratory blank detections (µg/L), 2009-2010.

Analysis	Chemical	Analysis Date	Value (µg/L)
LCMS	Aldicarb Sulfone	4/16/09	0.010 J
		4/22/09	0.009 J
	Aldicarb Sulfoxide	4/16/09	0.015 J
	Methiocarb	4/20/09	0.016 J
	Methomyl	4/16/09	0.013 J
	Oxamyl	4/16/09	0.006 J
		4/22/09	0.008 J
	Oxamyl oxime	6/22/09	0.022 J
LCMS\MS	Imidacloprid	4/14/10	0.001 J
		9/28/10	0.002 J
	Carbaryl	6/11/10	0.003 J
		7/23/10	0.004 J
GCMS	2,4'-DDT	6/11/10	0.015 J
	4,4'-DDD	6/11/10	0.012 J
	4,4'-DDE	6/11/10	0.007 J
	4,4'-DDT	6/11/10	0.018 J
	cis-Chlordane	6/11/10	0.002 J
	Mirex	6/11/10	0.012 J
	Trans-Chlordane	6/11/10	0.002 J

Surrogates

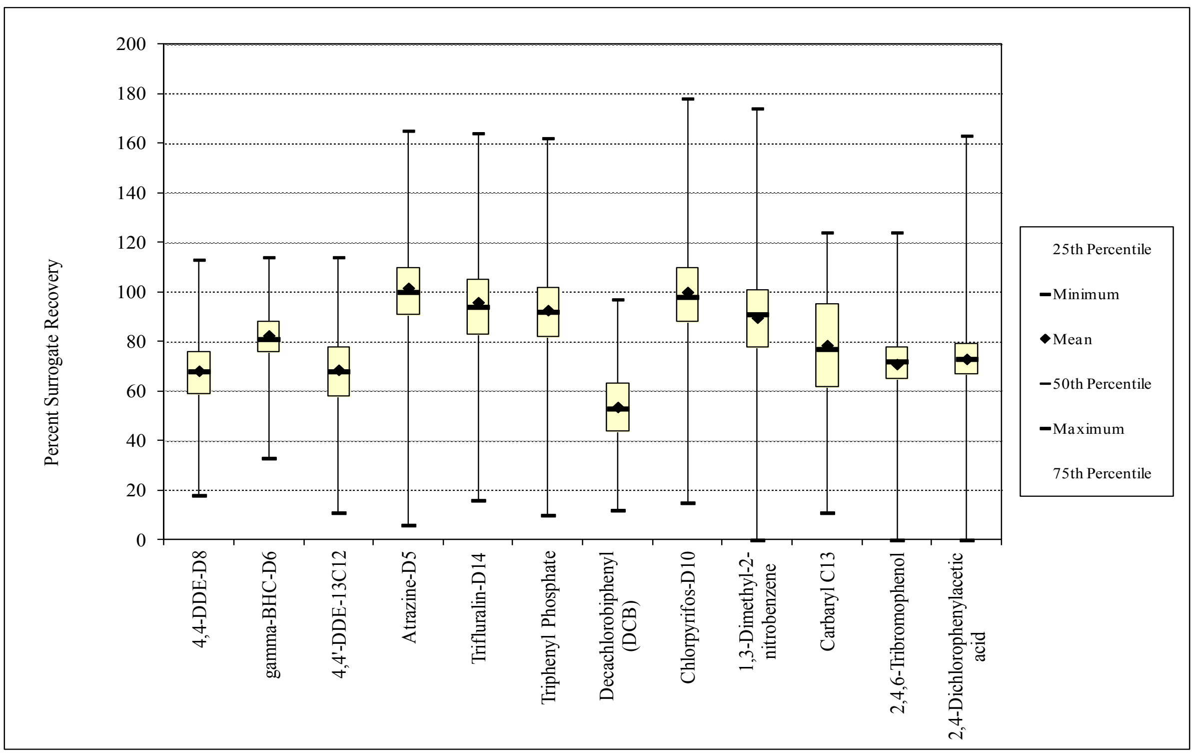
Surrogates are compounds that are spiked into field samples at the laboratory. They are used to check recovery for a group of compounds. For instance, triphenyl phosphate is a surrogate for organophosphate insecticides (Table E-10).

In 2010, MEL discontinued use of 4,4'-DDE-d8 and gamma-BHC-D6 as surrogates for the pesticide GCMS analysis. MEL could no longer purchase these standards from any supplier. The 4,4'-DDE-d8 standard was replaced with a carbon 13 labeled version, 4,4'-DDE-12C13. Atrazine-D5 and triflurin-D14 labeled surrogates were also added to support pesticide GCMS chemistries.

High pesticide surrogate recovery requires related detections to be qualified as estimates. Low pesticide surrogate recovery requires all related data to be qualified as estimates. The majority of surrogate recoveries fell within the control limits established by MEL for all compounds (Figure E-1). Outlier recoveries were outside of control limits for all surrogates. However, outliers represented a small part of overall surrogate recovery and did not quality the majority of data.

Table E-10. Manchester Environmental Laboratory (MEL) pesticide surrogates, 2009-2011.

Surrogate Compound	Years Used	Surrogate for...
2,4,6-tribromophenol	2009-2011	Acid-derivitizable herbicides
2,4-dichlorophenylacetic acid	2009-2011	
Carbaryl C13	2009-2011	Carbamate pesticides
4,4'-DDE-13C12	2009-2011	Chlorinated pesticides
4,4'-DDE-D8	2009	
Decachlorobiphenyl (DCB)	2009-2011	
Gamma BHC	2009	
Atrazine-D5	2010-2011	Chlorinated and nitrogen pesticides
1,3-dimethyl-2-nitrobenzene	2009-2011	Nitrogen pesticides
Trifluralin-D-14	2010-2011	
Chlorpyrifos-D10	2009-2011	Organophosphate insecticides
Triphenyl phosphate	2009-2011	



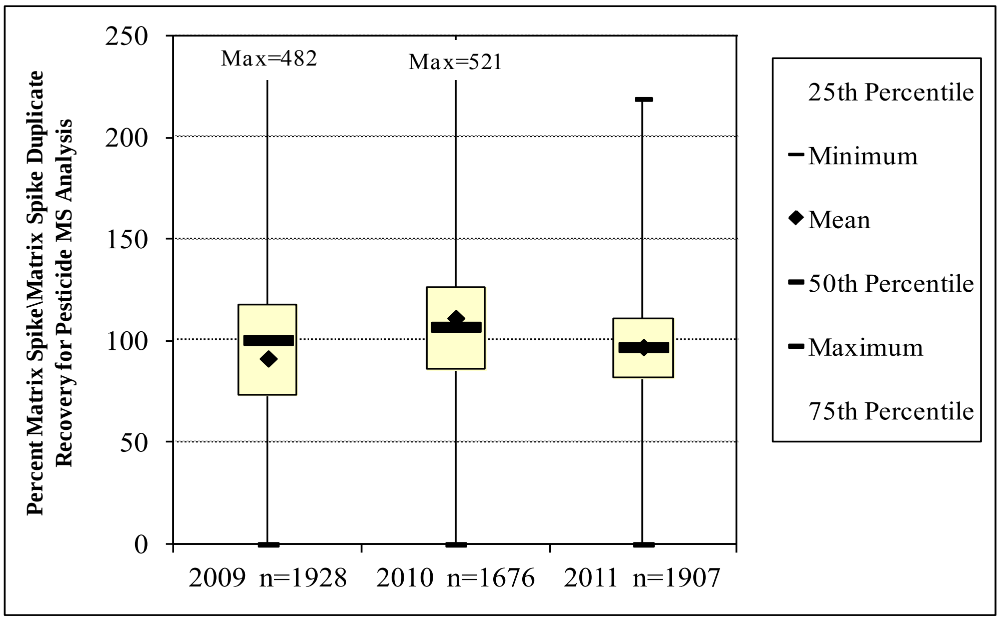
Boxes show 25th and 75th percentiles, whiskers show the minimum and maximum results, and diamonds indicate the mean result.

Figure E-1. Surrogate recoveries, 2009-2011.

Matrix Spike/Matrix Spike Duplicates (MS/MSD)

MS/MSD results reflect the process of sample duplication in the field, analyte degradation, or matrix interaction between the sample and the analytes in the standard, extraction efficiency, and analyte recovery. This measure is the best overall indicator of accuracy and reproducibility of the entire sampling process.

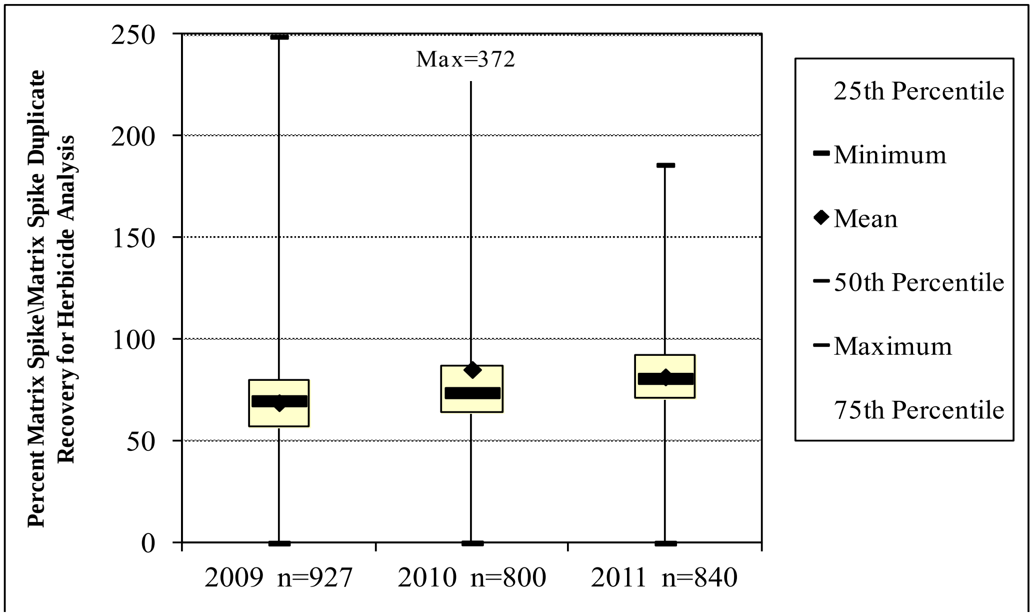
Figures E-2, E-3, and E-4 present the 2009-2011 percent MS/MSD spike duplicate recoveries for the pesticide mass spectrometer, herbicide, and carbamate analysis. Pesticide mass spectrometer recoveries were good with the median ranging from 97-107% and the 25th and 75th quartiles ranging from 73-126% during the three-year period (Figure E-2). Acceptable recovery values for pesticide mass spectrometer analysis ranged from 30-130%.



Boxes show 25th and 75th percentiles, whiskers show the minimum and maximum results, and diamonds indicate the mean result.

Figure E-2. Pesticide mass spectrometer MS/MSD percent recoveries, 2009-2011.

Herbicide recoveries tended to be low, with the median recovery ranging from 70-81%, and the 25th and 75th quartiles ranged from 57-92% during 2009-2011 (Figure E-3). Acceptable recovery range for herbicides is from 40-130%.

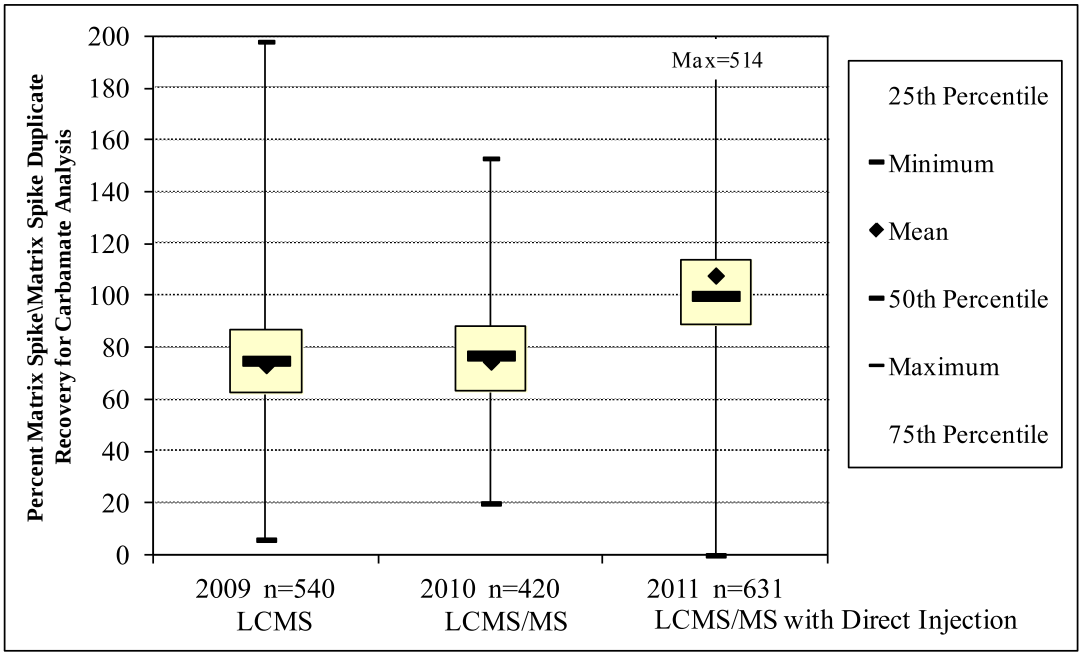


Boxes show 25th and 75th percentiles, whiskers show the minimum and maximum results, and diamonds indicate the mean result.

Figure E-3. Herbicide analysis MS/MSD percent recoveries, 2009-2011.

Carbamate analysis MS\MSD recoveries varied each year. This is likely due to changes in laboratory analysis. Figure E-4 presents MS/MSD recoveries by year. In 2009, the carbamate analysis method was LCMS, in 2010 the method was LCMS/MS, and in 2011 the laboratory switched to direct injection (omitting the extraction process) using LCMS/MS. Median recoveries in 2009 and 2010 were similar, 75 and 77% respectively. The 25th and 75th quartile recoveries during these years were also similar, ranging from 63-88%. The switch to direct injection in 2011 and the change to LCMS/MS in 2010 provided better recoveries, with median recoveries of 100% in 2011. Acceptable carbamate analysis recoveries ranged from 50-150% in 2009 and 2010 and from 40-130% in 2011.

Table E-11 presents the average and maximum RPD for the MS/MSDs for the three types of analyses. The average RPD was good, showing acceptable performance for most compounds. Higher RPDs were a result of low values for the paired results; the RPD statistic has limited effectiveness in assessing variability at low levels (Mathieu, 2006).



Boxes show 25th and 75th percentiles, whiskers show the minimum and maximum results, and diamonds indicate the mean result.

Figure E-4. Carbamate analysis MS/MSD percent recoveries, 2009-2011.

Table E-11. Mean, minimum, and maximum percent for MS/MSD recovery and MS/MSD RPD.

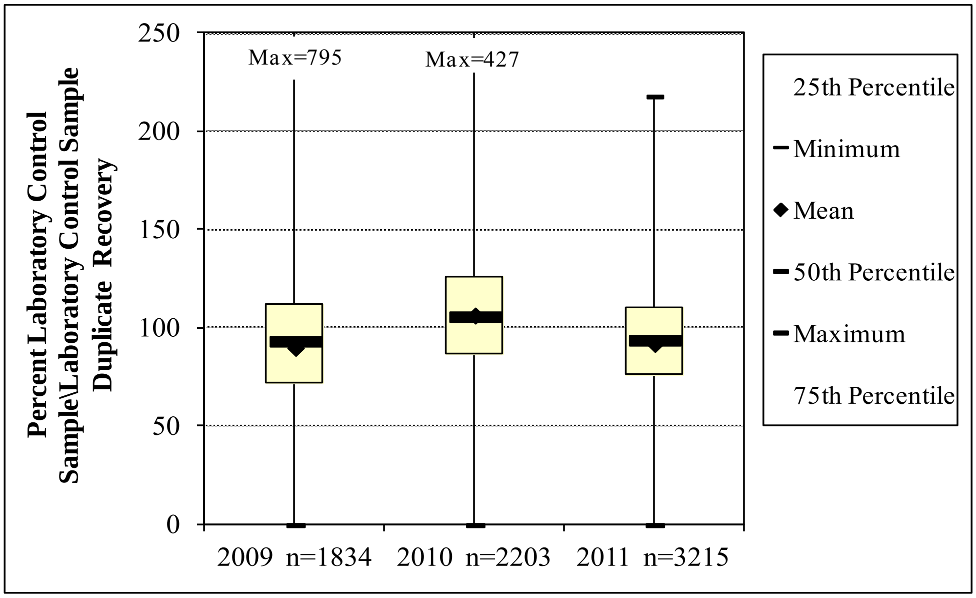
Analysis	MS\MSD Recovery			%RPD for MS\MSD		
	Mean	Minimum	Maximum	Mean	Minimum	Maximum
LCMS\MS	74%	36%	99.4%	10%	5%	35%
GCMS-Herbicides	82%	24%	299%	9%	5%	19%
GCMS-Pesticides	108%	5%	238%	7%	2%	31%

When analytes exceeded the acceptable recovery range, detections of these compounds were qualified as estimates.

Laboratory Control Samples

Laboratory control samples (LCS) are analyte compounds spiked into deionized water at known concentrations and subjected to analysis. They are used to evaluate accuracy of pesticide residue recovery for a specific analyte. Detections may be qualified based on low LCS recovery and/or high RPD between paired LCS.

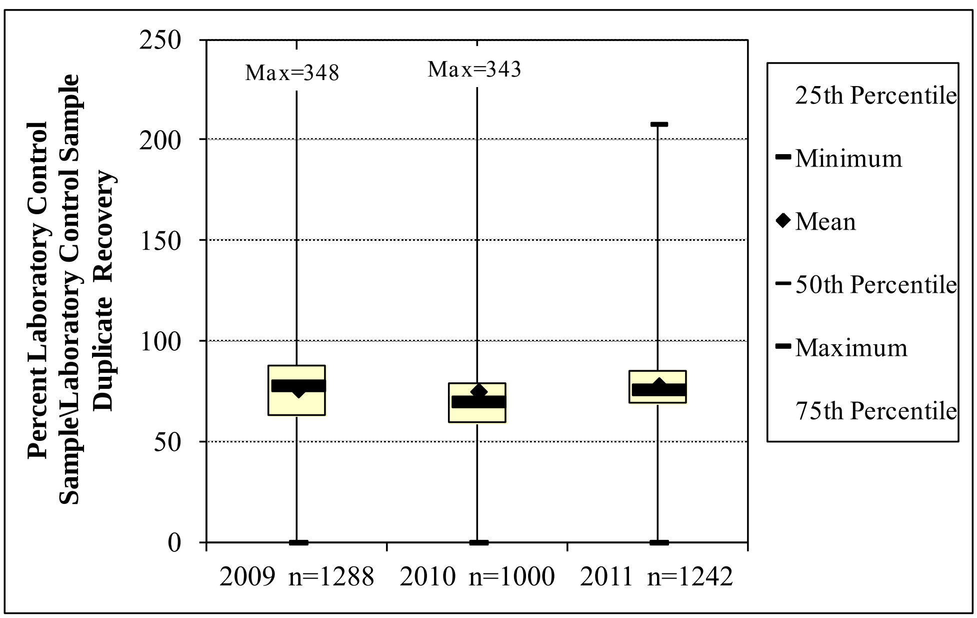
Figures E-5, E-6, and E-7 present the 2009-2011 percent LCS and LCS duplicate recoveries for the pesticide MS, herbicide, and carbamate analysis. Pesticide MS recoveries were good, with the median value ranging from 90-107% and the 25th and 75th quartiles ranging from 72-126% during 2009-2011 (Figure E-5). Acceptable recovery values for pesticide MS analysis range from 30-130%.



Boxes show 25th and 75th percentiles, whiskers show the minimum and maximum results, and diamonds indicate the mean result.

Figure E-5. Pesticide MS analysis LCS/LCS duplicate percent recoveries, 2009-2011.

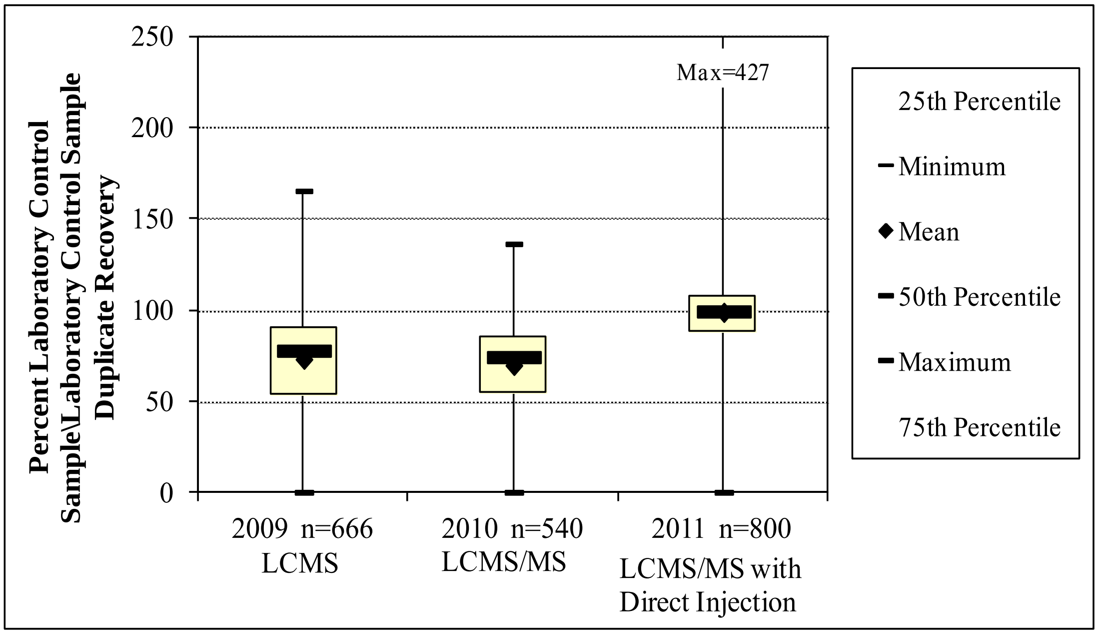
Herbicide LCS percent recoveries tended to be low, as with the MS/MSD recoveries, with a median range from 70-78% and the 25th and 75th quartiles ranging from 60-88% during 2009-2011 (Figure E-6). Acceptable recovery range for herbicides is generally from 40-130%.



Boxes show 25th and 75th percentiles, whiskers show the minimum and maximum results, and diamonds indicate the mean result.

Figure E-6. Herbicide analysis LCS/LCS duplicate percent recoveries, 2009-2011.

Carbamate LCS and duplicate percent recoveries varied each year, as with the MS/MSD recoveries; this is attributed to changes in laboratory analysis. Figure E-7 presents LCS and LCS duplicate recoveries by year. Median recoveries in 2009 and 2010 were similar, 74% and 78% respectively. The 25th and 75th quartile recoveries during these years were also similar, ranging from 54-91%. The change to direct injection in 2011 and LCMS/MS in 2010 provided better recoveries with a median recovery of 99% in 2011. Acceptable carbamate analysis recoveries generally ranged from 50-150% for 2009 and 2010 and from 40-130% in 2011.



Boxes show 25th and 75th percentiles, whiskers show the minimum and maximum results, and diamonds indicate the mean result.

Figure E-7. Carbamate analysis LCS/LCS duplicate percent recoveries, 2009-2011.

Table E-12 presents the mean, minimum, and maximum percent recovery for the LCS and LCS duplicate for the three types of analysis, as well as the RPD statistic for the LCS and LCS duplicate.

Table E-12. Mean, minimum, and maximum percent recovery for the LCS and RPD for the LCS and LCS duplicate, 2009-2011.

Analysis	LCS Recovery			%RPD for LCS and duplicate		
	Mean	Minimum	Maximum	Mean	Minimum	Maximum
LCMS\MS	70%	23%	95%	13%	7%	33%
GCMS-Herbicides	72%	37%	196%	18%	7%	108%
GCMS-Pesticides	106%	36%	155%	9%	3%	45%

Field Data Quality

Quality Control Procedures

Field meters were calibrated at the beginning of the field day according to manufacturers' specifications, using Ecology SOP EAP033 *Standard Operating Procedure for Hydrolab DataSonde® and MiniSonde® Multiprobes* (Swanson, 2010). Field meters were post-checked at the end of the field day using known standards. Dissolved oxygen (DO) meter results were compared to results from grab samples analyzed using the Winkler laboratory titration method. DO grab samples and Winkler titrations were collected and analyzed according to the SOP (Ward, 2007). Two to three Winkler grab samples were obtained during each sample day. Measurement quality objectives (MQOs) for meter post-checks, replicates, and Winkler DO comparisons are described in Anderson and Sargeant (2009).

2009 Field Data Quality Results

The hydrolab field meter (hydrolab MS5/hach®) for the Lower Yakima and Wenatchee-Entiat (eastern Washington) sites met quality control (QC) objectives including post-checks and Winkler comparisons (Table E-13) with the following exceptions:

- On March 18, 2009, DO meter readings for the Wenatchee-Entiat sites were biased high, and meter and Winkler DO ranged from 11.1-13.6% RSD. Only Winkler DO results will be reported for this day.
- On June 24, 2009, a conductivity result exceeded MQOs for Mission Creek; the conductivity results for this day will be qualified as an estimate.

The hydrolab field meter for the urban sites and the lower Skagit-Samish (western Washington) sites met QC objectives including post-checks and Winkler comparisons (Table E-13) with the following exceptions:

- Conductivity post-checks on March 16 and 25, April 22 and 27, and May 6, 20, and 26, 2009 did not meet MQOs. Conductivity results for these days are rejected and not reported.
- On July 17, 2009, Indian Slough conductivity and flow results exceeded MQOs. This is likely due to the tidal influence at this site (and Brown's Slough). Conductivity and flow results may vary more due to environmental conditions. Results are acceptable.

Table E-13. Quality control results (%RSD) for field meter and Winkler replicates, 2009.

Replicate Meter Parameter	Western Washington Sites		Eastern Washington Sites	
	Average	Maximum	Average	Maximum
Winkler and meter DO	1.5%	7.7%	2.3%	13.7%
Replicate Winkler's for DO	0.6%	2.2%	0.3%	1.3%
Meter flow	4.5%	21.5%	4.8%	23.7%

DO: dissolved oxygen.

For 2009 flow replicates, three replicate flows exceeded MQOs. These flow replicates occurred during low-flow conditions when the RSD statistic produces higher variability. Flow results for these days are acceptable.

2010 Field Data Quality Results

The hydrolab field meter for the Lower Yakima and Wenatchee-Entiat (eastern Washington) sites met QC objectives including post-checks and Winkler comparisons (Table E-14) with the following exceptions:

- Conductivity post-checks did not meet MQOs on the following dates: July 7, August 9 and 25, and October 20, 2010. Conductivity results for these days are qualified as estimates.

The hydrolab field meter for the urban sites and the lower Skagit-Samish (western Washington) sites met QC objectives including post-checks and Winkler comparisons (Table E-14) with the following exceptions:

- On June 15 and 28, 2010, DO measurements for Indian Slough did not meet MQOs. The hydrolab meter and Winkler DO results had an 11.3 and 14.5% RSD on June 15 and 28, respectively, slightly exceeding the MQO.
- On August 20, 2010, a replicate conductivity reading for Indian Slough had a 42.5% RSD, exceeding the MQO.

At times the Indian Slough site is influenced by incoming marine water. When this occurs, temperature, DO, and conductivity values can vary greatly by depth. Thus, it is difficult to obtain consistent meter readings at the Indian Slough site. It is likely that environmental factors are the cause of the differences in the DO and conductivity replicates. Field QC objectives were met. Indian Slough DO and conductivity results for these days will be qualified as estimates.

Table E-14. Quality control results (%RSD) for field meter and Winkler replicates, 2010.

Replicate Meter Parameter	Western Washington Sites		Eastern Washington Sites	
	Average	Maximum	Average	Maximum
Winkler and meter DO	1.6%	14.5%	1.4%	5.5%
Replicate Winkler's for DO	0.6%	2.5%	0.3%	1.8%
Meter flow	5.2%	29.0%	4.5%	32.6%

DO: dissolved oxygen.

Four replicate flow results exceeded the MQOs, three for the eastern Washington sites and one for the western Washington sites. Flow replicates were during low-flow conditions when the % RSD statistic produces higher variability. Flow results for these days are acceptable.

2011 Field Data Quality Results

The hydrolab field meter for the Lower Yakima and Wenatchee-Entiat (eastern Washington) sites met QC objectives including post-checks and Winkler comparisons (Table E-15) with the following exceptions:

- On March 7 and October 19, 2011, post-check pH values did not meet MQOs; pH values for those days are qualified as estimates.
- During the weeks of May 3 and May 11, 2011, hydrolab field meter DO values were biased high due to a bad LDO cap. Hydrolab meter DO results were regressed against the accurate Winker DO values to estimate meter DO values.

The hydrolab field meter for the urban sites and the lower Skagit-Samish (western Washington) sites met all QC objectives including post-checks and Winkler comparisons (Table E-15).

Table E-15. Quality control results (%RSD) for field meter and Winkler replicates, 2011.

Replicate Meter Parameter	Western Washington Sites		Eastern Washington Sites	
	Average	Maximum	Average	Maximum
Winkler and meter DO	0.9%	5.7%	1.0%	4.2%
Replicate Winkler's for DO	0.2%	1.1%	0.7%	2.6%
Meter flow	3.0%	9.4%	2.3%	7.8%

DO: dissolved oxygen.

All replicate flow results met MQOs.

Field Audits

Two field audits were conducted in 2010, and one was conducted in 2011: May 21 and July 28, 2010 and June 21, 2011. The purpose of the field audit is to ensure that sampling methodologies are consistent. For field audits, both the western and eastern Washington field teams met at a surface water location to measure hydrolab field parameters and flow and to obtain samples for measuring Winkler DO. Results and methods are compared to ensure that field teams are using consistent sampling methodologies that result in comparable data.

Field Audit Results

The day before the 2010 field audit, the electrolyte solution in the pH reference electrode was changed for both hydrolab multiprobe meters. In addition, the eastern Washington hydrolab meter LDO sensor and a daughter board were replaced. During the May 21, 2010 audit, the western Washington pH post-check did not meet MQOs because the pH electrolyte solution had leaked out of the reference electrode. In addition, the eastern Washington meter did not meet MQOs for conductivity and the DO results were less accurate than before replacement of the LDO sensor and daughter board.

Issues with both of the hydrolabs were resolved, and another audit took place on July 28, 2010. During this audit, the western Washington flow meter did not meet MQOs. The meter was sent in for re-calibration.

The results of the 2011 field audit were good with the exception of the eastern Washington Orion backup meter for conductivity. In addition, Winkler DO replicates failed to meet MQOs. This is likely because the Winkler DO samples were obtained at slightly different areas of the stream.

As a result of both the 2010 and 2011 audits, the following actions were taken:

- Routine maintenance occurs on all equipment, and replacement batteries are stocked in the field vehicle.
- The flow meters are sent to the manufacturer for recalibration once every two years unless quarterly checks show a need to send in sooner.
- Meters are calibrated and post-checked on a regular basis to ensure proper functioning, including linearity checks during calibration.
- The end-of-season maintenance includes replacement of LDO cap and pH reference tablets and solution.
- The Orion backup meter was retired due to age and unreliability.

Results of the 2010 and 2011 field audits found that both the eastern and western Ecology sampling teams are conducting field operations using consistent sampling methodologies that results in comparable data.

Appendix F. SEAWAVE-Q Modeling

To evaluate whether pesticide concentrations have changed significantly over time, we assessed trend using a parametric regression model called SEAWAVE-Q (Vecchia et al., 2008). This is a model developed by the U.S. Geological Survey (USGS) for analyzing long-term trends in pesticide concentrations in streams. We applied the model to each site/pesticide combination with ten or more detections. Using the model results, we tested trends for statistical significance at each site/pesticide combination. Details about this modeling are presented below.

We chose the SEAWAVE-Q model over the seasonal Kendall test because the model allows analysis at more site/pesticide combinations, based on a comparison of the two methods published by USGS (Sullivan et al., 2009). This model also allows us to incorporate streamflow and/or precipitation in the trend testing.

Three parameters were included in the model: seasonality, flow/precipitation, and trend.

- The seasonal term is an idealized wave function which mimics pesticide concentrations over the monitoring season.
- The flow term was used only at some of the sites; at the others we used precipitation. The reason for this difference is that we did not have continuous flow data available at most of the sites. Instead, flow data were collected weekly, and for some sites there are missing values due to unsafe conditions when staff could not enter the water. For western Washington sites, we found that precipitation was an effective substitute for the flow term. For eastern Washington sites, precipitation was not an effective substitute since little precipitation occurs during the monitoring season.
- The trend term is a linear term across all study years.

The SEAWAVE-Q model correctly accounts for non-detect observations by using maximum likelihood estimation (MLE) to calculate model coefficients. This avoids potential errors caused by substituting artificial values for non-detect observations (Helsel, 2005).

Concentration data were prepared for trend analysis by applying a uniform reporting level across all study years; data were then re-censored based on this level. The purpose of this is to avoid biasing trend results due to changing reporting levels over time. This is similar to data preparation performed by USGS (Martin, 2009; Ryberg et al., 2010). As pointed out by Martin (2009), the reporting level is not a detection limit, and changes in the reporting level reflect changes in the variability/precision of low-level quantifications, not changes in detection capability. Similar to Ryberg et al. (2010), we set the uniform reporting level to the median of low-level detections, although the exact procedure may differ.

For our procedure, we calculated a uniform reporting level for all studies by taking the median of all detections below the 95^{th} percentile of all reporting levels across the study. Detections below this uniform reporting level were changed to non-detects. Non-detects with reporting levels above this uniform level were removed from the data set prior to trend analysis.

The following equation specifies the form of the model that we used:

$$\text{Log } C(t) = \beta_0 + \beta_1 \text{ Wave}(t) + \beta_2 \text{ FlowAnomaly}(t) + \beta_3 \text{ Precip}(t) + \beta_4 t + \text{error}(t)$$

Where

- t is the sample time in decimal years with respect to an arbitrary origin.
- Log C(t) is the logarithm of the observed pesticide concentration at sample time t.
- β_0, β_1, β_2, β_3, β_4 are numeric regression coefficients to be calculated based on maximum likelihood estimation.
- Wave(t) is the seasonal wave (mimicking pesticide concentrations over the season) at sample time t. This is a dimensionless number between 0 and 1 at any given time.
- FlowAnomaly(t) is the flow anomaly computed from weekly streamflow for sample time t. Flow anomaly was calculated as the logarithm of that week's flow, minus the average of the logarithms of the latest four weeks of flows (the average includes the current week).
- Precip(t) is the total 48-hour precipitation for sample time t.
- error(t) is the difference between the model and the observed concentration at sample time t.

To fit the model, regression coefficients were calculated a number of times, using different seasonal waves each time. Given that the monitoring season runs from March-October, we used the following sets of seasonal wave models for calculating regression coefficients (Table F-1). See Vecchia et al. (2008) for further explanation.

Table F-1. Seasonal Waves Used in Modeling.

	Month											
Model#	1	2	3	4	5	6	7	8	9	10	11	12
1			1									
2			1	1								
3			1	1	1							
4			1	1	1	1						
5			1	1	1	1	1					
6			1	1	1	1	1	1				
7			1	1	1	1	1	1	1			
8			1	1	1	1	1	1	1	1		
9			1	1	1	1	1	1	1	1	1	
10			1	0.5								
11			1	0.8	0.5							
12			1	1	0.5	0.5						
13			1	1	0.8	0.5	0.5					
14			1	1	1	0.5	0.5	0.5				
15			1	1	1	0.8	0.5	0.5	0.5			
16			1	1	1	1	0.5	0.5	0.5	0.5		
17			1	1	1	1	0.8	0.5	0.5	0.5	0.5	
18			0.5	1								

	Month											
Model#	1	2	3	4	5	6	7	8	9	10	11	12
19			0.5	0.8	1							
20			0.5	0.5	1	1						
21			0.5	0.5	0.8	1	1					
22			0.5	0.5	0.5	1	1	1				
23			0.5	0.5	0.5	0.8	1	1	1			
24			0.5	0.5	0.5	0.5	1	1	1	1		
25			0.5	0.5	0.5	0.5	0.8	1	1	1	1	
26			1		1							
27			1			1						
28			1				1					
29			1					1				
30			1						1			
31			1							1		
32			1								1	
33			0.5	0.5	1							
34			0.5	0.5		1						
35			0.5	0.5			1					
36			0.5	0.5				1				
37			0.5	0.5					1			
38			0.5	0.5						1		
39			0.5	0.5							1	
40			1		0.5	0.5						
41			1			0.5	0.5					
42			1				0.5	0.5				
43			1					0.5	0.5			
44			1						0.5	0.5		
45			1							0.5	0.5	
46			1								0.5	0.5

Blank cells table represent zeroes.
Each seasonal wave was calculated using 4 different half lives: 4, 3, 2, and 1 month.

We used a higher number of models to fit our data than previous USGS studies did. Our model selection was made because we were uncertain about pesticide patterns in our study area, and we wanted to include as wide a variety as possible. It was probably not necessary to use such a high number of models for this study, and future work should refer to the model selection used in previous USGS studies (e.g., Sullivan et al., 2009; Ryberg et al., 2010).

The best model was selected based on maximum likelihood estimation using the survival package in R (R Core Team, 2012). This was done running MLE on each of the seasonal wave/ half-life combinations and selecting the model with the highest likelihood.

The final model was checked for the following assumptions: normality of residuals, constant variance, and independence. Models that violated assumptions were dropped from further analysis. For detected concentrations, model residuals were calculated as the difference between the model and the observation. For non-detect observations, the model residual is not known. Simply using the difference between the model and the uniform reporting level is not valid. For non-detected observations, A.V. Vecchia suggested calculating a randomized residual in the following way (A.V. Vecchia, personal communication):

Randomized Residual = Qnorm{ U[0,1] * f(R/σ)}

Where

- Qnorm is the quantile function for the normal distribution
- U[0,1] is the uniform distribution between 0 and 1
- R = model prediction – reporting level
- σ is the scale of the model computed during regression
- f is the standard normal probability density function

Calculating randomized residuals does not provide a unique set of residuals but rather a single possibility. We evaluated the normality of residuals by producing 1000 sets of randomized residuals, and calculating the Shapiro-Wilk p-value for each set. The Shapiro-Wilk test checks whether a distribution is similar to the normal distribution. We recorded the p-value for each one of these 1000 sets of randomized residuals, and then plotted all the p-values on a boxplot. If the lower bound of the box (the 25^{th} percentile) fell below 0.05, we considered the normality of residuals assumption to be violated, and we rejected the model. Randomized residuals were also plotted against year and Julian day to look for changes in variance. These plots were checked by eye to see if clear model violations were present.

To calculate whether the trend component of the model was significant, we ran the MLE twice: once with and once without the trend term. The test statistic is twice the difference in log-likelihoods between the two models (Helsel, 2005):

$$G^2_{partial} = 2 [\ln L(\beta_{with}) - \ln L(\beta_{without})]$$

A p-value is obtained by comparing the test statistic to a chi-square distribution with one degree of freedom. If the p-value was less than the significance level of 0.05, then the trend was considered significant at the 95% confidence level.

SEAWAVE-Q Model Results with a Significant Trend

SEAWAVE-Q model results with a significant trend are presented in Table F-2 and in Figures F-1 – F-42.

Table F-2. Sites with significant trends in pesticide concentrations.

Site	Pesticide and Type	Trend Time Period	Trend Direction	P value=	Percent change per year
Thornton Creek	Diazinon: I	2003-2011	decreasing	<0.002	-36%
	Diuron: H	2003-2011	decreasing	0.004	-19%
	Mecoprop (MCPP): H	2003-2011	decreasing	<0.001	-11%
	Triclopyr: H	2003-2011	decreasing	0.026	-7%
Big Ditch (upstream)	Picloram: H	2007-2011	decreasing	< 0.001	-45%
	Tebuthiuron: H	2007-2011	decreasing	< 0.001	-43%
Big Ditch (downstream)	Bentazon: H	2006-2011	decreasing	< 0.001	-18%
	Eptam: H	2006-2011	decreasing	0.013	-23%
	Metalaxyl: F	2006-2011	decreasing	0.005	-26%
	Picloram: H	2006-2011	decreasing	< 0.001	-29%
	Chlorpropham: H	2006-2011	increasing	0.01	68%
	MCPA: H	2006-2011	increasing	0.004	38%
Indian Slough	Tebuthiuron: H	2006-2011	decreasing	0.001	-11%
	Hexazinone: H	2006-2011	increasing	0.002	20%
	Metolachlor: H	2006-2011	increasing	0.01	16%
Browns Slough	Diuron: H	2006-2011	decreasing	0.001	-27%
	Simazine: H	2006-2011	decreasing	< 0.001	-29%
	DCPA: H	2006-2011	increasing	< 0.001	63%
	MCPA: H	2006-2011	increasing	0.019	59%
	Metolachlor: H	2006-2011	increasing	< 0.001	94%
Spring Creek (upstream)	Dicamba-I: H	2005-2011	increasing	0.025	+16%
Spring Creek (downstream)	Azinphos-methyl: I	2003-2011	decreasing	0.028	-14%
	Diuron: H	2003-2011	decreasing	0.001	-18%
	Simazine: H	2003-2011	decreasing	0.039	-12%
	Dicamba-I: H	2004-2011	increasing	< 0.001	20%
Marion Drain	Atrazine: H	2003-2011	decreasing	0.018	-6%
	Chlorpyrifos: I	2003-2011	decreasing	0.036	-7%
	Clopyralid: H	2007-2011	decreasing	0.001	-17%
	Simazine: H	2003-2011	decreasing	0.05	-7%
	Dicamba-I: H	2004-2011	increasing	< 0.001	17%
	Ethoprop: I	2003-2011	increasing	0.022	24%
	Pendimethalin: H	2003-2011	increasing	0.019	5%
	Terbacil: H	2003-2011	increasing	0.012	6%
	Trifluralin: H	2003-2011	increasing	0.009	6%
Sulphur Creek Wasteway	Azinphos-methyl: I	2003-2011	decreasing	< 0.001	-17%
	Diuron: H	2003-2011	decreasing	0.024	-10%
	Norflurazon: H	2003-2011	decreasing	0.003	-14%
	DCPA: H	2003-2011	increasing	< 0.001	11%
	Dicamba-I: H	2004-2011	increasing	< 0.001	21%
	MCPA: H	2004-2011	increasing	0.01	11%
	Pendimethalin: H	2003-2011	increasing	< 0.001	19%
Brender Creek	Total-Endosulfan: I	2007-2011	decreasing	< 0.001	-30%

Cedar-Sammamish WRIA 8: Thornton Creek (TC-3)

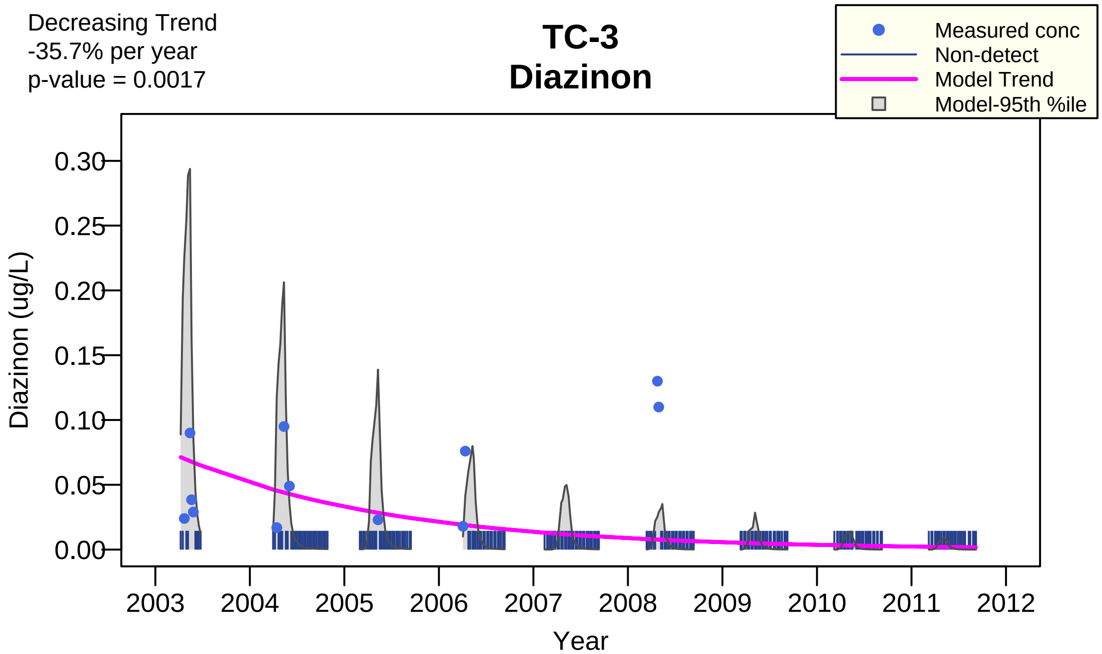


Figure F-1. Decreasing trend in diazinon concentrations for downstream Thornton Creek (TC-3), 2003-2011.

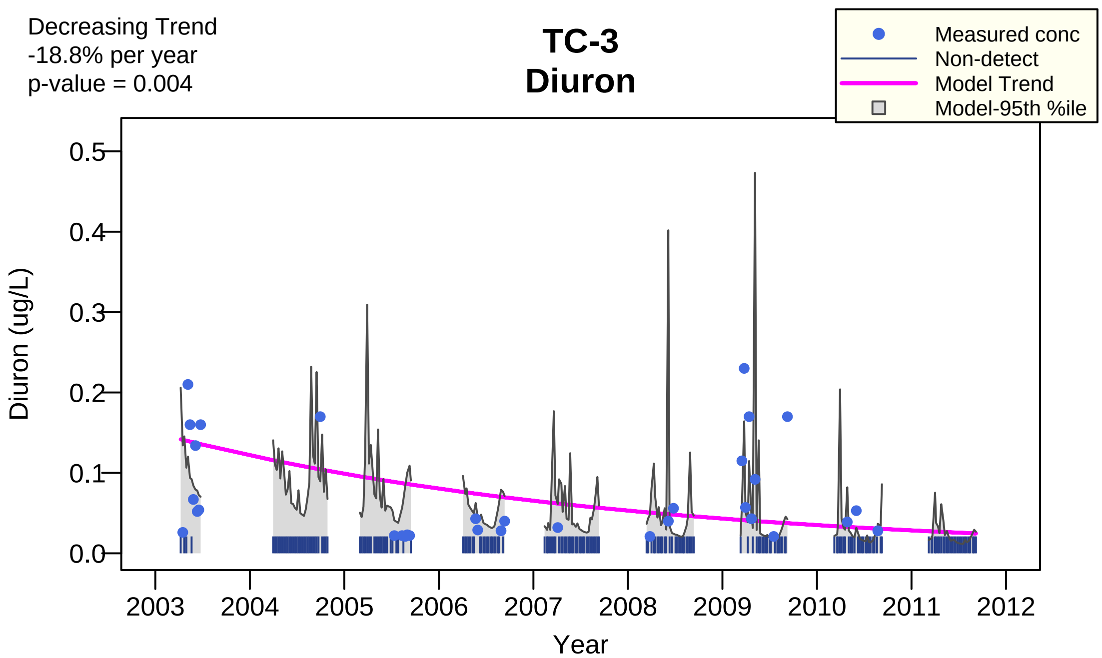


Figure F-2. Decreasing trend in diuron concentrations for downstream Thornton Creek (TC-3), 2003-2011.

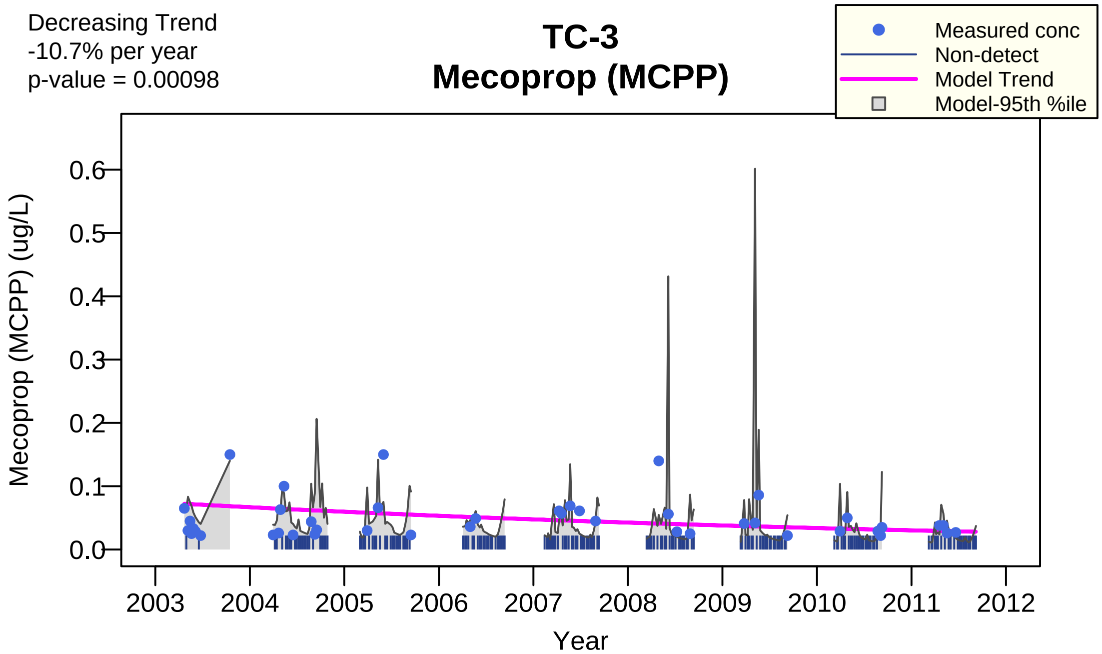


Figure F-3. Decreasing trend in mecoprop concentrations for downstream Thornton Creek (TC-3), 2003-2011.

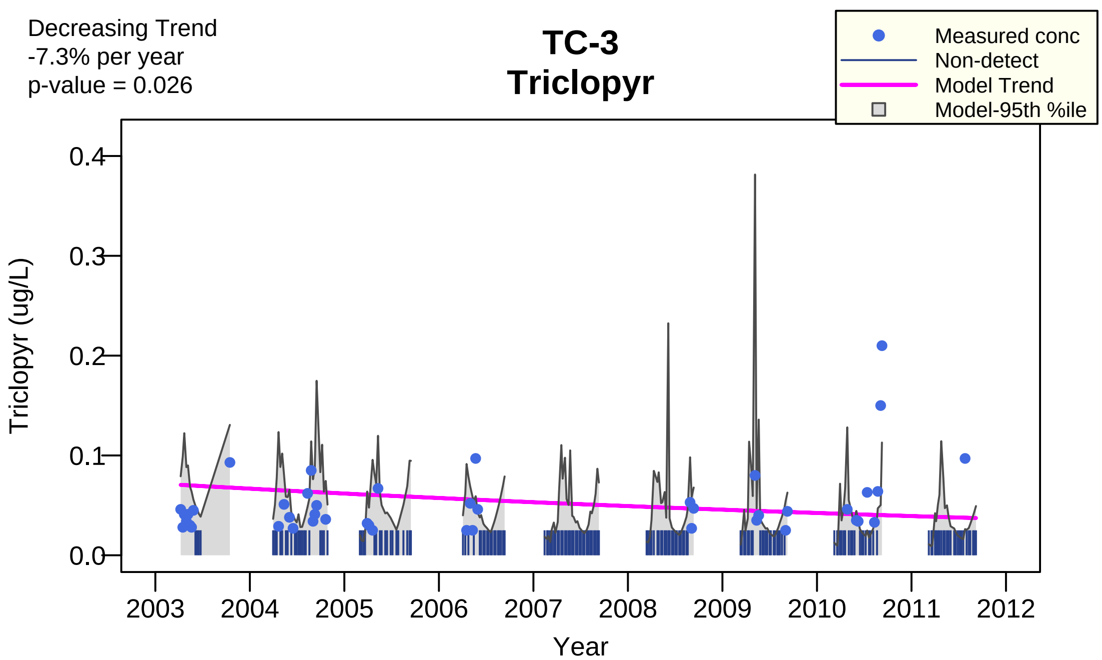


Figure F-4. Decreasing trend in triclopyr concentrations for downstream Thornton Creek (TC-3), 2003-2011.

Big Ditch – Upstream (BD-2)

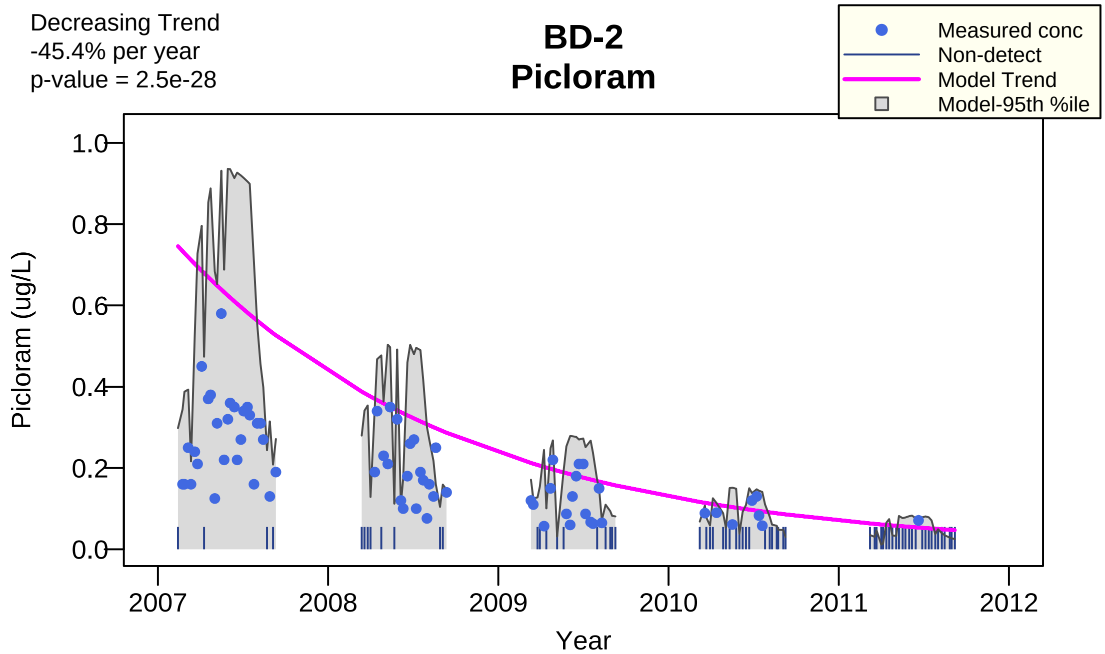


Figure F-5. Decreasing trend in picloram concentrations for the upstream Big Ditch site (BD-2), 2007-2011.

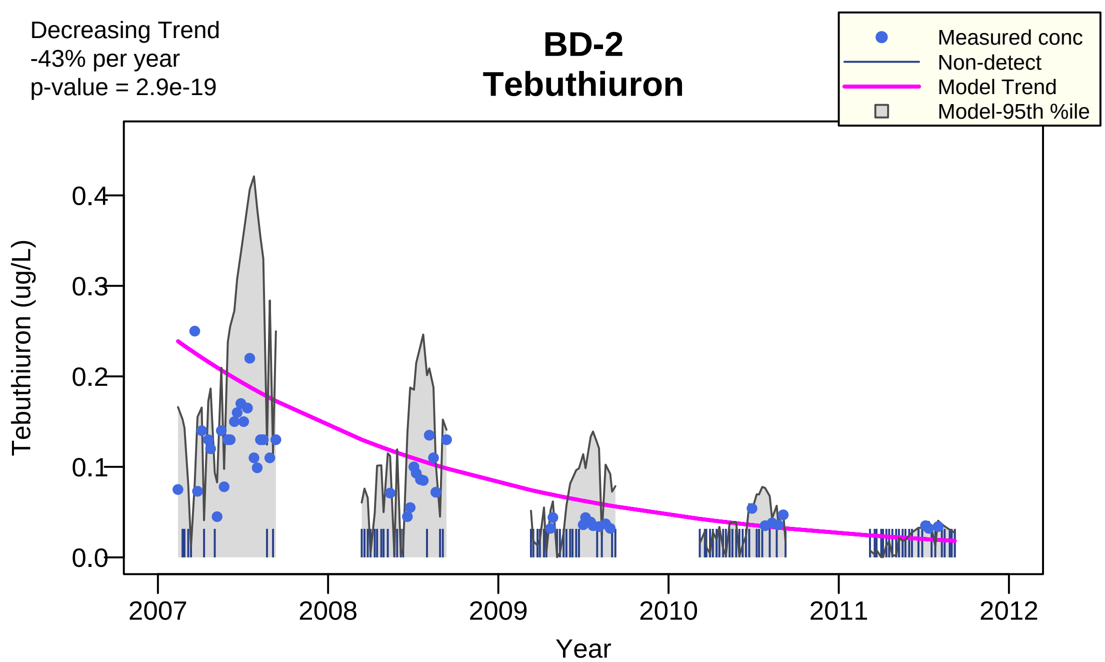


Figure F-6. Decreasing trend in tebuthiuron concentrations for the upstream big Ditch site (BD-2), 2007-2011.

Big Ditch – Downstream (BD-1)

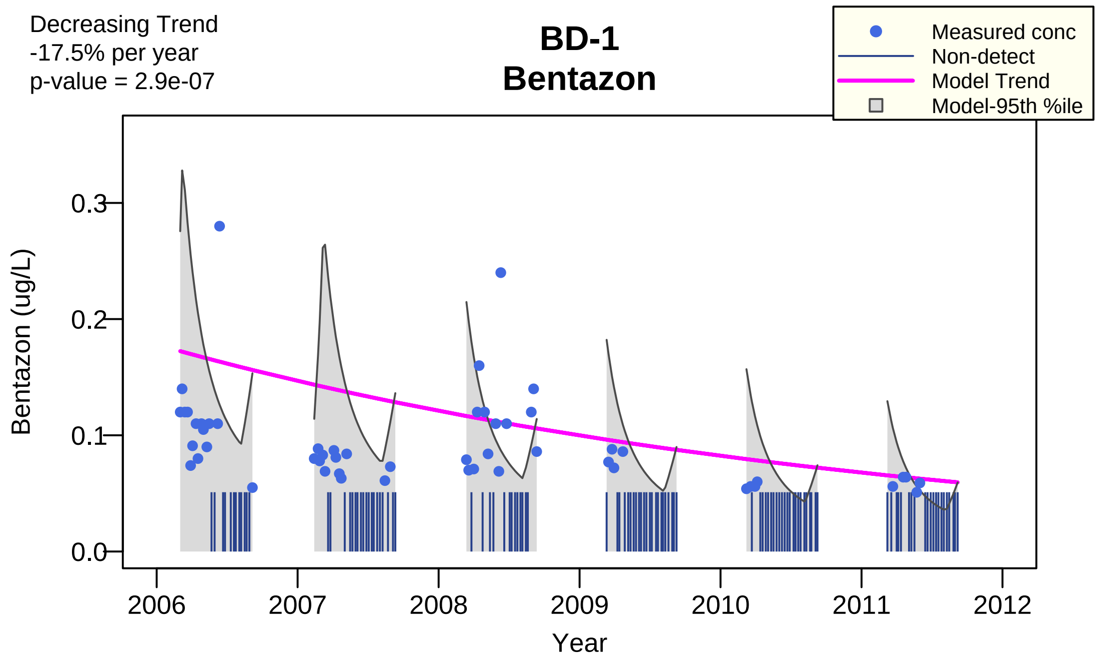


Figure F-7. Decreasing trend in bentazon concentrations for the downstream Big Ditch site (BD-1), 2006-2011.

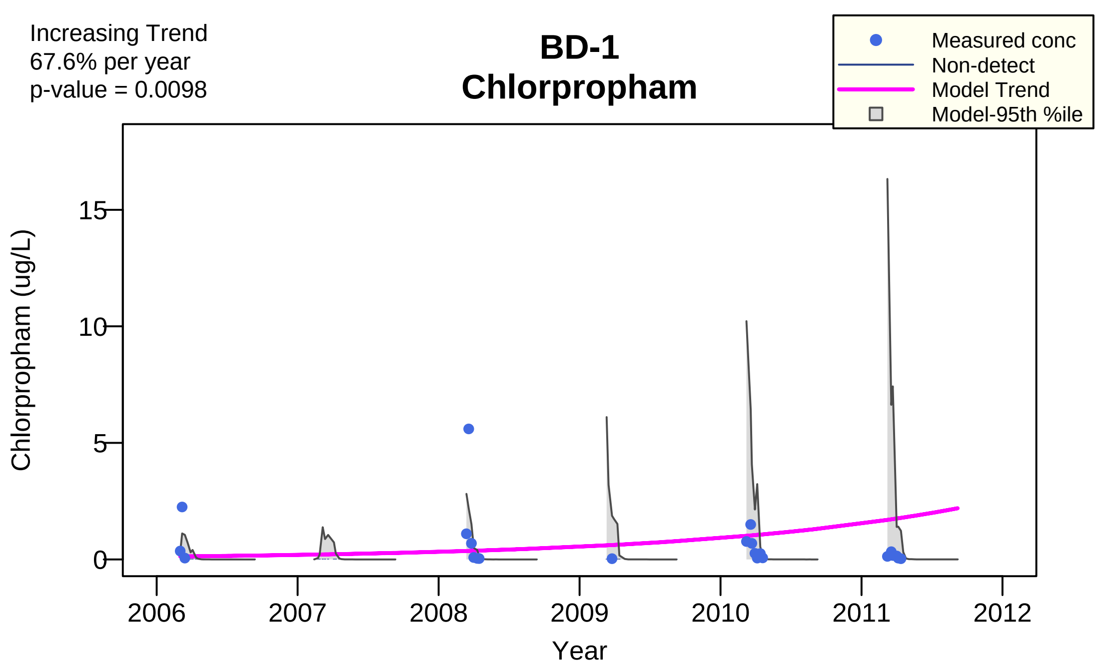


Figure F-8. Increasing trend in chlorpropham concentrations for the downstream Big Ditch site (BD-1), 2006-2011.

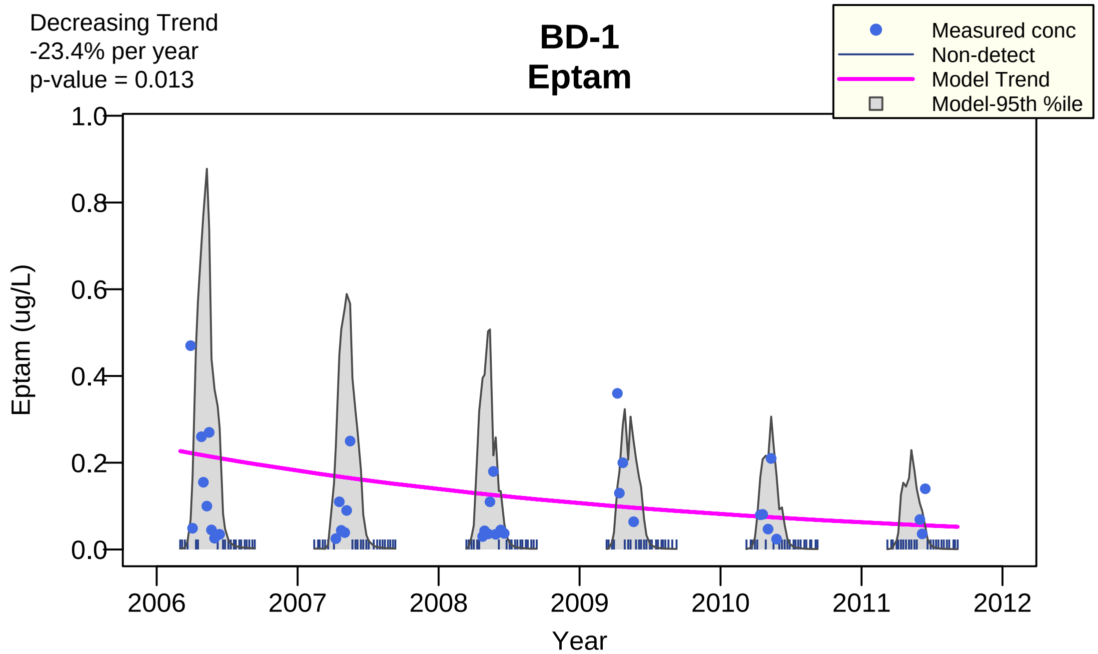


Figure F-9. Decreasing trend in eptam concentrations for the downstream Big Ditch site (BD-1), 2006-2011.

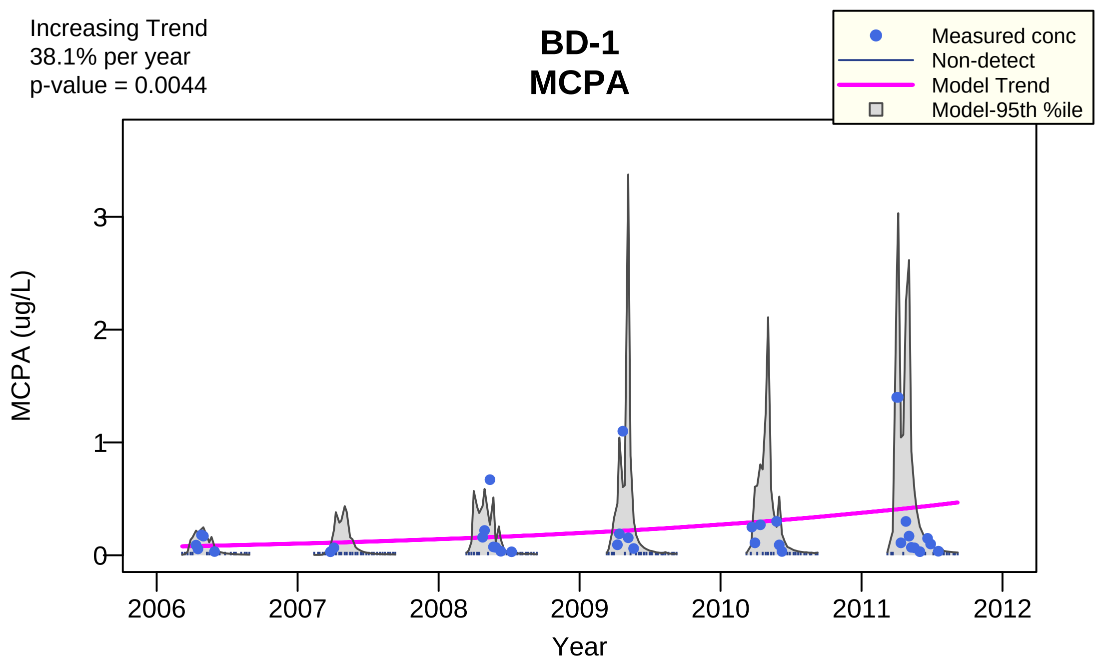


Figure F-10. Increasing trend in MCPA concentrations for the downstream Big Ditch site (BD-1), 2006-2011.

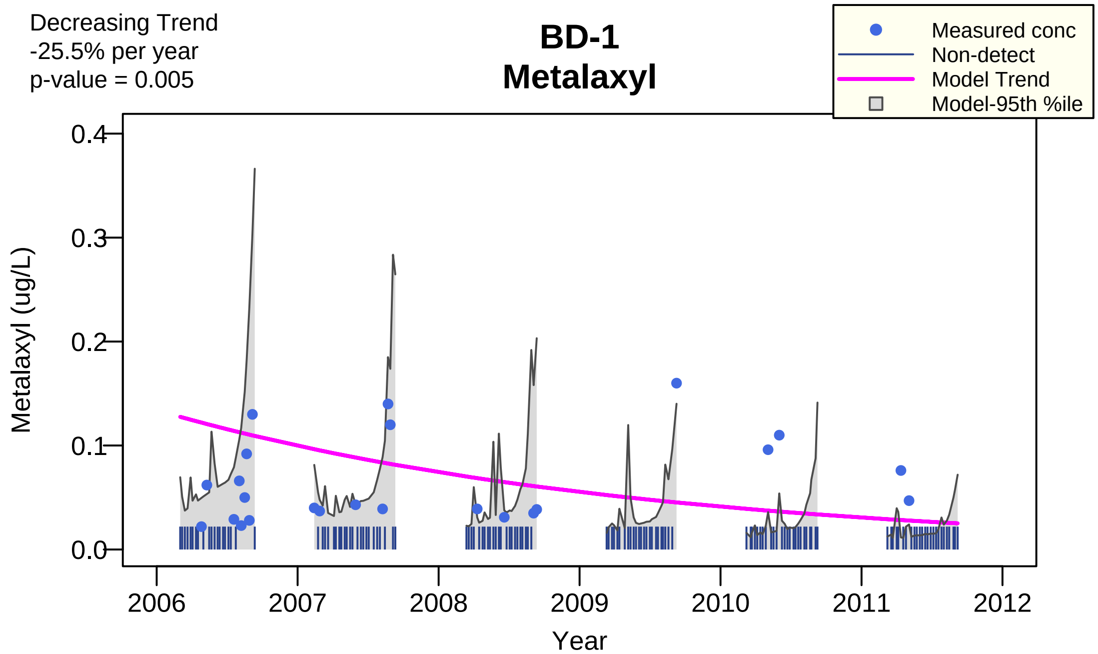


Figure F-11. Decreasing trend in metalaxyl concentrations for the downstream Big Ditch site (BD-1), 2006-2011.

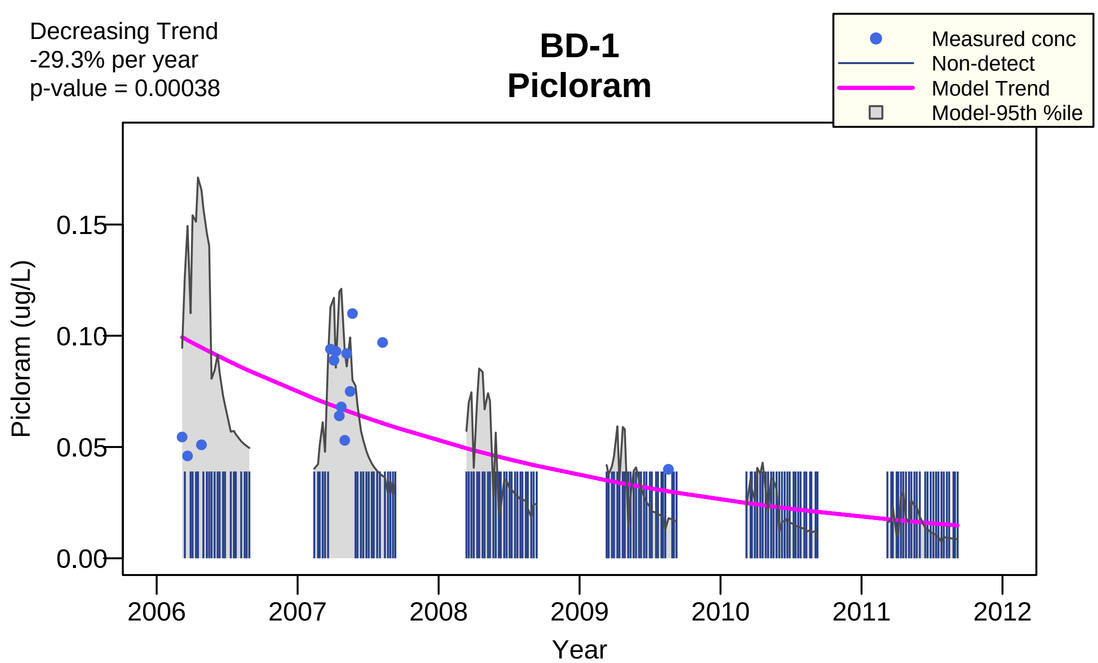


Figure F-12. Decreasing trend in picloram concentrations for the downstream Big Ditch site (BD-1), 2006-2011.

Indian Slough (IS-1)

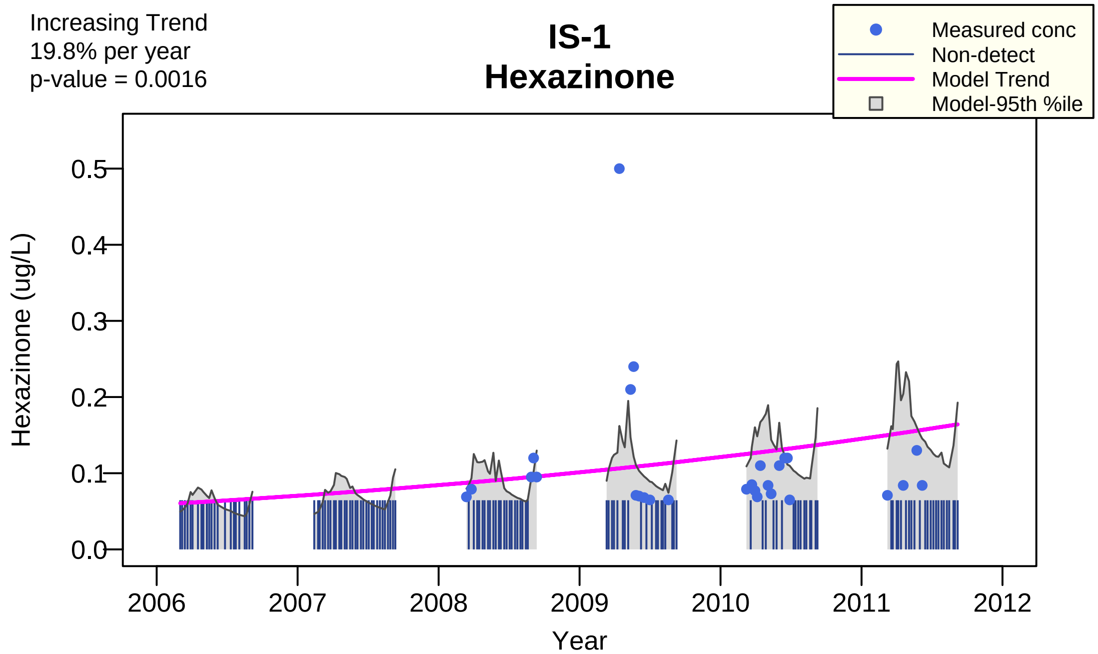


Figure F-13. Increasing trend in hexazinone concentrations at Indian Slough (IS-1), 2006-2011.

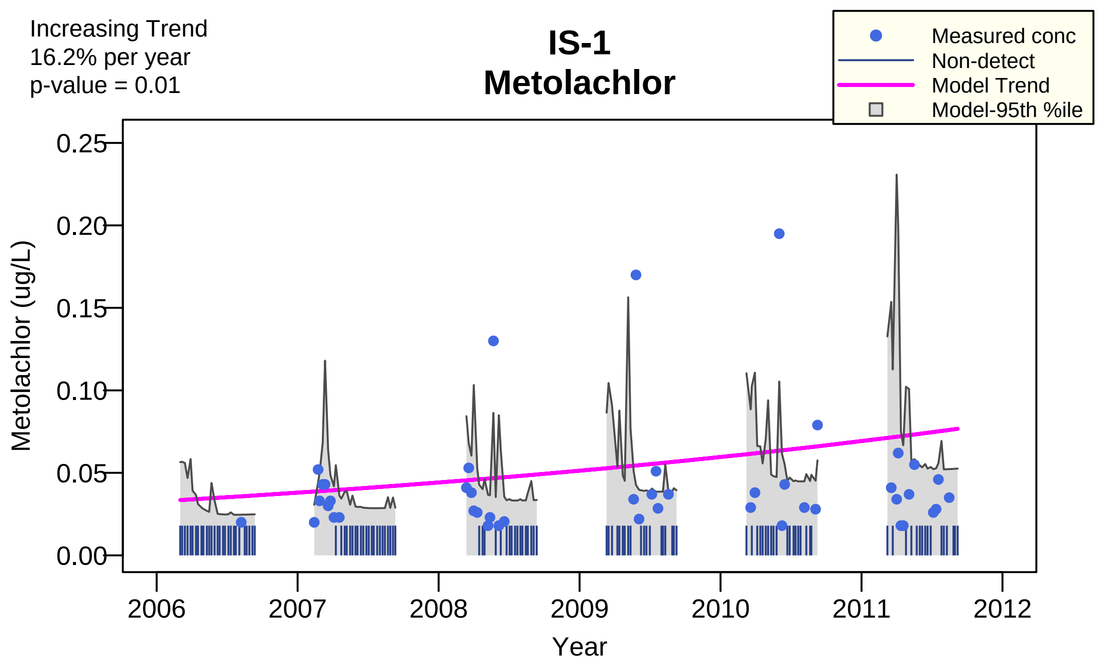


Figure F-14. Increasing trend in metolachlor concentrations at Indian Slough (IS-1), 2006-2011.

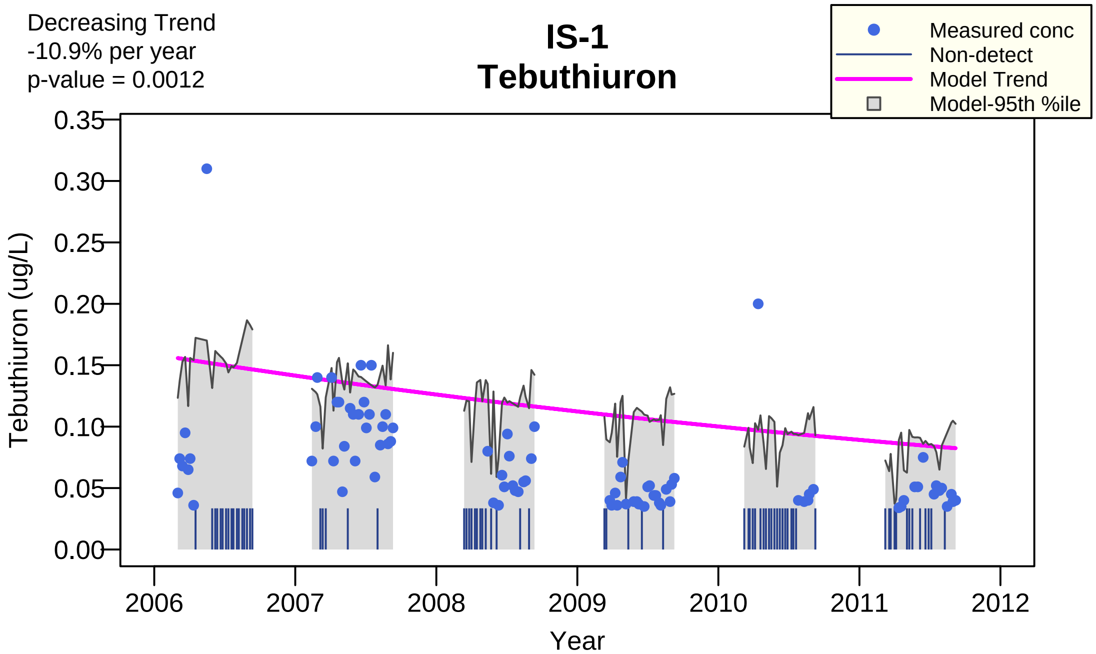


Figure F-15. Decreasing trend in tebuthiuron concentrations at Indian Slough (IS-1), 2006-2011.

Browns Slough (BS-1)

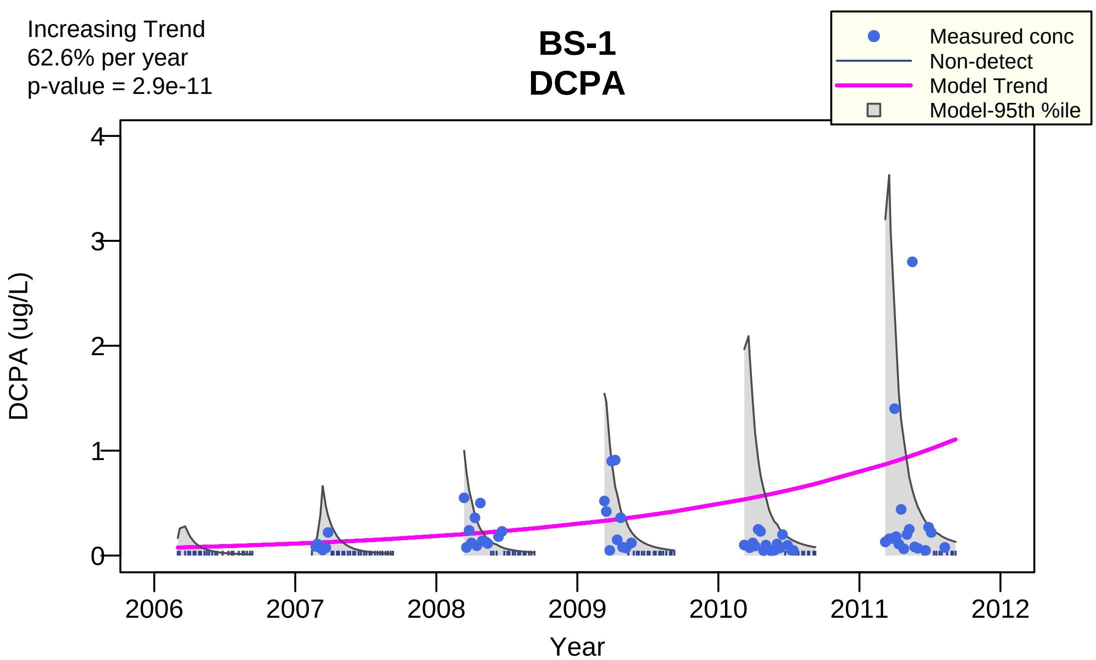


Figure F-16. Increasing trend in DCPA concentrations at Browns Slough (BS-1), 2006-2011.

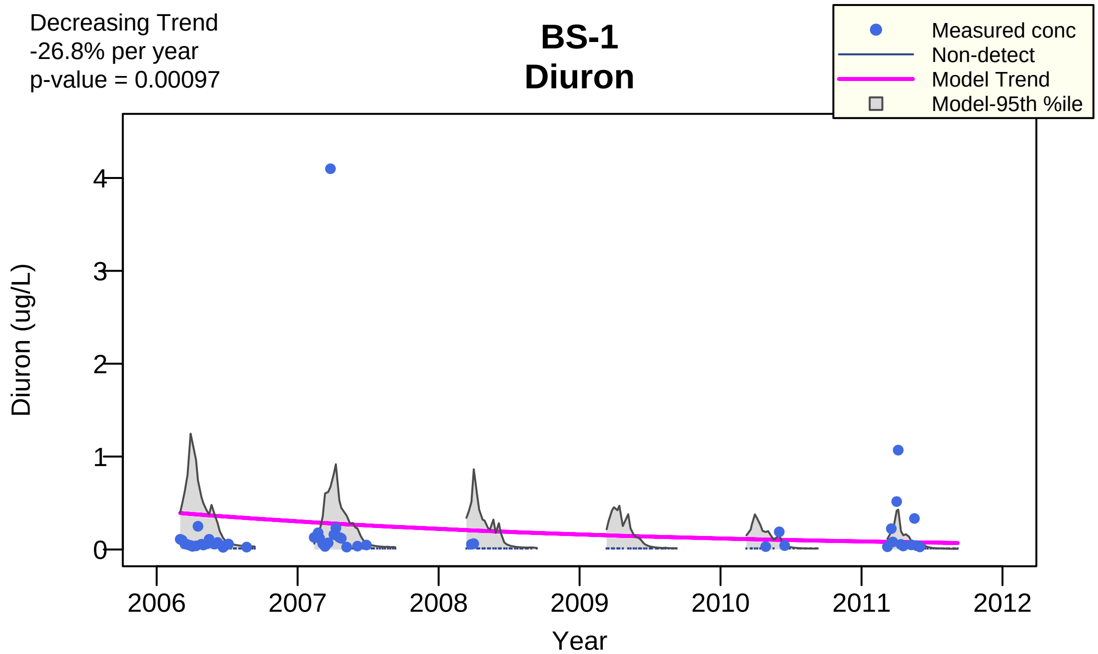


Figure F-17. Decreasing trend in diuron concentrations at Browns Slough (BS-1), 2006-2011.

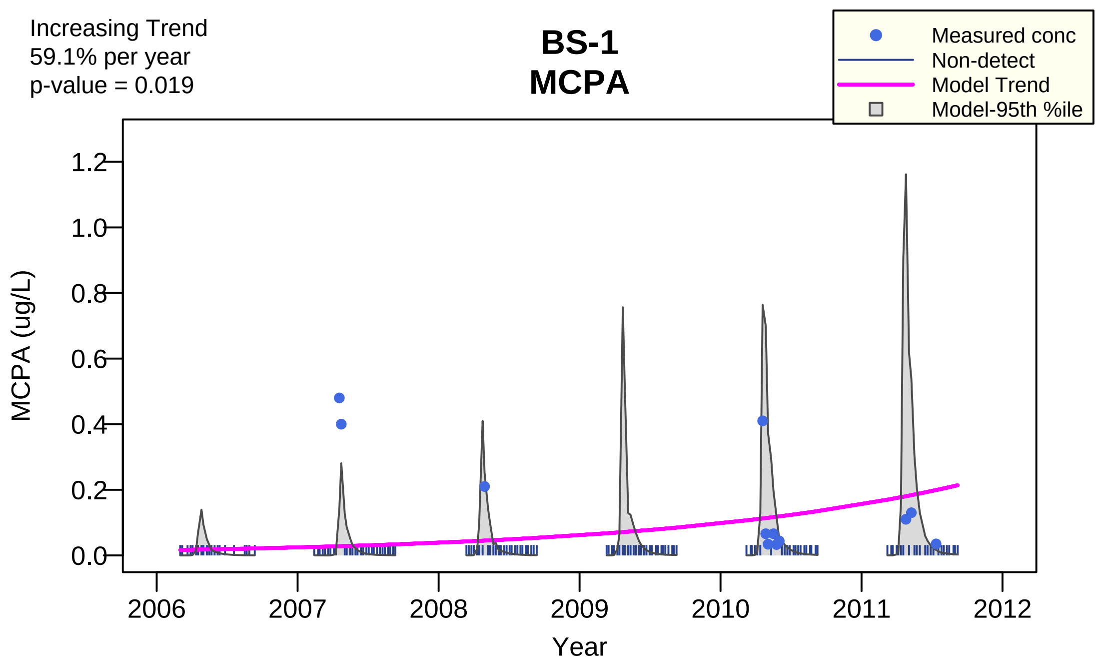


Figure F-18. Increasing trend in MCPA concentrations at Browns Slough (BS-1), 2006-2011.

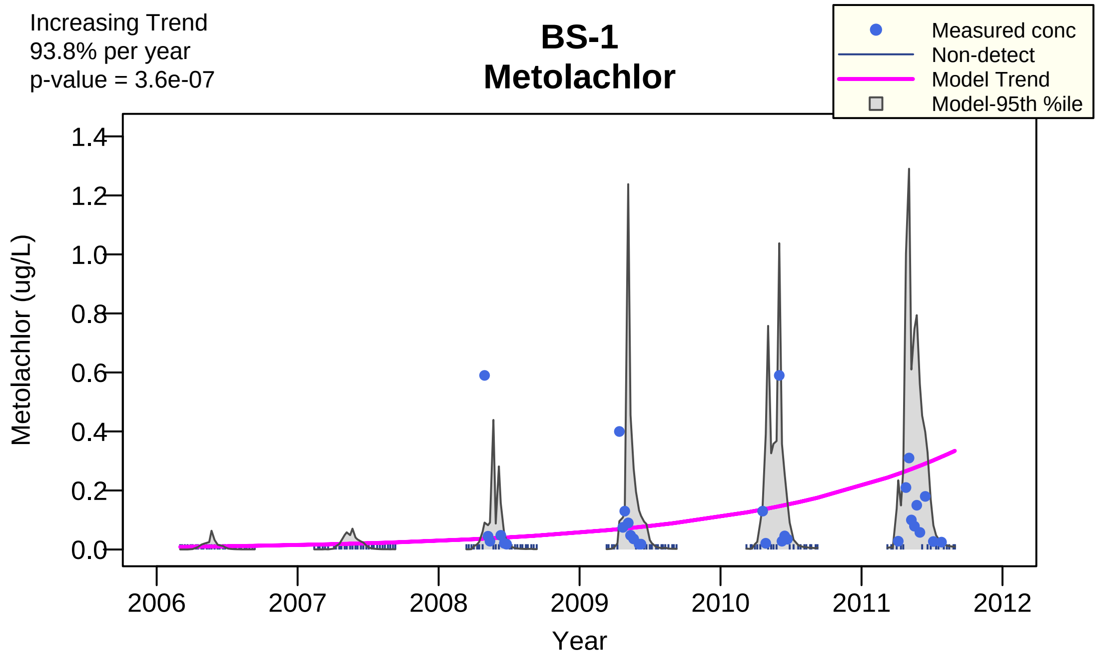


Figure F-19. Increasing trend in metolachlor concentrations at Browns Slough (BS-1), 2006-2011.

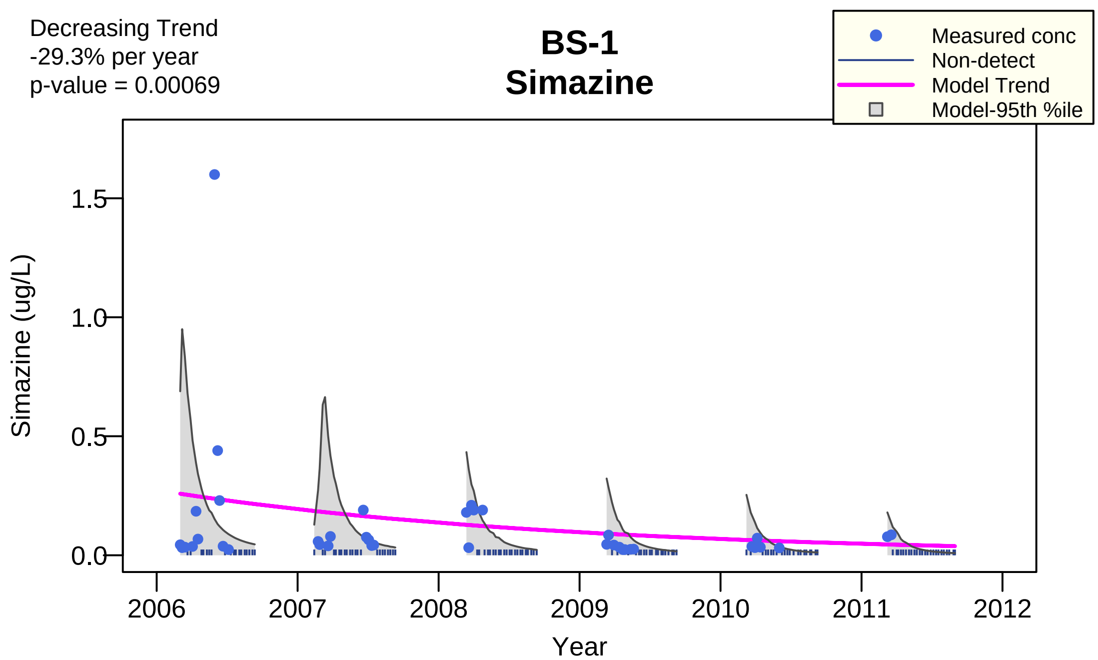


Figure F-20. Decreasing trend in simazine concentrations at Browns Slough (BS-1), 2006-2011.

Spring Creek – Upstream (SP-2)

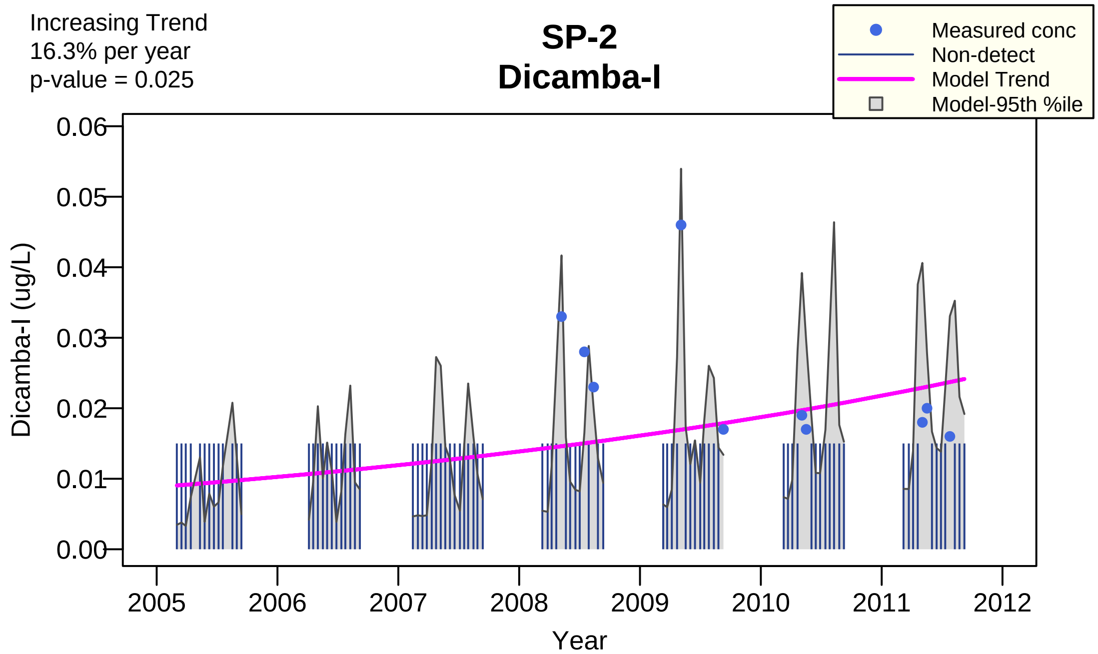


Figure F-21. Increasing trend in dicamba-I concentrations at upstream Spring Creek (SP-2), 2005-2011.

Spring Creek – Downstream (SP-3)

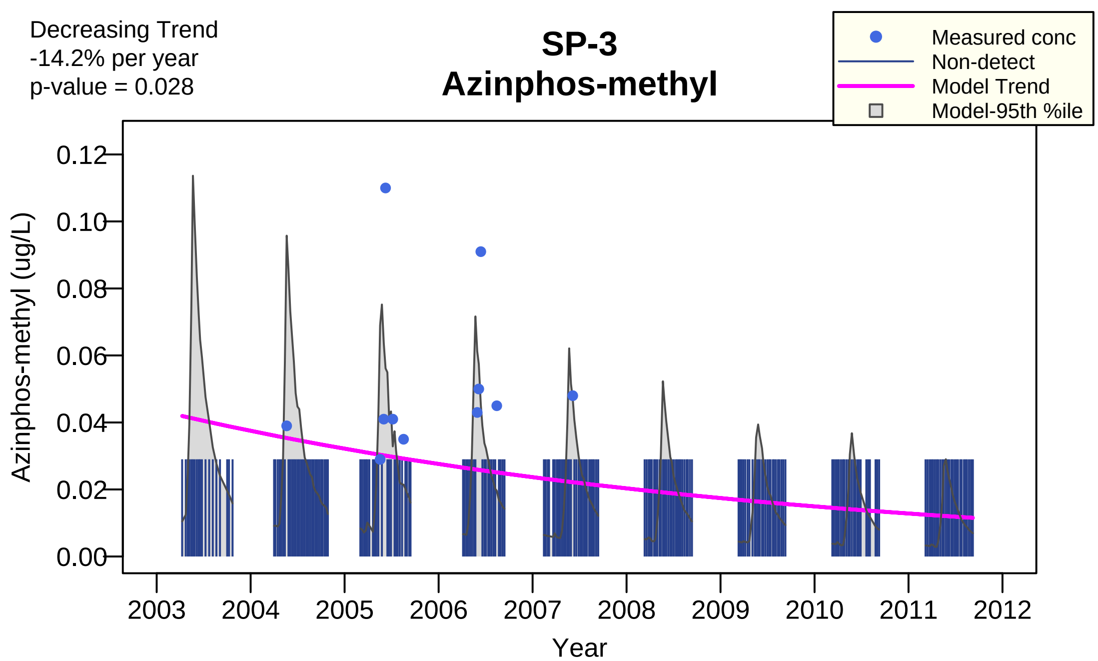


Figure F-22. Decreasing trend in azinphos-methyl concentrations at downstream Spring Creek (SP-3), 2003-2011.

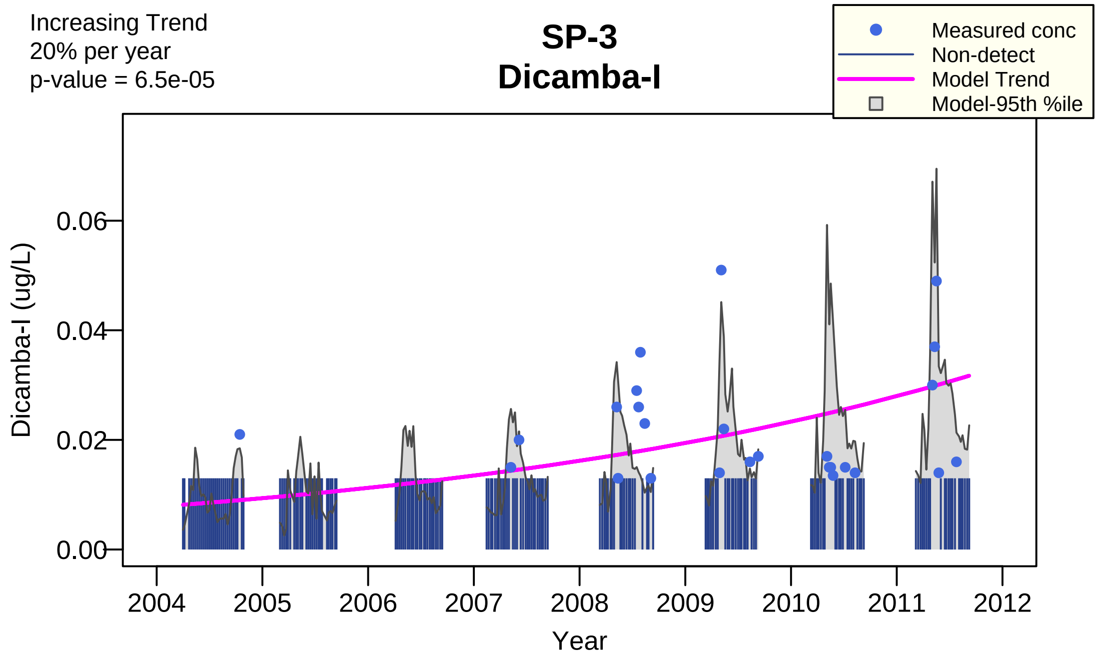


Figure F-23. Increasing trend in dicamba-I concentrations at downstream Spring Creek (SP-3), 2003-2011.

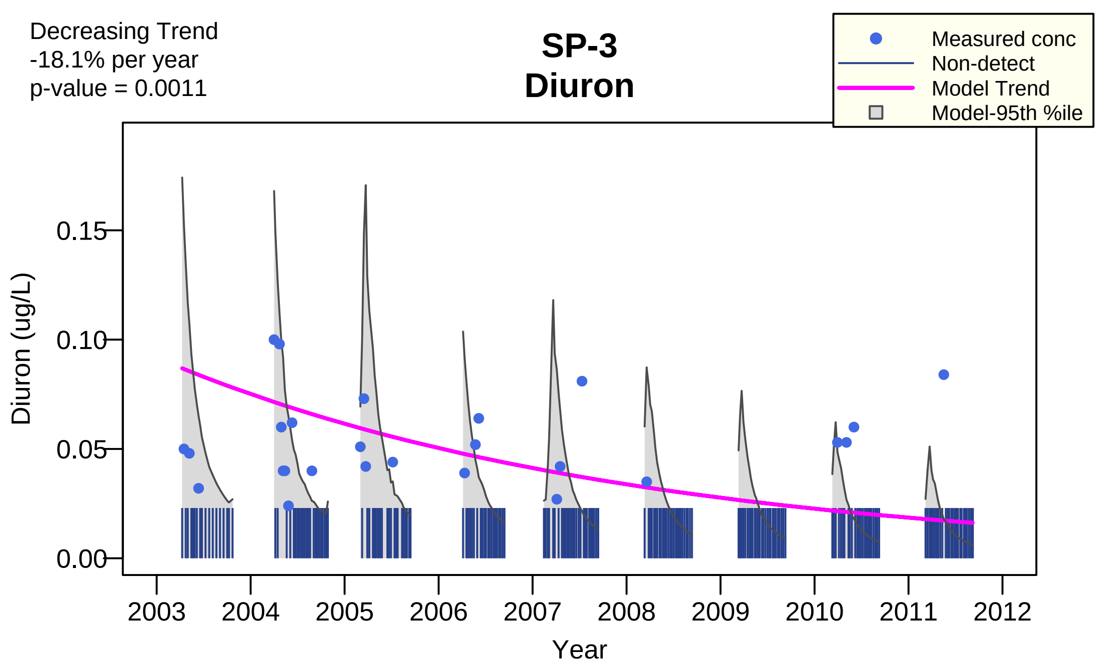


Figure F-24. Decreasing trend in diuron concentrations at downstream Spring Creek (SP-3), 2003-2011.

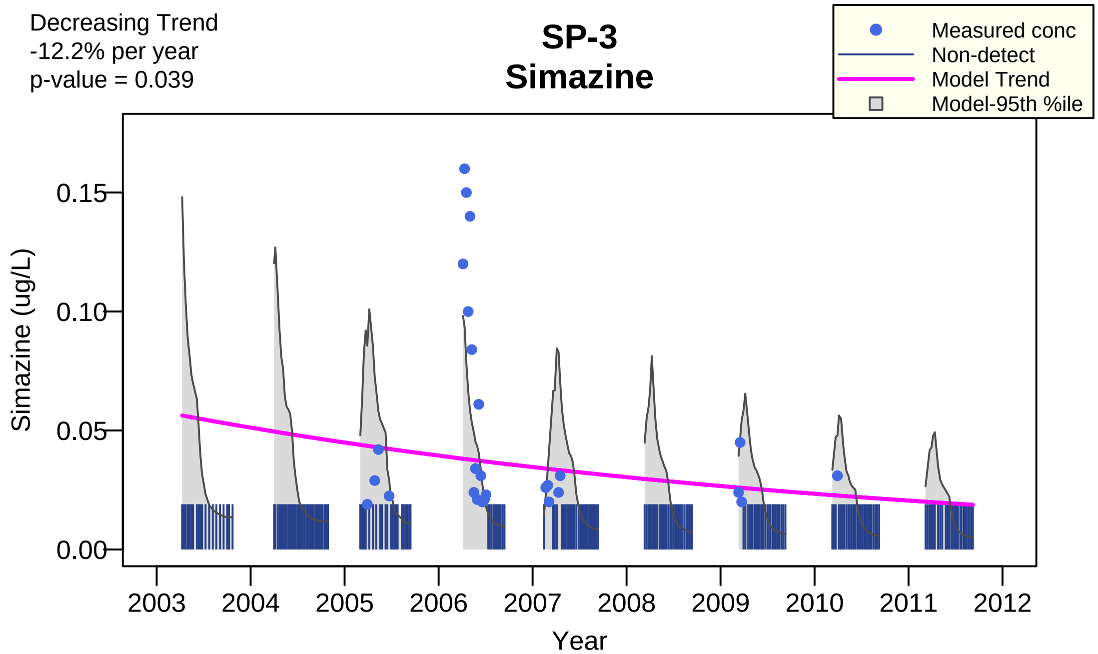


Figure F-25. Decreasing trend in simazine concentrations at downstream Spring Creek (SP-3), 2003-2011.

Marion Drain (MA-2)

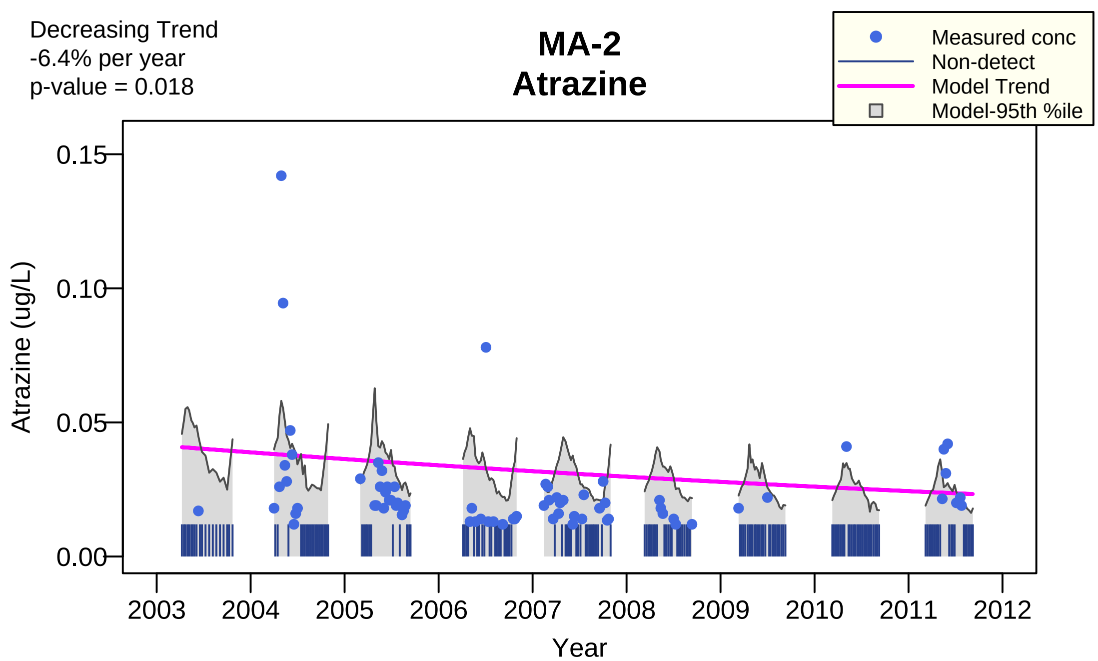


Figure F-26. Decreasing trend in atrazine concentrations at Marion Drain (MA-2), 2003-2011.

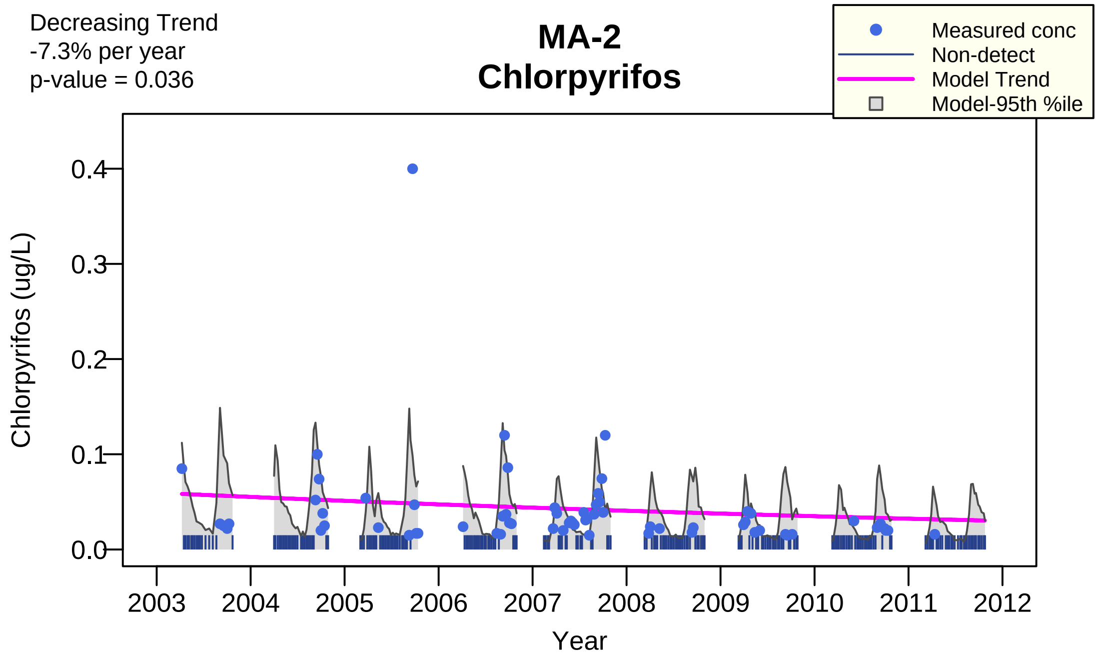


Figure F-27. Decreasing trend in chlorpyrifos concentrations at Marion Drain (MA-2), 2003-2011.

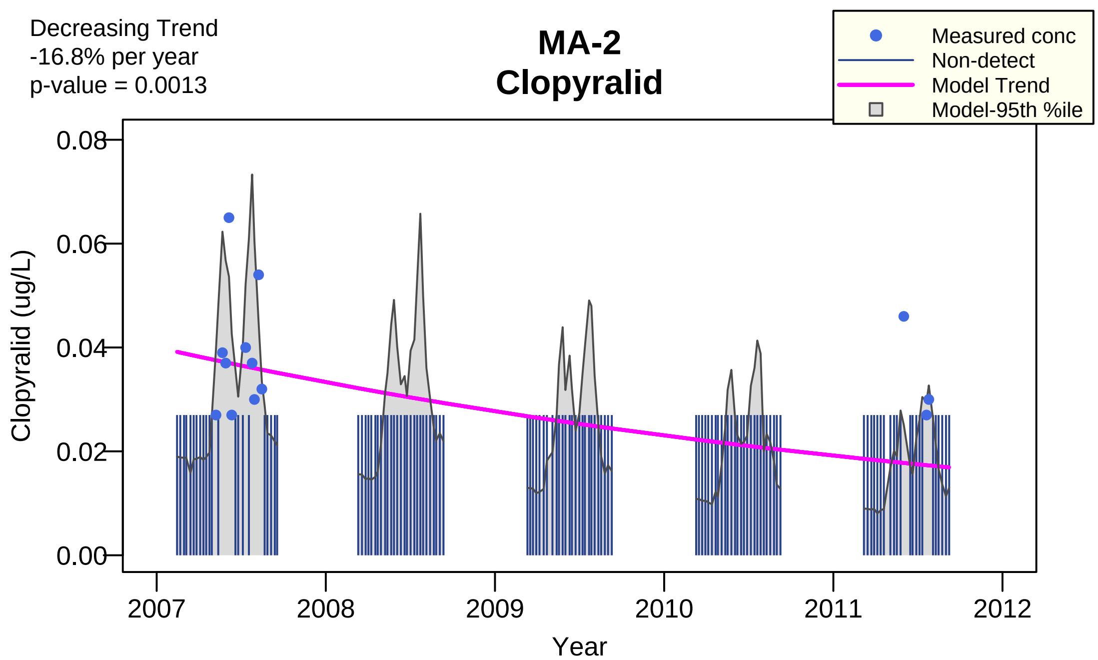


Figure F-28. Decreasing trend in clopyralid concentrations at Marion Drain (MA-2), 2003-2011.

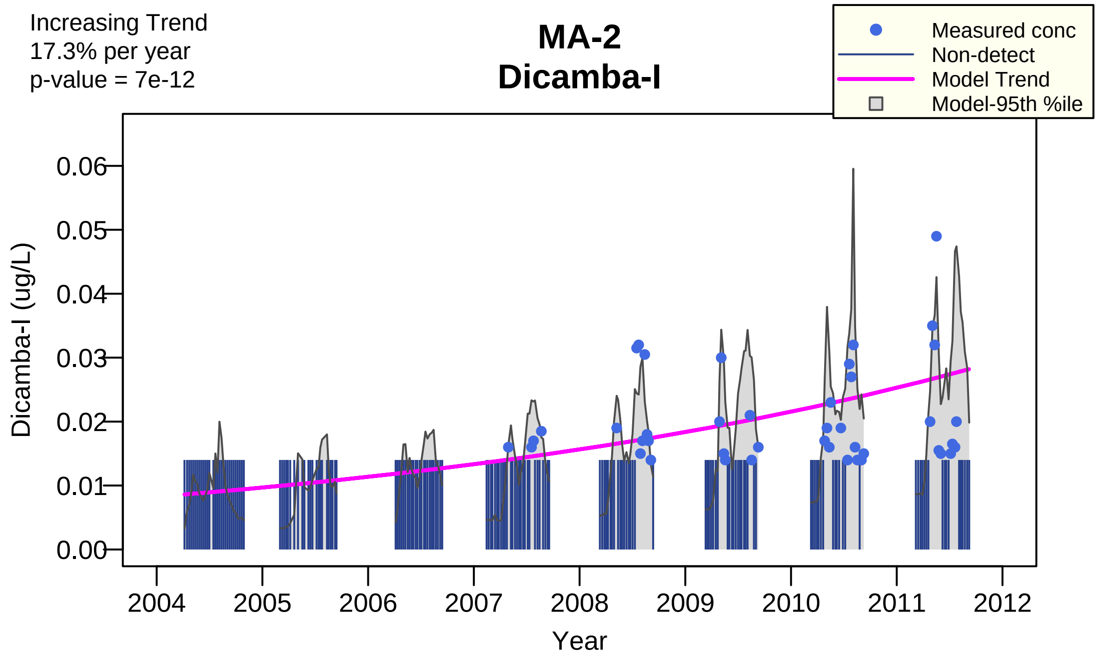


Figure F-29. Increasing trend in dicamba-I concentrations at Marion Drain (MA-2), 2003-2011.

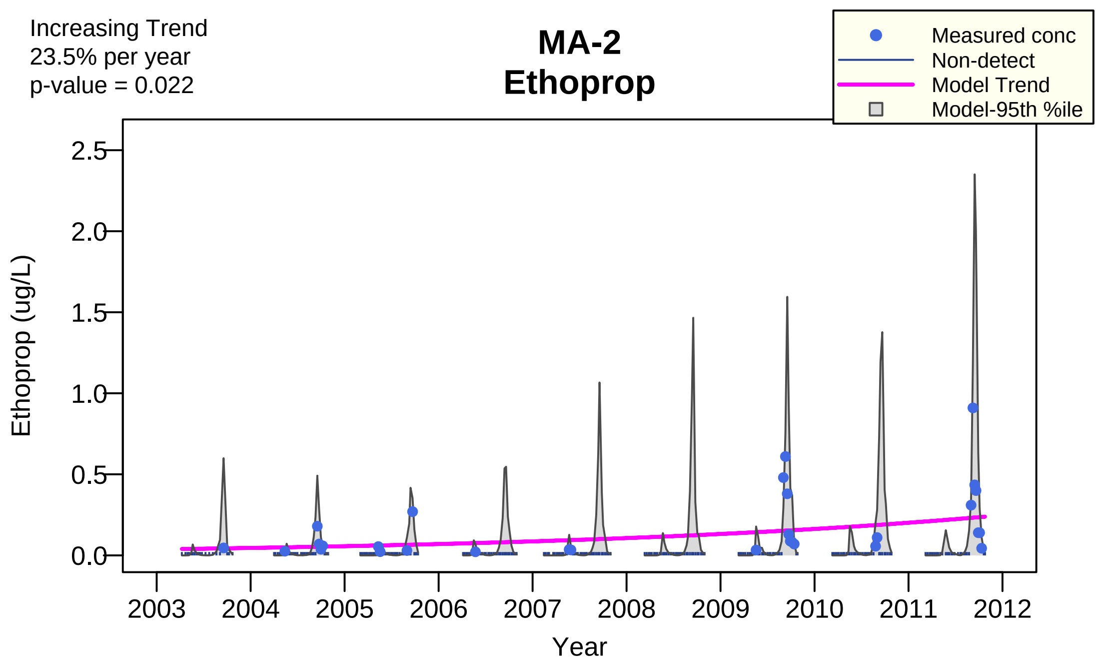


Figure F-30. Increasing trend in ethoprop concentrations at Marion Drain (MA-2), 2003-2011.

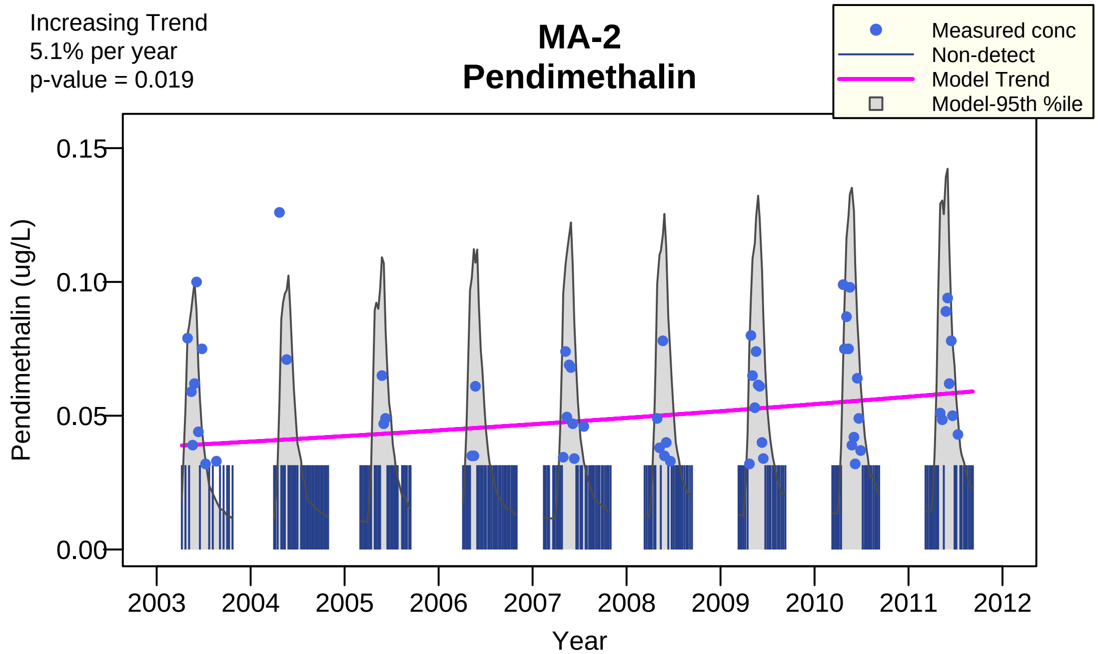


Figure F-31. Increasing trend in pendimethalin concentrations at Marion Drain (MA-2), 2003-2011.

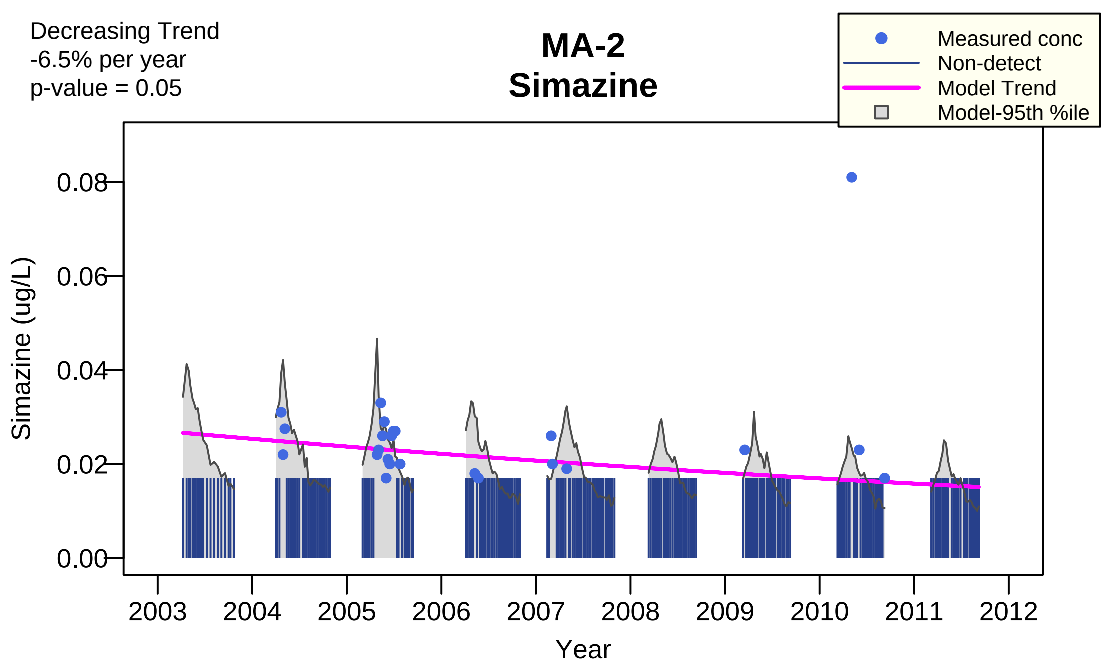


Figure F-32. Decreasing trend in simazine concentrations at Marion Drain (MA-2), 2003-2011.

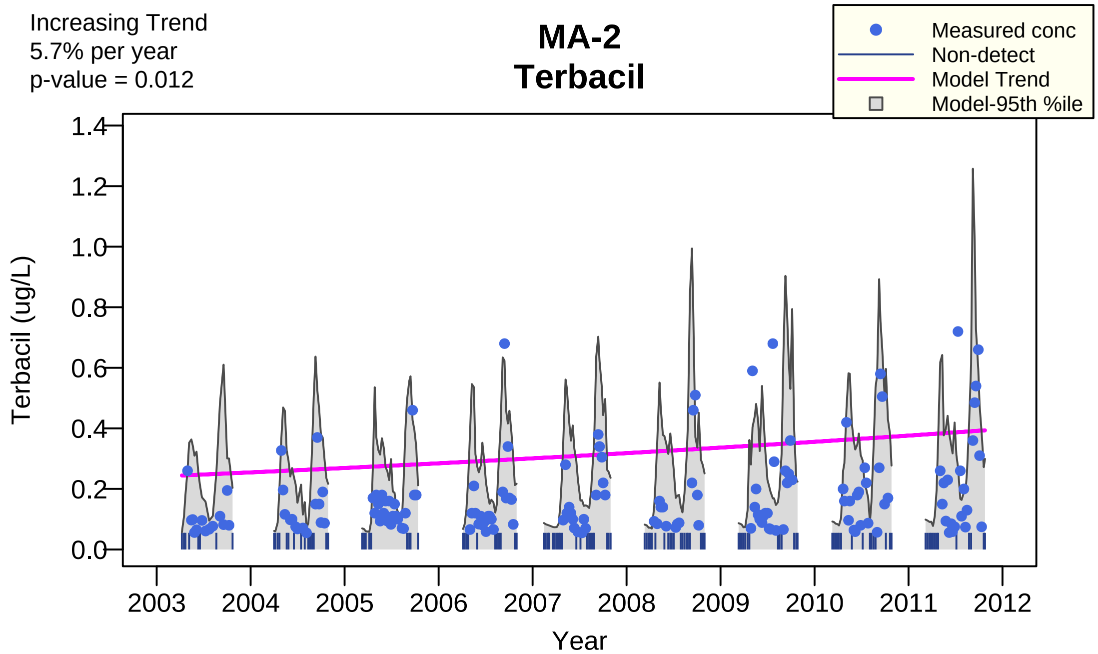


Figure F-33. Increasing trend in terbacil concentrations at Marion Drain (MA-2), 2003-2011.

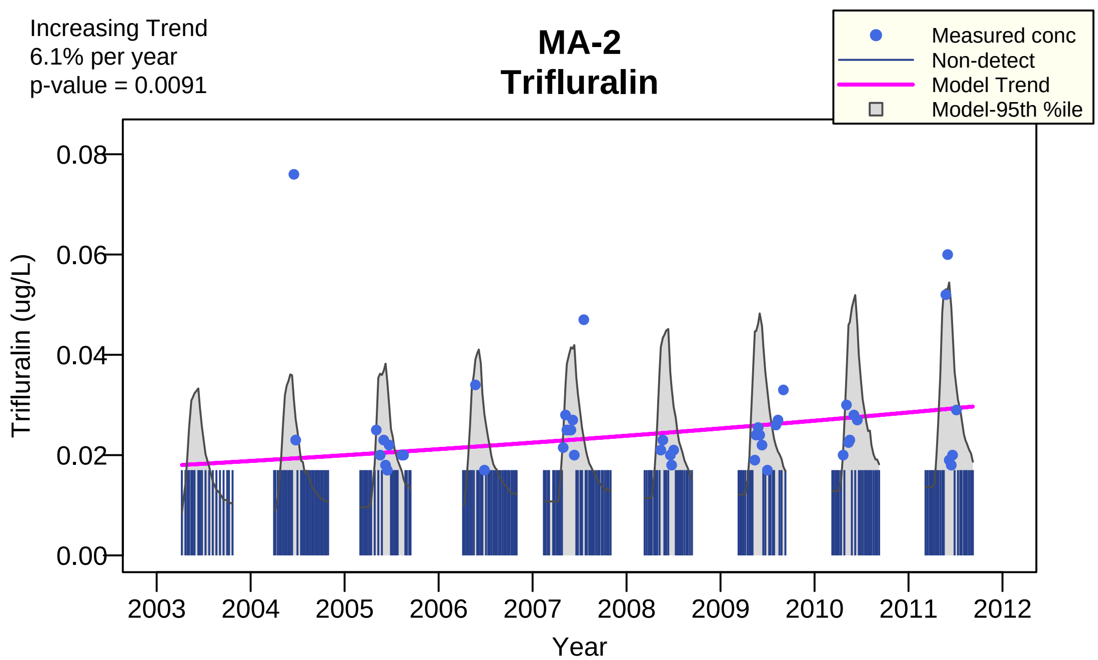


Figure F-34. Increasing trend in trifluralin concentrations at Marion Drain (MA-2), 2003-2011.

Sulphur Creek Wasteway (SU-1)

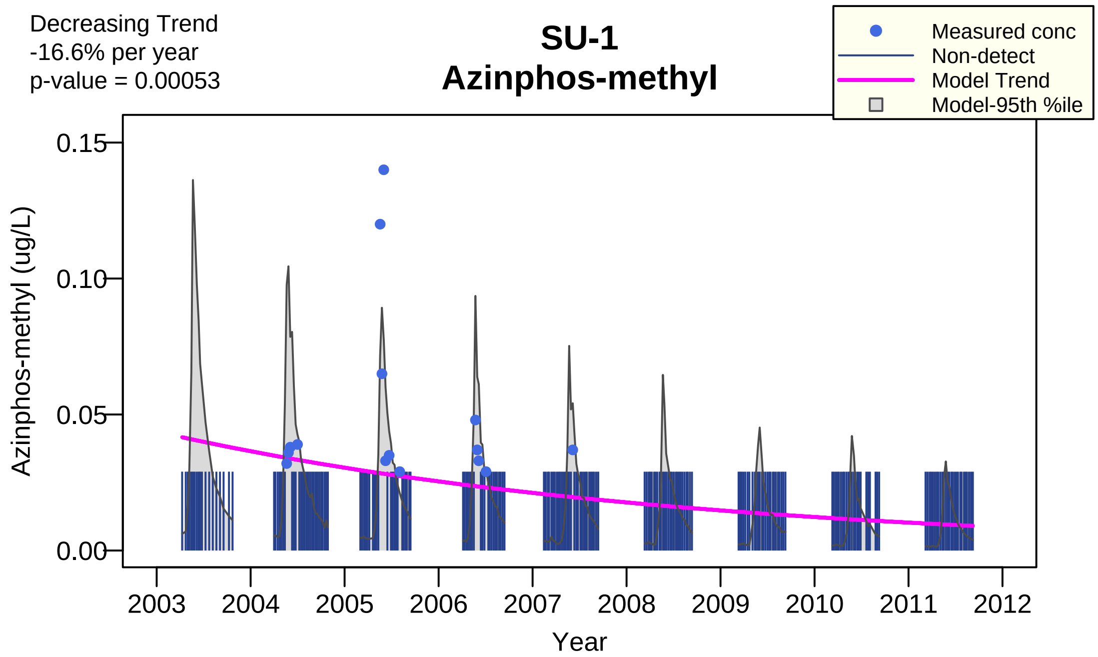


Figure F-35. Decreasing trend in azinphos-methyl concentrations at Sulphur Creek Wasteway (SU-1), 2003-2011.

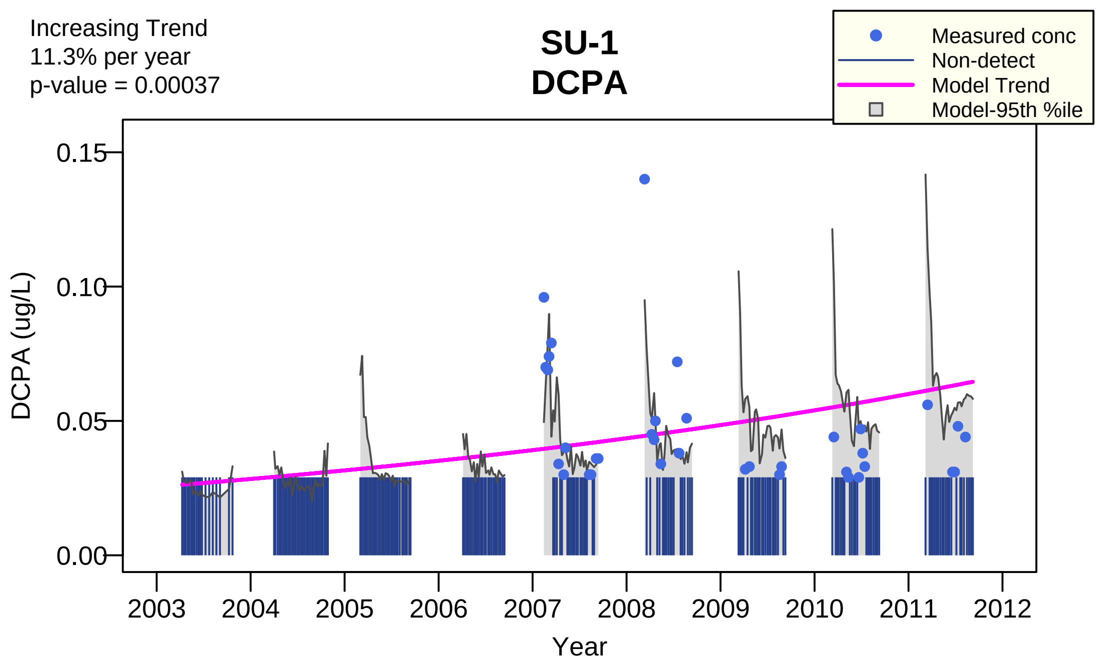


Figure F-36. Increasing trend in DCPA concentrations at Sulphur Creek Wasteway (SU-1), 2003-2011.

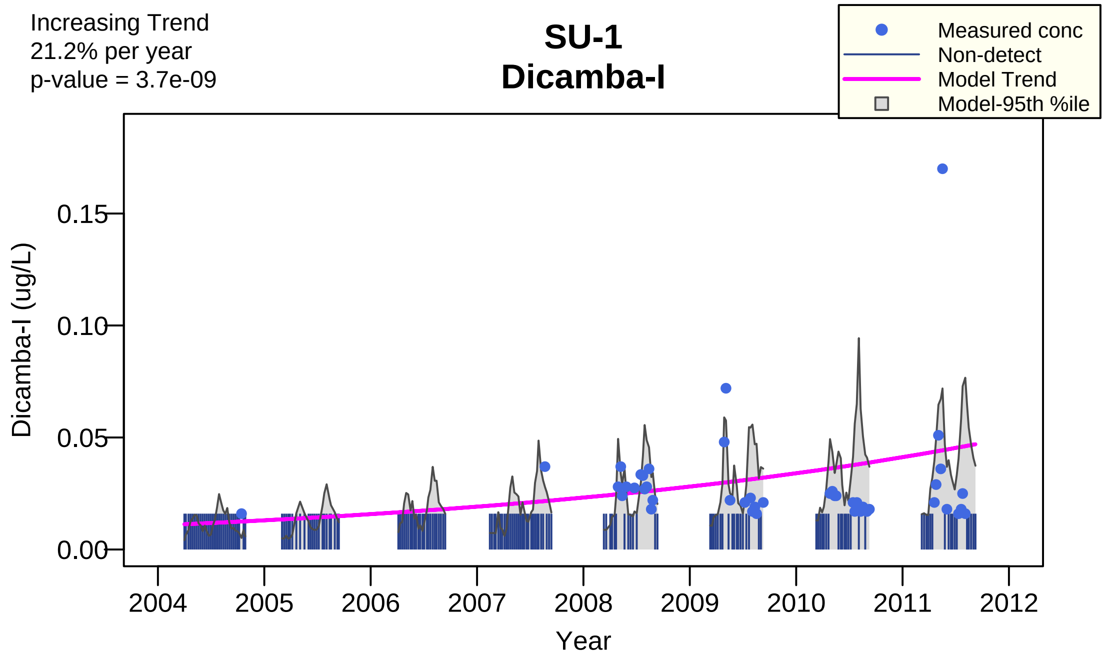


Figure F-37. Increasing trend in dicamba-I at Sulphur Creek Wasteway (SU-1), 2003-2011.

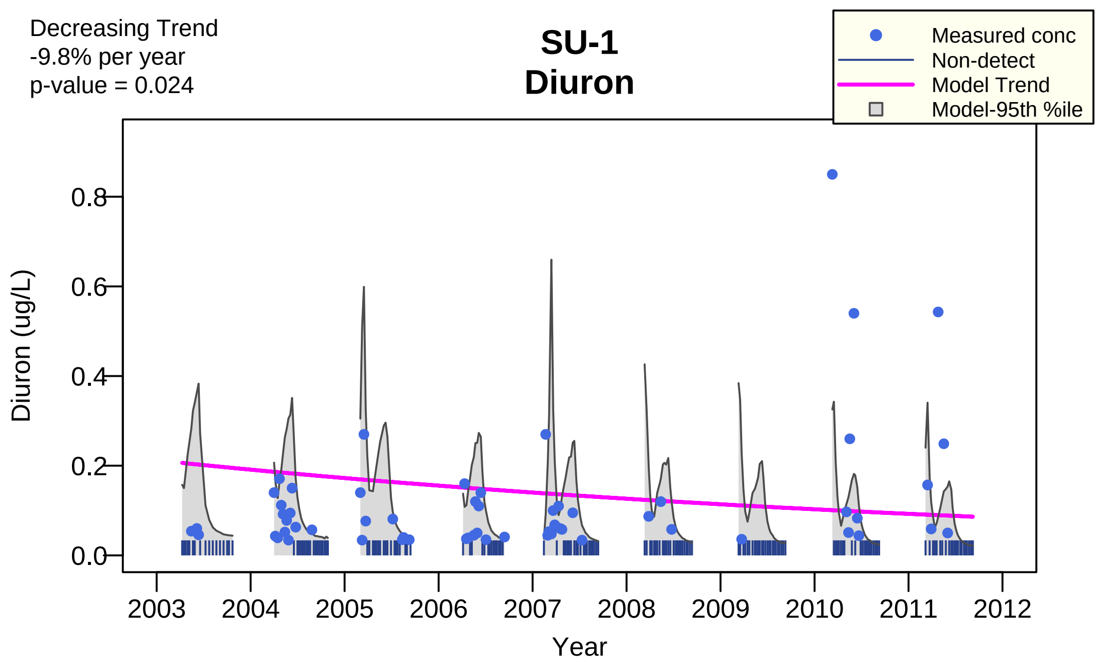


Figure F-38. Decreasing trend in diuron concentrations at Sulphur Creek Wasteway (SU-1), 2003-2011.

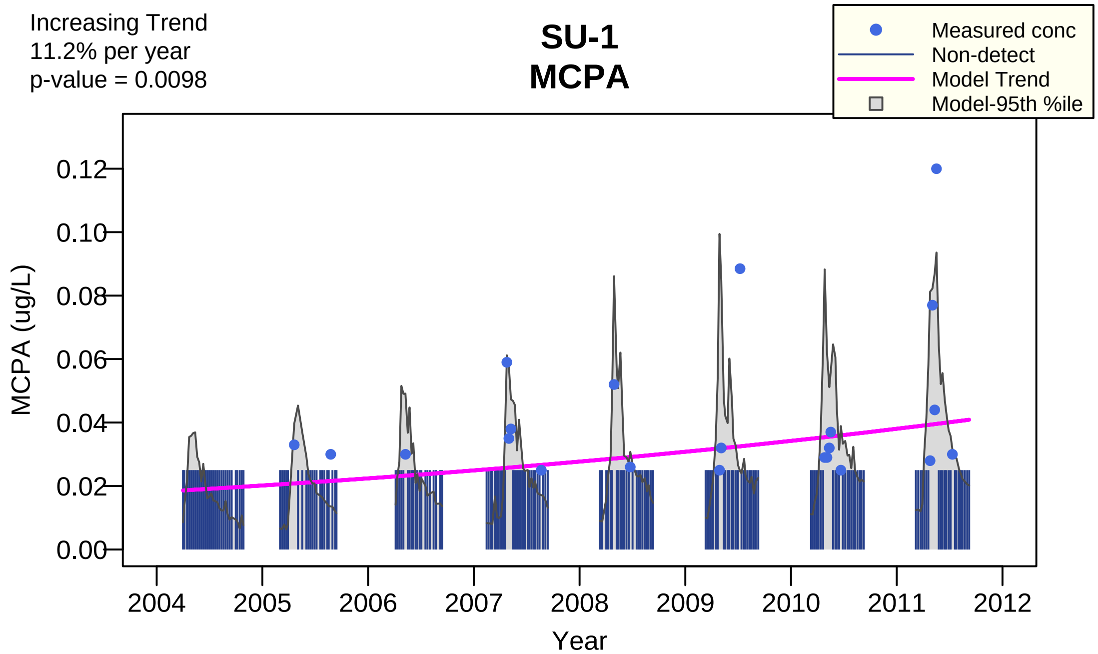


Figure F-39. Increasing trend in MCPA concentrations at Sulphur Creek Wasteway (SU-1), 2003-2011.

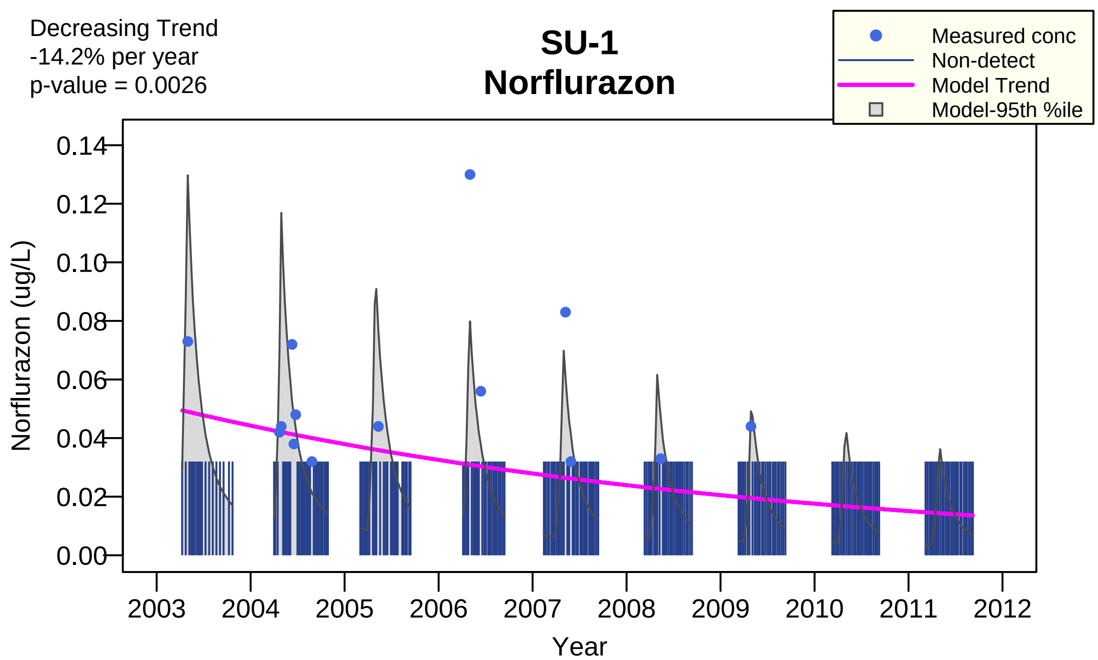


Figure F-40. Decreasing trend in norflurazon concentrations at Sulphur Creek Wasteway (SU-1), 2003-2011.

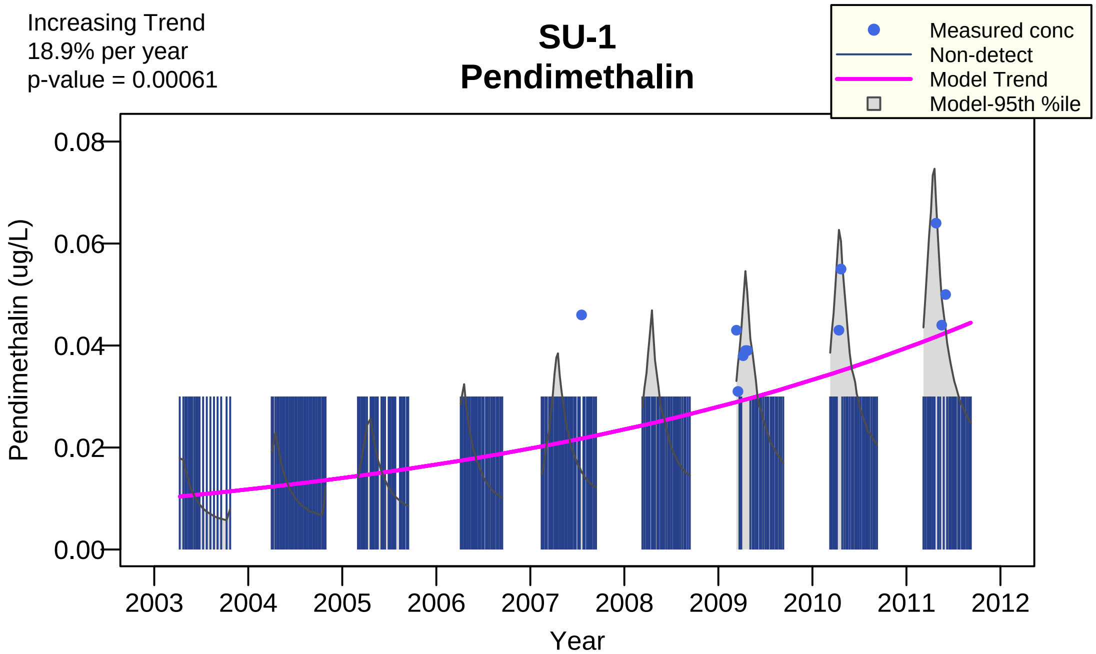


Figure F-41. Increasing trend in pendimethalin concentrations at Sulphur Creek Wasteway (SU-1), 2003-2011.

Wenatchee-Entiat Basins WRIAs 45 and 46

Brender Creek (BR-1)

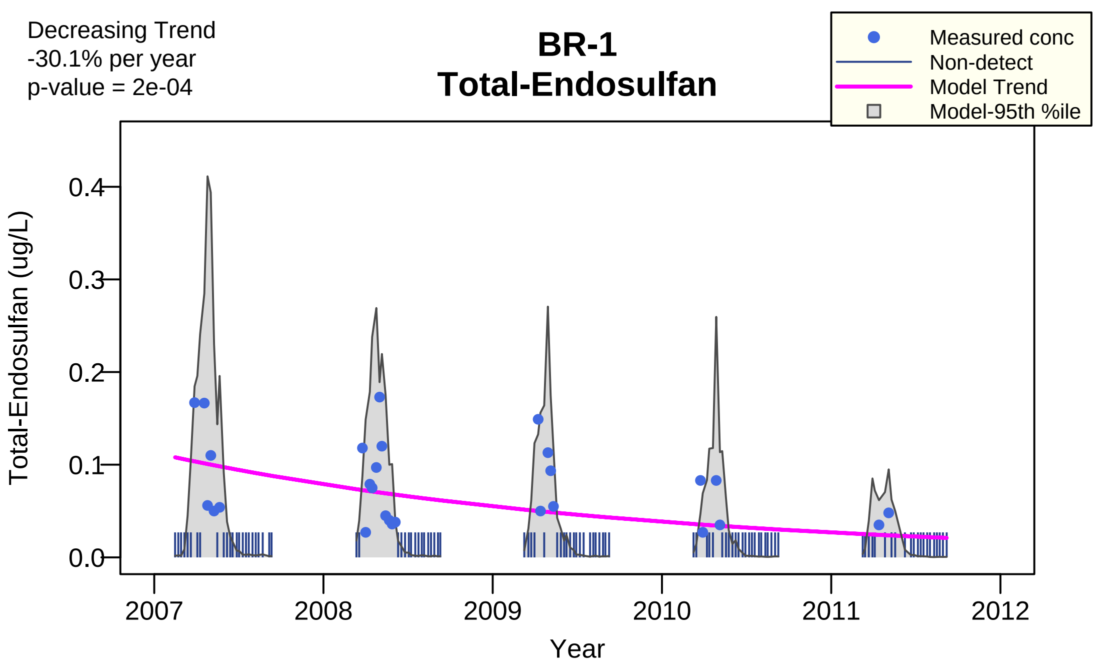


Figure F-42. Decreasing trend in total endosulfan concentrations at Brender Creek (BR-1), 2007-2011.

References for Appendix F

Helsel, D.R., 2005. Nondetects and Data Analysis: Statistics for Censored Environmental Data. Published by John Wiley and Sons.

Martin, J.D., 2009. Sources and Preparation of Data for Assessing Trends in Concentrations of Pesticides in Streams of the United States, 1992-2006. U.S. Geological Survey Scientific Investigations Report 2009-5062.

R Core Team, 2012. R: A Language and Environment for Statistical Computing (v 2.14.1). R Foundation for Statistical Computing, Vienna, Austria. www.R-project.org

Ryberg, K.R., A.V. Vecchia, J.D. Martin, and R.J. Gilliom, 2010. Trends in Pesticide Concentrations in Urban Streams in the United States, 1992-2008. U.S. Geological Survey Scientific Investigations Report 2010-5139.

Sullivan, D.J., A.V. Vecchia, D.L. Lorenz, R.J. Gilliom, and J.D. Martin, 2009. Trends in Pesticide Concentrations in Corn-Belt Streams 1996-2006. U.S. Geological Survey Scientific Investigations Report 2009-5132.

Vecchia, A.V., J.D. Martin, and R.J. Gilliom, 2008. Modeling Variability and Trends in Pesticide Concentrations in Streams. Journal of the American Water Resources Association, vol. 44, no. 5.

Appendix G. Assessment Criteria and Water Quality Standards

EPA pesticide assessment documents were reviewed to determine the most comparable and up-to-date toxicity guidelines for freshwater species (Table G-1) and marine species (Table G-2).

EPA Toxicity Criteria

Rainbow trout (*Oncorhynchus mykiss*) are a surrogate for freshwater endangered and threatened species. *Daphnia magna* (invertebrate) and *Pseudokirchneria subcapitata* (green algae formerly called *Selenastrum capricornutum*) represent components of the aquatic food web that may be affected by pesticide use. Alternative species are used only if no data are available for rainbow trout, *Daphnia magna*, or *Pseudokirchneria subcapitata.*

Marine toxicity criteria were evaluated for detections at Browns Slough in the Skagit watershed, a site with estuarine influence. Criteria were generated for marine species including (1) sheepshead minnow (*Cyprinodon variegatus*) and tidewater silverside (*Menidia beryllina*) for fish; (2) Pink shrimp (*Penaeus duorarum*), Eastern and Pacific Oysters (*Crassostrea virginica* and *gigas* respectively), Grass shrimp (*Palaemonetes pugio*), *Acartia tonsa* (copepod), and mysid (*Americamysis bahia*) for invertebrates; and (3) *Isochrysis galbana*, and a diatom, *Skeletonema costatum* for aquatic plants.

EPA classifies a laboratory study as “core” if it meets guidelines appropriate for inclusion in pesticide registration. Usually a core designation may be made if the study is appropriately designed and monitored, the conditions controlled, and the duration of exposure is consistent with other studies. Core study criteria are used in the assessment table. Keeping with the pesticide review precedent, the most toxic, acceptable criteria from core studies are used.

Water Quality Standards and Assessment Criteria

The most recent versions of Washington State water quality standards and EPA National Recommended Water Quality Criteria (NRWQC) were applied for this report. The NRWQC remained largely unchanged from the 2003 update through 2011.

The toxic standards for Washington State waters were also used. These remain essentially unchanged following the 1997 rule and 2003 updates (Washington Administrative Code (WAC), Chapter 173-201A).

Table G-1. Freshwater toxicity and regulatory guidelines. All values reported in ug/L.

Chemical	[1]Freshwater Toxicological and Registration Criteria													Freshwater Standards and Criteria				Maximum Conc. Limit for Salmon	
	Fisheries					Invertebrate				Plant				WAC		NRWQC		NMFS Biop	
	Acute	Chronic	ESLOC	Spp.	Ref	Acute	Chronic	Spp.	Ref	Acute	Chronic	Spp.	Ref	Acute	Chronic	CMC	CCC	Acute	Ref.
1-Naphthol	1400	100	70	RT-A; FM-C	10	700		DM	10	1100		SC	10						
2,4,6-Trichlorophenol																			
2,4-D (Acids, Salts, Amines)[m]	101000	14200	5050	RT; FM	1	25000	16050	DM	1	3880	1440	ND	1					100	91
2,4-D (BEE Ester)[m]	428		21.4	BS	1	4970	200	DM	1	1020	538	ND	1					100	91
2,4'-DDD														1.1[a,b]	0.001[a,c]	1.1[a]	0.001[a]		
2,4'-DDE														1.1[a,b]	0.001[a,c]	1.1[a]	0.001[a]		
2,4'-DDT														1.1[a,b]	0.001[a,c]	1.1[a]	0.001[a]		
3,5-Dichlorobenzoic Acid																			
3-Hydroxycarbofuran	362	5.7	18.1	RT	54; 60	2.23	0.75	CD	54										
	88		4.4	BS	54	29	9.8/27	DM	60										
4,4'-DDD														1.1[a,b]	0.001[a,c]	1.1[a]	0.001[a]		
4,4'-DDE														1.1[a,b]	0.001[a,c]	1.1[a]	0.001[a]		
4,4'-DDT														1.1[a,b]	0.001[a,c]	1.1[a]	0.001[a]		
4-Nitrophenol	4000		200	RT	69	5000		DM	69										
Acetochlor	380	130	19	RT	70	8200	22.10	DM	70	1.43		SC	70						
Alachlor	1800	187	90	RT	2	7700	110	DM	2	1.64	0.35	SC	2						
Aldicarb	52	0.46	2.6	BS	3	20	3	CT	3	>5000		MD	3						
Aldicarb Sulfone	42000		2100	RT	3	280	3	DM	3										
Aldicarb Sulfoxide	7140		357	RT	3	43	3	DM	3										
Atrazine	5300	65	265	RT-A; BT-C	4	3500	140	DM	4	49		SC	4						
Azinphos Ethyl	20		1	RT	71	4		DM	71										
Azinphos Methyl	2.9	0.44	0.145	RT	5	1.13	0.25	DM	5								0.01		90
	3.2		0.16	Coho	5														
Bentazon	>100000		>5000	RT	6	>100000		DM	6	4500		SC	6						
Bifenthrin	0.15	0.04	0.0075	RT-A; FM-C	72	1.6	0.0013	DM	72										
Bromacil	36000	3000	1800	RT	7	121000	8200	DM	7	6.8	1100	SC	7						
Bromoxynil	50	9	2.5	RT-A; FM-C	8	11	2.5	DM	8	80		SC	83						
Captan	26.2	16.5	1.31	BrT-A; FM-C	73	8400	560	DM	73	1770		SC	73						91
Carbaryl	1200	210	60	RT-A; FM-C	9,10	5.6	1.5	DM	10	1100	370	SC	10						89
	2400		120	Chinook	9,10														
	2400		120	Coho	9,10														
Carbofuran	362	5.7	18.1	RT	54; 60	2.23		CD	54										89
	88		4.4	BS	54	29	9.8	DM	60										
Carboxin	2300		115	RT	74	84400		DM	74	370	110	SC	74						
Chlorothalonil	42.3	3	2.115	RT; FM	46	68	39	DM	46	190		SC	46					1.05	91
Chlorpropham	5700		285	RT	47	3700	770	DM	47										
Chlorpyrifos	3	0.57	0.15	RT; FM	11; 12	0.1	0.04	DM	11					0.083d	0.041e	0.083	0.041	1.122	88
cis-Permethrin[n]	5	0.56	0.25	RT	58	1.04	0.039	DM	58										
	17	1.11	0.85	Coho	58														
	0.79	0.30	0.0395	BS-A; FM-C	58														
Clopyralid	1968000	N/A	98400	BS	64	113000	N/A	DM	64	6900		SC	64						
Cycloate	4500		225	RT	87	24000		DM	87										
DCPA	6600	N/A	330	RT	56	27000	N/A	DM	56	>12380		SC	56						
DDVP	183	5.2	9.15	LT-A;RT-C	75	0.07	0.0058	DM	75	14000		ND	75						
Di-allate (Avadex)	no criteria found																		

Table G-1 (continued). Freshwater toxicity and regulatory guidelines. All values reported in ug/L.

Chemical	[1]Freshwater Toxicological and Registration Criteria													Freshwater Standards and Criteria				Maximum Conc. Limit for Salmon	
	Fisheries					Invertebrate				Plant				WAC		NRWQC		NMFS Biop	
	Acute	Chronic	ESLOC	Spp.	Ref	Acute	Chronic	Spp.	Ref	Acute	Chronic	Spp.	Ref	Acute	Chronic	CMC	CCC	Acute	Ref.
Diazinon	90	0.8	4.5	RT; BT	13; 14	0.8	0.17	DM	13	3700		SC	13			0.17	0.17	1.122	88
Dicamba I	28000		1400	RT	15	34600	16400	DM	15	>3700	3700	SC	15						
Dichlobenil	4930	330	247	RT	16; 17	6200	560	DM	17	1500	160	SC	17						
Dichlorprop	214000	14700	10700	RT	76	558000	74900	DM	76	77	13	NP	76						
Dimethoate	6200	430	310	RT	29	3320	40	DM	29	36000		SC	29					60	90
Dinoseb																			
Diphenamid	97000		4850	RT	59	58000		DM	59										
Disulfoton (Di-Systo	1850	220	92.5	RT	19	13	0.037	DM	19										90
Disulfoton Sulfone	9200		460	RT	19	35	0.14	DM	19										
Disulfoton Sulfoxide	60000		3000	RT	19	64	1.53	DM	19										
Diuron	1950	26.4	97.5	RT-A; FM-C	21, 22	1400	200	DM	21, 22	2.4		SC	21, 22					5	91
	2400		120	Coho	21, 22														
Endosulfan I	0.8	0.1	0.04	RT	23	166	2	DM	23					0.22[b,f]	0.056[c,f]	0.22[i]	0.056[i]		
Endosulfan II	0.8	0.1	0.04	RT	23	166	2	DM	23					0.22[b,f]	0.056[c,f]	0.22[i]	0.056[i]		
Endosulfan Sulfate	3.6		0.18	BS	82	580		DM	23										
Endrin Aldehyde																			
EPN	143		7.15	RT	84														
Eptam (EPTC)	14000		700	BS	24	6500	810	DM	24	1400	900	SC	24						
Ethoprop	1020	180	51	RT; FM	25	44	0.8	DM	25									20	90
Fenamiphos	68	3.8	3.4	RT	77	1.3	0.12	DM	77										90
Fenarimol	2100	870	105	RT	67	6800	113	DM	67		100	SC	67						
Fipronil	246	6.6	12.3	RT	78	190	9.8	DM	78	140	<140	SC	78						
Fipronil Sulfide (MB4	83	6.6	4.15	ND	78	100	0.11	)M-A; ND-	78	140	<140	ND							
Fipronil Sulfone (MB	39	0.67	1.95	RT-A; ND-C	78	29	0.037	)M-A; ND-	78	140	<140	ND							
Hexachlorobenzene	30	3.68	1.5	RT	26	30	16	DM	26	30		SC	26						
	50000		2500	Coho	26														
Hexazinone	180000	17000	9000	RT; FM	27; 28	151600	20000	DM	27	7	4	SC	27						
	317000		15850	Chinook	27														
	246000		12300	Coho	27														
	317000		15850	Sockeye	27														
Imidacloprid	>83000	1200	>4150	RT	61	69	1300	T-A; DM-	61	10000		ND	61						
Imidian (Phosmet)	230	3	11.5	RT	79	6	0.8	DM	79	150		SC	79						
Ioxynil																			
Linuron	3000	5.58	150	RT	48	120	0.09	DM	48	67		SC	49						91
Malathion	4.1	21	0.205	RT	31	1	0.06	DM	31								0.1	1.122	88
	170		8.5	Coho	31														
MCPA Acid or Ester										950	9	SC	32						
MCPP salt and ester	124800	N/A	6240	RT	65	100000		DM	65										
Metalaxyl	18400	9100	920	RT-A; FM-C	51	12000	1270	DM	51	140000		SC	51						
Methiocarb	436	50	21.8	ND	30	7	0.1	ND	30										
Methomyl	860	57	43	RT-A; FM-C	57	5	0.7	DM	57										89
Methomyl Oxime																			
Metolachlor	3800	2500	190	RT	33	1100	1	DM	33	8	1.5	SC	33						
Metribuzin	42000	3000	2100	RT	52	4200	1290	DM	52	11.9	8.9	NP	52						
Monocrotophos																			
Monuron																			

Table G-1 (continued). Freshwater toxicity and regulatory guidelines. All values reported in ug/L.

Chemical	[1]Freshwater Toxicological and Registration Criteria													Freshwater Standards and Criteria				Maximum Conc. Limit for Salmon	
	Fisheries					Invertebrate				Plant				WAC		NRWQC		NMFS Biop	
	Acute	Chronic	ESLOC	Spp.	Ref	Acute	Chronic	Spp.	Ref	Acute	Chronic	Spp.	Ref	Acute	Chronic	CMC	CCC	Acute	Ref.
Napropamide	6400	1100	320	RT	80	14300	1100	DM	80	3400	71	SC-A, LM-C	80						
Norflurazon	8100	770	405	RT	34	15000	1000	DM	34	9.7	3.2	SC	34						
Oryzalin	3260	>460	163	RT	85	1500	358	DM	85	52	13.8	SC	85					10	92
Oxamyl	4200	770	210	RT	62	420	27	DM	62	120	30000	SC	62						
Oxamyl Oxime																			
Oxyfluorfen	250	38	12.5	RT-A; FM-C	35	80	13	DM	35	0.29	0.1	SC	35						
Pendimethalin	138	6.3	6.9	RT-A; FM-C	37	280	14.5	DM	37	5.4	3	SC	37					1	92
Pentachlorophenol	15	11	0.75	RT	38	450	240	DM	38	50		SC	38	8.2 to 41.0[d,g]	5.2-25.9[e,h]	7.9-107.6[j]	6.1-82.6[k]		
Phorate O.A.																			
Picloram	5500	N/A	275	RT	53	34400	N/A	DM	53										
Piperonyl butoxide	1900	40	95	RT	81	510	30	DM	81										
Promecarb																			
Prometon	12000	9500	600	RT-A; FM-C	68	25700	3500	DM	68	98	32	SC	68						
Pronamide (Kerb)	72000	7700	3600	RT	66	5600	600	DM	66	4000	390	AF	66						
Propargite	118	16	5.9	RT-A; FM-C	40	74	9	DM	40	66.2	5	SC	40						
Propazine		720		FM-C	20	5320	47	DM	20	29	12	SC	20						
Propoxur	3700		185	RT	63	11		DM	63										
Ronnel																			
Simazine	40500	2500	2025	RT	36, 41	1000		DM	41	36	5.4	SC	36						
Simetryn																			
Tebuthiuron	143000	26000	7150	RT	42	297000	21800	DM	42	50	13	SC	42						
Terbacil	46220	1200	2310	RT	43	65000	640	DM	43	11	7	NP	43						
Triadimefon	4100	41	205	RT	55	1600	52	DM	55	1710	100	SC	55						
Triclopyr	1900	19	95	RT	44	13400	25000	DM	44	2300	2	SC-A; NP-C	44						91
Trifluralin	43.6	2.18	2.18	RT	45	251	2.4	DM	45	7.52	5.37	SC	45					1	92

*Values are not analytically qualified. Non-asterisk values have been J-qualified as estimates, normally below the practical quantitation limit.

[1]Criteria identified in EPA reregistration and review documents or peer reviewed literature. References listed separately.

Time component of standards are explained in body of report.

ESLOC refers to Endangered Species Level of Concern: A refers to acute, and C refers to chronic.

Fish species abbreviated in table: BS-Bluegill Sunfish; BT-Brook Trout, BrT-Brown Trout, Coho-Coho Salmon, Chinook-Chinook salmon, FM- Fathead Minnow, LT-Lake Trout, RT-Rainbow Trout, ND-Not Described, Sockeye-Sockeye Salmon.

Invertebrate species abbreviated in table: CD-Ceriodaphnia dubia, CT-Chironomus tentans (midge), DM-Daphnia magna, ND-Not Described

Plant species abbreviated in table: AF-*Anabaena flos-aquae*, LM-*Lemma minor*, MD-marine diatom, NP-*Navicula pelliculosa*, SC-*Pseudokirchneriella subcapitata* formerly *Selenastrum capricornutum* (aka; *Pseudokirchneria subcapitata*), ND-Not Described

[2]WAC: Promulgated standards according to Chapter 173-201A WAC.

[3]EPA National Recommended Water Quality Criteria (EPA-822-R-02-047).

CMC: Criteria Maximum Concentration; estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed briefly without resulting in an unacceptable effect.

CCC: Criteria Continuous Concentration; estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect.

a-Criteria applies to DDT and its metabolites (ΣDDT).

(continued on next page)

b-An instantaneous concentration not to be exceeded at any time.

c-A 24-hour average not to be exceeded.

d-A 1-hour average concentration not to be exceeded more than once every three years on average.

e-A 4-day average concentration not to be exceeded more than once every three years on average.

f-Chemical form of endosulfan is not defined in WAC 173-201A. Endosulfan sulfate may be applied in this instance.

g≤ e[1.005(pH)-4.830], pH range of 6.9 to 9.5 shown.

h≤ e[1.005(pH)-5.29], pH range of 6.9 to 9.5 shown.

i-Value refers to ∑α and β-endosulfan.

j≤ e[1.005(pH)-4.869], pH range of 6.9 to 9.5 shown.

k≤ e[1.005(pH)-5.134], pH range of 6.9 to 9.5 shown.

m-There are many forms of 2,4-D that include acids, salts, amines, and esters, all of which have unique toxicity values. The criteria presented are in acid equivalents and are intended to provide a range of possible effects. Toxicity values for each form of 2,4-D are available in the referenced document.

n-Assessment criteria for permethrin are based on a formulation of cis and trans-permethrin isomers. Manchester Laboratory analysis includes only the cis-permethrin isomer, the more toxic of the two; and cis-permethrin concentrations are compared to the assessment criteria for permethrin.

Table G-2. Marine toxicity and regulatory guidelines for the Browns Slough site. All values are reported in ug/L.

Chemical	EPA Marine Toxicological and Registration Criteria													Marine Standards and Criterion			
	Fisheries					Invertebrate				Plant				[2]WAC		[3]NRWQC	
	Acute	Chronic	ESLOC	Spp.	Ref	Acute	Chronic	Spp.	Ref	Acute	Chronic	Spp.	Ref	Acute	Chronic	CMC	CCC
1-Naphthol	1200		60	SM	10	200		MS	10								
2,4-D (Acids, Salts, Amines) [m]	>80,000 (175,000 definitive)		4000	TS	1	57000		EO	1								
4-Nitrophenol																	
Aldicarb Sulfone																	
Aldicarb Sulfoxide																	
Atrazine	2000	1100	100	SM	4	94	100	AT-A; PO-C	4	22		IG	4				
Bentazon	136		6.8	SM	6	>132.5; >109		PS; EO	6								
Bromoxynil	170		8.5	SM	8	65		MS	8	140		SkC	83				
Captan																	
Carbaryl	2600		130	SM	9,10	5.7		MS	10								
	250		12.5	AS	9,10												
Carbofuran	33	2.6	1.65	AS-A; SM-C	54	4.6	0.4	PS-A; MS-C	54								
Chlorpropham																	
Chlorpyrifos	270	0.28	13.5	SM-A; AS-C	11	0.035	<0.0046	MS	11					0.011[c]	0.0056[d]	0.011[G]	0.0056[G]
Cycloate																	
DCPA	>1000		50	SM	56	620		EO	56	>11000		SkC	56				
Diazinon	150	<0.47	7.5	SM	14	25	0.23	MS	14							0.82	0.82
Dicamba I	>180000		>9000	SM	15												
Dichlobenil	14000		700	SM	16	1630		EO	16								
						>1000		PS	16								
Dimethoate	111000		5550	SM	18	15000		MS	18								
Diuron	6700	440	335	SM	21	4900	270	EO-A; MS-C	21								
Endosulfan Sulfate	3.1		0.155	SM	82		0.38	MS	82								
Eptam																	
Imidacloprid	163000		8150	SM	61	37	0.6	MS	61								
MCPA Acid or Ester	179000		8950	AS	32	150000	115000	EO	32	300	15	SkC	32				
MCPP salt and ester (Mecoprop)																	
Metalaxyl						5980		MS	51								
						4400		EO	51								
Methomyl	1160	260	58	SM	50	>140000;		EO	50								
						230	29	MS	50								
Metolachlor	9800	3600	490	SM	33	1600	700	EO	33	61	1.7	SkC	33				
Metribuzin	85000		4250	SM	52	42000		EO	52	8.7	5.8	SkC	52				
						48300		PS	52								
Norflurazon																	
Oxamyl	2600		130	SM	62	400		EO	62								
Pentachlorophenol	240	64	12	SM	38	48		PO	38	27		SkC	38	13.0[c]	7.9[d]		
Simazine	>4300		215	SM	41	113000; >3700		PS-A; EO-C	41	600	250	SkC	36				

Table G-2 (continued). Marine toxicity and regulatory guidelines for the Browns Slough site. All values are reported in ug/L.

Chemical	EPA Marine Toxicological and Registration Criteria														Marine Standards and Criterion			
	Fisheries					Invertebrate				Plant					[2]WAC		[3]NRWQC	
	Acute	Chronic	ESLOC	Spp.	Ref	Acute	Chronic	Spp.	Ref	Acute	Chronic	Spp.	Ref		Acute	Chronic	CMC	CCC
Tebuthiuron						180000		EO	42	31	50	SkC	42					
						62000		PS	42									
Terbacil	108500	2800	5425	SM	43	4900		EO	43									
Triclopyr	130000		6500	TS	86	58000		EO	86	6700	400	SkC	86					
Trifluralin	240	1.3	12	SM	45	136	138	MS-A; GS-C	45	28	4.6	SkC	45					

*Values are not analytically qualified. Non-asterisk values have been J-qualified as estimates, normally below the practical quantitation limit.

[1]Criteria identified in EPA reregistration and review documents or peer reviewed literature. References listed separately.
Time component of standards are explained in body of report.

ESLOC refers to Endangered Species Level of Concern: A refers to acute, and C refers to chronic.

Fish species abbreviated in table: AS-Atlantic silverside, ND-Not Described, SM-Sheepshead Minnow, TS-Tidewater silverside.

Invertebrate species abbreviated in table: AT-Acartia tonsa (copepod), EO-Eastern Oyster, GS-Grass Shrimp, MS-Mysid shrimp, ND-Not Described, PO-Pacific Oyster, PS-Pink Shrimp.

Plant species abbreviated in table: IG-*Isochrysis galbana*, SkC-*Skeletonema costatum*

[2]WAC: Promulgated standards according to Chapter 173-201A WAC.

[3]EPA National Recommended Water Quality Criteria (EPA-822-R-02-047).

CMC: Criteria Maximum Concentration; estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed briefly without resulting in an unacceptable effect.

CCC: Criteria Continuous Concentration; estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect.

a-Criteria applies to DDT and its metabolites (ΣDDT).

b-An instantaneous concentration not to be exceeded at any time.

c-A 24-hour average not to be exceeded.

d-A 1-hour average concentration not to be exceeded more than once every three years on average.

e-A 4-day average concentration not to be exceeded more than once every three years on average.

f-Chemical form of endosulfan is not defined in WAC 173-201A. Endosulfan sulfate may be applied in this instance.

g≤ e[1.005(pH)-4.830], pH range of 6.9 to 9.5 shown.

h≤ e[1.005(pH)-5.29], pH range of 6.9 to 9.5 shown.

i-Value refers to ∑α and β-endosulfan.

j≤ e[1.005(pH)-4.869], pH range of 6.9 to 9.5 shown.

k≤ e[1.005(pH)-5.134], pH range of 6.9 to 9.5 shown.

m-There are many forms of 2,4-D that include acids, salts, amines, and esters, all of which have unique toxicity values. The criteria presented are in acid equivalents and are intended to provide a range of possible effects. Toxicity values for each form of 2,4-D are available in the referenced document.

n-Assessment criteria for permethrin are based on a formulation of cis- and trans-permethrin isomers. Manchester Laboratory analysis includes only the cis-permethrin isomer, the more toxic of the two; and cis-permethrin concentrations are compared to the assessment criteria for permethrin.

References for Appendix G

[1]Draft EFED Chapter for 2,4-D Reregistration Eligibility Decision (RED). As modified 12-2004. www.epa.gov/oppfead1/endanger/litstatus/effects/24d/attachment-b.pdf

[2]Potential Risks of Alachlor Use to Federally Threatened California Red-legged Frog (*Rana aurora draytonii*) and Delta Smelt (*Hypomesus transpacificus*) Pesticide Effects Determinations (2009). EFED, EPA Document ID: EPA-HQ-OPP-2009-0081-0115. www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2009-0081-0115.

[3]Risks of Aldicarb Use to Federally Listed Endangered California Red Legged Frog (2007). EFED, EPA. Document ID: EPA-HQ-OPP-2009-0081-0092. www.epa.gov/espp/litstatus/effects/redleg-frog/aldicarb/esa_final.pdf.

[4]Risks of Atrazine Use to Federally Listed Endangered Pallid Sturgeon (*Scaphirhynchus albus*) Pesticide Effects Determination; Appendix A. Ecological Effects Characterization (2007). EFED, EPA. www.epa.gov/espp/litstatus/effects/appendix_a_ecological_effects_sturgeon.pdf.

[5]Risks of Azinphos Methyl Use to the Federally Listed California Red Legged Frog (*Rana aurora draytonii*) Pesticide Effects Determination (2007). EFED, EPA. Docket ID: EPA-HQ-OPP-2009-0081-0029. www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2009-0081-0029.

[6]Reregistration Eligibility Decision (RED) Bentazon (1995). OPP, EPA. Document ID: EPA-HQ-OPP-2009-0081-0104. www.epa.gov/oppsrrd1/REDs/0182.pdf

[7]Risks of Bromacil and Bromacil Lithium Use to the Federally Listed California Red-Legged Frog (*Rana aurora draytonii)* Pesticide Effects Determination (2007). EFED, EPA. Document ID: EPA-HQ-OPP-2009-0081-0006. www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2009-0081-0006.

[8]Bromoxynil Analysis of Risks to Endangered and threatened Salmon and Steelhead (2004) Author: M. Patterson, OPP, EPA. www.epa.gov/espp/litstatus/effects/bromoxynil/brom-analysis.pdf

[9]Risks of Carbaryl Use to the Federally Listed Endangered Barton Springs Salamander *(Eurycea sosorum)* Pesticide Effects Determination (2007). EFED, EPA. www.epa.gov/espp/litstatus/effects/carbaryl/esa-assessment.pdf

[10]Carbaryl Environmental Fate and Risk Assessment, Revised EFED Risk Assessment of Carbaryl in Support of the Reregistration Eligibility Decision (RED) (2003). EFED, EPA. www.epa.gov/espp/litstatus/effects/carb-riskass.pdf

[11]Chlorpyrifos Analysis of Risks to Endangered and Threatened Salmon and Steelhead (2003). L. Turner, OPP, EPA. www.epa.gov/oppfead1/endanger/litstatus/effects/chlorpyrifos-analysis.pdf

[12]Chlorpyrifos Interim Reregistration Eligibility Decision (IRED). 2-2002. www.epa.gov/oppsrrd1/REDs/chlorpyrifos_ired.pdf

[13]Diazinon Interim Reregistration Eligibility Decision (IRED). 4-2004. www.epa.gov/oppsrrd1/REDs/diazinon_ired.pdf

[14]Turner, L. 2002. Diazinon Analysis of Risks to Endangered and Threatened Salmon and Steelhead. www.epa.gov/oppfead1/endanger/litstatus/effects/diazinon-analysis-final.pdf

[15]EFED Reregistration Chapter for Dicamba/Dicamba salts (2005). EFED, EPA. Document ID: EPA-HQ-OPP-2009-0081-0073. www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2009-0081-0073.

[16]Dichlobenil Analysis of Risks to Endangered and Threatened Salmon and Steelhead (2003). A. Stavola and L. Turner, OPP, EPA www.epa.gov/oppfead1/endanger/litstatus/effects/dichlobenil2.pdf

[17]Reregistration Eligibility Decision (RED) Dichlobenil (1998). OPP, EPA. Document ID: EPA-738-R-98-003. www.epa.gov/oppsrrd1/REDs/0263red.pdf

[18]Dimethoate Analysis of Risks to Endangered and Threatened Salmon and Steelhead (2004). M. Patterson, EFED, EPA. www.epa.gov/oppfead1/endanger/litstatus/effects/dimethoate/dimethoate_analysis.pdf.

[19]Potential Risks of Disulfoton Use to Federally Threatened California Red-legged Frog, Pesticide Effects Determination (2008). EFED, EPA. Document ID: EPA-HQ-OPP-2009-0081-0091. www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2009-0081-0091.

[20]Ecological Risk Assessment Section 3 (New Use on Sorghum) Propazine (2006). EFED, EPA. Document ID: EPA-HQ-OPP-2009-0081-0244. www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2009-0081-0244

[21]Environmental Risk Assessment for the Reregistration of Diuron. OPP, EPA www.epa.gov/oppfead1/endanger/litstatus/effects/diuron_efed_chapter.pdf

[22]Reregistration Eligibility Decision (RED) for Diuron (2003). www.epa.gov/oppsrrd1/REDs/diuron_red.pdf

[23]Reregistration Eligibility Decision (RED) for Endosulfan (2002). OPP, EPA. Document ID: EPA 738-R-02-013. www.epa.gov/oppsrrd1/REDs/endosulfan_red.pdf

[24]Risks of EPTC Use to Federally Threatened California Red-legged Frog Pesticide Effects Determination (2008). EFED, EPA. Document ID: EPA-HQ-OPP-2009-0081-0053. www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2009-0081-0053.

[25]Ethoprop Analysis of Risks to Endangered and Threatened Pacific Salmon and Steelhead (2003). M. Patterson, OPP, EPA. www.epa.gov/oppfead1/endanger/litstatus/effects/ethoprop-analysis.pdf

[26]Hexachlorobenzene (HCB) as a Contaminant of Pentachlorophenol Ecological Hazard and Risk Assessment for the Pentachlorophenol Reregistration Eligibility Decision (RED) Document (2005). OPP, EPA. Document ID: EPA-HQ-OPP-2004-0402-0031. www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2004-0402-0031.

[27]Hexazinone Analysis of Risks to Endangered and Threatened Salmon and Steelhead (2004). J. Leyhe, OPP, EPA www.epa.gov/oppfead1/endanger/litstatus/effects/hexazin-analysis.pdf

[28]Reregistration Eligibility Decision (RED) for Hexazinone (1994). OPP, EPA. Document ID: EPA 738-R-022. www.epa.gov/oppsrrd1/REDs/0266.pdf

[29]Risks of Dimethoate Use to the Federally-Listed California Red Legged Frog (*Rana aurora draytonii*) Pesticide Effects Determination (2008). EFED, EPA. Document ID: EPA-HQ-OPP-2009-0081-0038. www.epa.gov/oppfead1/endanger/litstatus/effects/redleg-frog/dimethoate/analysis.pdf.

[30]Reregistration Eligibility Decision Document Methiocarb (1994). OPP, EPA. Document ID: EPA-HQ-OPP-2009-0081-0042. www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2009-0081-0042.

[31]Malathion Analysis of Risks to Endangered and Threatened Salmon and Steelhead (2004). J. Martinez, J. Leyhe, OPP, EPA. www.epa.gov/oppfead1/endanger/litstatus/effects/malathion/finalanalysis.pdf.

[32]Environmental Fate and Effects Division's Risk Assessment for the Reregistration Eligibility Document for 2-methyl-4-chlorophenoxyacetic acid (MCPA). OPP, EPA. Document ID: EPA-HQ-OPP-2009-0081-0061. www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2009-0081-0061.

[33]Risks of Metolachlor Use to Federally Listed Endangered Barton Springs Salamander Reregistration Eligibility Decision for Metolachlor, Appendix B: Ecological Effects (2007). EFED, EPA. www.epa.gov/oppfead1/endanger/litstatus/effects/redleg-frog/2010/metolachlor-s/assessment.pdf.

[34]Risks of Norflurazon Use to Federally Threatened California Red-legged Frog Pesticide Effects Determination (2009). EFED, EPA. Document ID: EPA-HQ-OPP-2009-0081-0048. www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2009-0081-0048.

[35]Risks of Oxyfluorfen Use to the Federally threatened California Red-legged Frog (*Rana aurora draytonii)* Pesticide Effects Determination, Appendix F Ecological Effects Data (2008). EFED, EPA. www.epa.gov/oppfead1/endanger/litstatus/effects/redleg-frog/oxyfluorfen/determination.pdf.

[36]Risks of Simazine Use to Federally Listed Endangered Barton Springs Salamander *(Eurycea sosorum)* Pesticide Effects Determination, Appendix A: Ecological Effects Characterization (2007). EFED, EPA. www.epa.gov/oppfead1/endanger/litstatus/effects/simazine/effects-determ.pdf.

[37]Pendimethalin Analysis of Risks to Endangered and Threatened Salmon and Steelhead (2004). K. Pluntke, OPP, EPA.
www.epa.gov/espp/litstatus/effects/pendimeth/analysis.pdf

[38]Revised Ecological Hazard and Environmental Risk Assessment RED Chapter for Pentachlorophenol (2008). OPP, EPA. Document ID: EPA-HQ-OPP-2004-0402-0108.
www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2004-0402-0108

[39]Reregistration Eligibility Decision for Pronamide (RED). 6-1994.
www.epa.gov/oppsrrd1/REDs/old_reds/pronamide.pdf

[40]Risks of Propargite Use to Federally Threatened California Red-legged Frog (*Rana aurora draytonii*) Environmental Effects Determination, Appendix A: Ecological Effects Data (2008). EFED, EPA.
www.epa.gov/oppfead1/endanger/litstatus/effects/redleg-frog/propargite/appendix-a.pdf.

[41]Simazine Analysis of Risks to Endangered and Threatened Salmon and Steelhead (2003). L. Turner, OPP, EPA. www.epa.gov/oppfead1/endanger/litstatus/effects/simazine-final.pdf.

[42]Tebuthiuron Analysis of Risks to Endangered and Threatened Salmon and Steelhead (2004). A. Stavola, OPP, EPA.
www.epa.gov/oppfead1/endanger/litstatus/effects/tebuthiuron/tebuthiuron_analysis.pdf

[43]EFED Risk Assessment for the Proposed New Use of Terbacil on Watermelon (2005). OPP, EPA. Document ID: EPA-HQ-OPP-2009-0081-0003.
www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2009-0081-0003.

[44]Risks of Triclopyr Use to Federally Threatened California Red-legged Frog (*Rana aurora draytonii*) Pesticide Effects Determination, Appendix A: Ecological Effects Data (2009). EFED, EPA.
www.epa.gov/oppfead1/endanger/litstatus/effects/redleg-frog/triclopyr/analysis.pdf.

[45]Risks of Trifluralin Use to the Federally Listed California Red-legged Frog (*Rana Aurora draytonii*), Delta Smelt (*Hypomesus transpacificus*), San Francisco Garter Snake (*Thamnophis sirtalis tetrataenia*), and San Joaquin Kit Fox (*Vulpes macrotis mutica*) Pesticide Effects Determination, Appendix F: Ecological Effects Data (2009). EFED, EPA.
www.epa.gov/oppfead1/endanger/litstatus/effects/redleg-frog/trifluralin/appendix-f.pdf.

[46]Chlorothalonil Analysis of Risks to Endangered and Threatened Salmon and Steelhead (2003). L. Turner, OPP, EPA. www.epa.gov/oppfead1/endanger/litstatus/effects/chloroth-analysis.pdf

[47]Reregistration Eligibility Decision (RED) for Chlorpropham (1996). OPP, EPA. Document ID: EPA 738-R-96-023. www.epa.gov/oppsrrd1/REDs/0271red.pdf

[48]Risks of Linuron Use to Federally Threatened California Red-legged Frog Pesticide Effects Determination (2009). EFED, EPA. Document ID: EPA-HQ-OPP-2009-0081-0015. www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2009-0081-0015.

[49]Reregistration Eligibility Decision (RED) Linuron (1995). OPP, EPA. Document ID: EPA 738-R-95-003. www.epa.gov/oppsrrd1/REDs/0047.pdf.

[50]Methomyl Analysis of Risks to Endangered and Threatened Salmon and Steelhead (2003). W.Erickson and L. Turner, EFED, EPA. www.epa.gov/oppfead1/endanger/litstatus/effects/methomyl-analysis.pdf.

[51]Reregistration Eligibility Decision (RED) Metalaxyl (1994). OPP, EPA. Document ID: 738-R-017. www.epa.gov/oppsrrd1/REDs/0081.pdf

[52]Reregistration Eligibility Decision (RED) for Metribuzin (1998). OPP, EPA. Document ID: EPA-HQ-OPP-2009-0081-0017 6-1997. www.epa.gov/oppsrrd1/REDs/0181red.pdf

[53]Reregistration Eligibility Decision (RED) Picloram (1995). OPP, EPA. Document ID: EPA-HQ-OPP-2009-0081-0058. www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2009-0081-0058.

[54]Reregistration Eligibility Decision Carbofuran (2007). EFED, EPA. Publication # EPA-738-R-031. www.epa.gov/pesticides/reregistration/REDs/carbofuran_red.pdf

[55]Reregistration Eligibility Decision (RED) for Triadimefon and Tolerance Reassessment for Triadimenol (2006). OPP, EPA. Document ID: EPA 738-R-06-003 www.epa.gov/oppsrrd1/REDs/triadimefon_red.pdf

[56]Reregistration Eligibility Decision (RED) for DCPA (Dacthal) (1998). OPP, EPA. Document ID: EPA-HQ-OPP-2009-0081-0131. www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2009-0081-0131.

[57]Risks of Methomyl Use to the Federally Listed California Red-Legged Frog (*Rana aurora draytonii*) Pesticide Effects Determination (2007). EFED, EPA. www.epa.gov/espp/litstatus/effects/redleg-frog/methomyl/analysis.pdf.

[58] Risks of Permethrin Use to the Federally Threatened California Red-legged Frog (*Rana aurora draytonii*) and Bay Checkerspot Butterfly (*Euphydryas editha bayensis*), and the Federally Endangered California Clapper Rail (*Rallus longirostris obsoletus*), Salt Marsh Harvest Mouse (*Reithrodontomys raviventris*), and San Francisco Garter Snake (*Thamnophis sirtalis tetrataenia*)

Pesticide Effects Determinations (2008). EFED, EPA. Document ID: EPA-HQ-OPP-2009-0081-0016. www.regulations.gov and www.epa.gov/oppfead1/endanger/litstatus/effects/redleg-frog/index.html and Reregistration Eligibility Decision for Permethrin (RED). 4-2006. www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2009-0081-0016.

[59]EPA's ECOTOX Accessed May 2012 for Diphenamid, CAS# 957-54-7, referenced EFED Division, EPA data. EPA 2007. ECOTOX User Guide: ECOTOXicology Database System. Version 4.0. www.epa.gov/ecotox/

[60]Carbofuran Analysis of Risks to Endangered and Threatened Salmon and Steelhead (2004). G. Tarkowski, EFED, EPA. www.epa.gov/espp/litstatus/effects/carbofuran/riskanalysis.pdf.

[61]Environmental Fate and Effects Division Problem Formulation for the Registration Review of Imidacloprid (2008). EFED, EPA. Document ID: EPA-HQ-OPP-2009-0081-0108. www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2009-0081-0108.

[62]Risks of Oxamyl Use to Federally Threatened California Red-legged Frog (*Rana aurora draytonii*) Pesticide Effects Determination (2009). EFED, EPA. Document ID: EPA-HQ-OPP-2009-0081-0174.
www.epa.gov/oppfead1/endanger/litstatus/effects/redleg-frog/oxamyl/analysis.pdf.

[63]Registration Review: Preliminary Problem formulation for Ecological Risk, Environmental Fate, Endangered Species, and Drinking Water Assessments for Propoxur (2009). EFED, EPA. Docket ID: EPA-HQ-OPP-2009-0081-0183.
www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2009-0081-0183/

[64]IR-4 Registrations of Clopyralid in Canola, Crambe, Mustard for Seed, and Hops (2001). OPP, EPA. Document ID: EPA-HQ-OPP-2009-0081-0051.
www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2009-0081-0051

[65]EPA's ECOTOX Accessed May 2012 for MCPP salt and ester, CAS# 7085-19-0, 93-65-2, referenced EFED Division, EPA data. EPA 2007. ECOTOX User Guide: ECOTOXicology Database System. Version 4.0. www.epa.gov/ecotox/

[66]Risks of Propyzamide Use to Federally Threatened California Red-legged Frog (*Rana aurora* draytonii) Pesticide Effects Determination (2008). EFED, EPA.
www.epa.gov/oppfead1/endanger/litstatus/effects/redleg-frog/propyzamide/analysis.pdf.

[67]Environmental Risk Assessment for the Fenarimol Section 3 New Use on Hops (2007). EFED, EPA. Document ID: EPA-HQ-OPP-2009-0081-0222.
www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2009-0081-0222.

[68]Risks of Prometon Use to Federally Listed Endangered Barton Springs Salamander *(Eurycea sosorum)* Pesticide Effects Determination (2007). EFED, EPA
www.epa.gov/oppfead1/endanger/litstatus/effects/prometon/effects-determ.pdf.

[69]Reregistration Eligibility Decision for Paranitrophenol (RED) (1998). OPP, EPA. Document ID: EPA 738-R-97-016. www.epa.gov/oppsrrd1/REDs/2465red.pdf.

[70]Section 3 Environmental Risk Assessment for the New Use Registration of Acetochlor on Sorghum and Sweet Corn (2006). EFED, EPA. Document ID: EPA-HQ-OPP-2009-0081-0043. www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2009-0081-0043;oldLink=false

[71] EPA's ECOTOX Accessed May 2012 for Azinphos-Ethyl, CAS# 2642-71-9, referenced EcoManual of Acute Toxicity: Interpretation and Data Base for 410 Chemicals and 66 Species of Freshwater Animals (Mayer, F.L, and MR Ellersieck Fish & Wildlife Service DC, 1986). EPA 2007. ECOTOX User Guide: ECOTOXicology Database System. Version 4.0. www.epa.gov/ecotox/

[72]Section 24C (Special Local Need) for Use of Bifenthrin to control larval dragonflies in commercially operated freshwater bait and ornamental fish ponds in the State of Arkansas. Environmental Effects Division, EPA. Document ID: EPA-HQ-OPP-2009-0081-0116. www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2009-0081-0116

[73]Pesticide Effects Determination: Risks of Captan Use to Federally Threatened California Red-legged Frog. Environmental Fate and Effects Division, EPA. Document ID: EPA-HQ-OPP-2009-0081-0103. www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2009-0081-0103

[74]Environmental Fate and Ecological Risk Assessment for the Registration of Carboxin: 5,6 dihydro-2-methyl-1,4-oxathiin-3-carboxanilide (2009). EFED, EPA. Document ID: EPA-HQ-OPP-2009-0081-0119. www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2009-0081-0119

[75]Registration Review Ecological Risk Assessment Problem Formulation For: Dichlorvos (DDVP) (2009). EFED, EPA. Document ID: EPA-HQ-OPP-2009-0081-0135. www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2009-0081-0135

[76] Reregistration Eligibility Decision (RED) for Dichlorprop-p (2,4-DP-p) (2007). EFED, EPA. Document ID: EPA 738-R-07-008. www.epa.gov/oppsrrd1/REDs/24dp_red.pdf

[77] Fenamiphos Analysis of Risks to Endangered and Threatened Pacific Salmon and Steelhead (2003). A. Stavola and L. Turner, OPP, EPA www.epa.gov/oppfead1/endanger/litstatus/effects/fenami-analysis.pdf.

[78]Ecological Risk Assessment for Fipronil Uses (2007). EFED, EPA. Document ID: EPA-HQ-OPP-2009-0081-0207. www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2009-0081-0207

[79]Risks of Phosmet Use to Federally Threatened California Red-legged Frog (*Rana aurora draytonii*) Pesticide Effects Determination (2008). EFED, EPA. Document ID: EPA-HQ-OPP-2009-0081-0098. www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2009-0081-0098

[80]Reregistration Eligibility Decision for Napropamide (2005). OPP, EPA. Document ID: EPA-HQ-OPP-2009-0081-0037. www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2009-0081-0037.

[81]Reregistration Eligibility Decision for Piperonyl Butoxide (PBO) (2006). EPA. Document ID: EPA 738-R-06-005. www.epa.gov/oppsrrd1/REDs/piperonyl_red.pdf.

[82]Risks of Endosulfan Use to the Federally Threatened California Red-legged Frog, Bay Checkerspot butterfly, Valley Elderberry Longhorn Beetle, and California Tiger Salamander And the Federally Endangered San Francisco Garter Snake, San Joaquin Kit Fox, and Salt March harvest Mouse – Pesticide Effects Determination (2009). EFED, EPA. Document ID: EPA-HQ-OPP-2009-0081-0142. www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2009-0081-0142.

[83]Reregistration Eligibility Decision (RED) Bromoxynil (1998). OPP, EPA www.epa.gov/oppsrrd1/REDs/2070red.pdf

[84]EPA's ECOTOX Accessed May 2012 for EPN, CAS# 2104645, referenced EFED Division, EPA data. EPA 2007. ECOTOX User Guide: ECOTOXicology Database System. Version 4.0. www.epa.gov/ecotox/

[85]Risks of Oryzalin Use to Federally Threatened California Red-legged Frog (*Rana aurora draytonii*) Pesticide Effects Determination, Appendix A-Ecological Effects Data (2008). EFED, EPA. www.epa.gov/oppfead1/endanger/litstatus/effects/redleg-frog/2010/oryzalin/appendix-a2.pdf.

[86]Reregistration Eligibility Decision (RED)Triclopyr (1998). OPP, EPA. Document ID: EPA 738-R-98-011. www.epa.gov/oppsrrd1/REDs/2710red.pdf.

[87]Reregistration Eligibility Decision (RED) for Cycloate (*S*-ethyl cyclohexyl (ethyl) thiocarbamate) (2004). OPP, EPA. Document ID: EPA-HQ-OPP-2009-0081-0013. www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2009-0081-0013.

[88]National Marine Fisheries Service Endangered Species Act Section 7 Consultation Biological Opinion Environmental Protection Agency Registration of Pesticides Containing Chlorpyrifos, Diazinon, Malathion (2008). NMFS. www.epa.gov/oppfead1/endanger/litstatus/effects.

[89]National Marine Fisheries Service Endangered Species Act Section 7 Consultation Biological Opinion Environmental Protection Agency Registration of Pesticides Containing Carbaryl, Carbofuran, and Methomyl (2009). NMFS. www.epa.gov/oppfead1/endanger/litstatus/effects.

[90]National Marine Fisheries Service Endangered Species Act Section 7 Consultation Biological Opinion Environmental Protection Agency Registration of Pesticides Containing Azinphos methyl, Bensulide, Dimethoate, Disulfoton, Ethoprop, Fenamiphos, Naled, Methamidophos, Methidathion, Methyl parathion, Phorate and Phosmet (2010). NMFS. www.epa.gov/oppfead1/endanger/litstatus/effects.

[91]National Marine Fisheries Service Endangered Species Act Section 7 Consultation Biological Opinion Environmental Protection Agency Registration of Pesticides 2,4-D, Triclopyr BEE, Diuron, Linuron, Captan, and Chlorothalonil (2011). NMFS. www.epa.gov/oppfead1/endanger/litstatus/effects.

[92]DRAFT National Marine Fisheries Service Endangered Species Act Section 7 Consultation Draft Biological Opinion Environmental Protection Agency Registration of Pesticides Oryzalin, Pendimethalin, Trifluralin (2012). NMFS. www.epa.gov/oppfead1/endanger/litstatus/effects.

[93]Reregistration Eligibility Decision (RED) for Mecoprop-p (mcpp) (2007) OPP, EPA. Document ID: EPA-738-R-07-009. www.epa.gov/oppsrrd1/REDs/mcpp_red.pdf.

Appendix H. Pesticide Detection Summary Tables, 2009-2011

Following are abbreviations used in Appendix H tables.

ALPQL: average lower practical quantitation limit
C: carbamate
D: degradate compound
Det: detection
DS: downstream
F: fungicide
Freq: frequency
H: herbicide
I: insecticide
J: number value an approximate concentration
Max: maximum
n: number
N: neonicotinoid
ND: not detected
OC: organochlorine
OP: organophosphate
Py: pyrethroid
Pyra: pyrazole
SE: sulfite ester
Sy: synergist
US: upstream
WP: wood preservative

Table H-1. Summary of pesticide detections in Thornton Creek (downstream site), 2009-2011. Concentrations reported as µg/L.

Chemical Name	Type	ALPQL	2009 n=27			2010 n=27			2011 n=27		
			# Det	Freq	Max	# Det	Freq	Max	# Det	Freq	Max
Carbaryl	I-C	0.017	1	3.7%	0.025	1	3.7%	0.005 J	ND		
Carbofuran	I-C	0.017	1	3.7%	0.031	ND			ND		
Imidacloprid	I-N	0.019	ND			5	18.5%	0.005 J	ND		
Methiocarb	I-C	0.021	2	7.4%	0.215	ND			ND		
Methomyl	I-C	0.036	1	3.7%	0.065	ND			ND		
Propoxur	I-C	0.036	1	3.7%	0.053	1	3.7%	0.008 J	ND		
2,4,6-Trichlorophenol	D-M	0.063	1	3.7%	0.510	ND			ND		
3-Hydroxycarbofuran	D-C	0.036	2	7.4%	0.076	ND			ND		
4,4'-DDD	D-OC	0.034	ND			ND			1	3.7%	0.061
4-Nitrophenol	D-M	0.063	1	3.7%	0.120	ND			1	3.7%	0.390
Methomyl Oxime	D-C	0.036	1	3.7%	0.079 J	ND			ND		
Oxamyl oxime	D-C	0.022	1	3.7%	0.028 J	ND			ND		
Chlorothalonil	F	0.033	1	3.7%	0.028 J	ND			ND		
Pentachlorophenol	WP	0.063	3	11.1%	0.024 J	9	33.3%	0.049 J	4	14.8%	0.036 J
2,4-D	H	0.063	6	22.2%	0.130	7	25.9%	0.110	4	14.8%	0.160
Dicamba I	H	0.063	1	3.7%	0.010 J	ND			3	11.1%	0.037 J
Dichlobenil	H	0.033	27	100.0%	0.053	24	88.9%	0.044 J	22	81.5%	0.320
Diuron	H	0.043	1	3.7%	0.057	3	11.1%	0.053 J	8	29.6%	0.020
MCPA	H	0.063	ND			1	3.7%	0.031 J	1	3.7%	0.170
Mecoprop (MCPP)	H	0.063	3	11.1%	0.086	2	7.4%	0.050 J	2	7.4%	0.038 J
Prometon	H	0.033	2	7.4%	0.075	ND			2	7.4%	0.150
Triclopyr	H	0.063	3	11.1%	0.080	5	18.5%	0.210	1	3.7%	0.022 J

Table H-2. Summary of pesticide detections in Longfellow Creek, 2009-2011. Concentrations reported as µg/L.

Chemical Name	Type	ALPQL	2009 n=27			2010 n=27			2011 n=27		
			# Det	Freq	Max	# Det	Freq	Max	# Det	Freq	Max
Carbaryl	I-C	0.017	ND			1	3.7%	0.003 J	ND		
Carbofuran	I-C	0.017	ND			1	3.7%	0.003 J	ND		
Diazinon	I-OP	0.033	ND			ND			1	3.7%	0.038
Fipronil	I-Pyra	0.101	ND			ND			1	3.7%	0.050 J
Imidacloprid	I-N	0.019	ND			9	33.3%	0.007 J	1	3.7%	0.005 J
Methiocarb	I-C	0.021	2	7.4%	0.200	ND			ND		
Methomyl	I-C	0.036	ND			1	3.7%	0.004 J	ND		
Oxamyl	I-C	0.037	ND			1	3.7%	0.004 J	ND		
2,4,6-Trichlorophenol	D-M	0.063	1	3.7%	0.510	ND			ND		
3,5-Dichlorobenzoic Acid	D-M	0.063	1	3.7%	0.520	ND			ND		
4-Nitrophenol	D-M	0.063	ND			ND			1	3.7%	0.270
Oxamyl oxime	D-C	0.022	ND			1	3.7%	0.013 J	ND		
Chlorothalonil	F	0.033	ND			ND			1	3.7%	0.028 J
Metalaxyl	F	0.033	ND			1	3.7%	0.042 J	ND		
Pentachlorophenol	WP	0.063	4	14.8%	0.037 J	5	18.5%	0.035 J	3	11.1%	0.014 J
2,4-D	H	0.063	9	33.3%	0.110	12	44.4%	0.540	4	14.8%	0.180
Dicamba I	H	0.063	ND			1	3.7%	0.076	2	7.4%	0.021 J
Dichlobenil	H	0.033	26	96.3%	0.130	22	81.5%	0.210 J	20	74.1%	0.046
Diuron	H	0.043	ND			1	3.7%	0.030 J	1	3.7%	0.006 J
MCPA	H	0.063	1	3.7%	0.025 J	ND			ND		
Mecoprop (MCPP)	H	0.063	2	7.4%	0.051 J	2	7.4%	0.160	2	7.4%	0.085
Prometon	H	0.033	ND			1	3.7%	0.110	1	3.7%	0.032 J
Triclopyr	H	0.063	12	44.4%	0.110	19	70.4%	0.150	3	11.1%	0.038 J

Table H-3. Summary of pesticide detections in Big Ditch, 2009-2011.
Concentrations reported as µg/L.

Chemical Name	Type	Site	ALPQL	2009 n=27			2010 n=27			2011 n=27		
				# Det	Freq	Max	# Det	Freq	Max	# Det	Freq	Max
Bifenthrin	I-Py	Upstream	0.101	ND			ND			3	11.1%	0.110
		Downstream		ND			ND			1	3.7%	0.042 J
Carbaryl	I-C	Upstream	0.017	ND			1	3.7%	0.005 J	1	3.7%	0.008 J
		Downstream		1	3.7%	0.024	1	3.7%	0.012 J	ND		
Carbofuran	I-C	Upstream	0.017	ND			1	3.7%	0.003 J	ND		
		Downstream		1	3.7%	0.102	7	25.9%	0.584	ND		
Ethoprop	I-OP	Upstream	0.033	ND			ND			ND		
		Downstream		3	11.1%	0.740	1	3.7%	0.200 J	1	3.7%	0.080
Fipronil	I-Pyra	Upstream	0.101	ND			ND			ND		
		Downstream		ND			1	3.7%	0.037 J	ND		
Imidacloprid	I-N	Upstream	0.019	11	40.7%	1.74	22	81.5%	0.879	15	55.6%	0.962
		Downstream		ND			13	48.1%	0.166	9	33.3%	0.031
Malathion	I-OP	Upstream	0.033	1	3.7%	0.94	ND			ND		
		Downstream		ND			ND			ND		
Methiocarb	I-C	Upstream	0.021	2	7.4%	0.11 E	1	3.7%	0.003 J	1	3.7%	0.015 J
		Downstream		2	7.4%	0.085	2	7.4%	0.060	ND		
Oxamyl	I-C	Upstream	0.037	ND			3	11.1%	0.004 J	ND		
		Downstream		ND			ND			ND		
Piperonyl butoxide	Sy	Upstream	0.101	ND			1	3.7%	0.120	2	7.4%	1.8
		Downstream		ND			ND			1	3.7%	0.500
3-Hydroxycarbofuran	D-C	Upstream	0.036	1	3.7%	0.054	ND			ND		
		Downstream		1	3.7%	0.074	1	3.7%	0.004 J	ND		
4-Nitrophenol	D-M	Upstream	0.063	1	3.7%	0.150	ND			ND		
		Downstream		1	3.7%	0.110 J	ND			ND		
Methomyl Oxime	D-C	Upstream	0.036	ND			ND			1	3.7%	0.034 J
		Downstream		ND			ND			ND		
Chlorothalonil	F	Upstream	0.033	1	3.7%	0.017 J	ND			ND		
		Downstream		2	7.4%	0.072	ND			ND		
Metalaxyl	F	Upstream	0.033	6	22.2%	1.3	6	22.2%	1.0	4	14.8%	0.180
		Downstream		1	3.7%	0.160	2	7.4%	0.110 J	2	7.4%	0.076
Pentachlorophenol	WP	Upstream	0.063	4	14.8%	0.027 J	8	29.6%	0.032 J	11	40.7%	0.074
		Downstream		3	11.1%	0.052 J	10	37%	0.031 J	7	25.9%	0.031 J
2,4-D	H	Upstream	0.063	8	29.6%	1.2	10	37%	0.235 J	9	33.3%	0.720
		Downstream		8	29.6%	1.10	10	37%	0.160	8	29.6%	0.580
Atrazine	H	Upstream	0.034	ND			ND			ND		
		Downstream		3	11.1%	0.860	2	7.4%	0.059	2	7.4%	0.064
Bentazon	H	Upstream	0.063	ND			ND			ND		
		Downstream		2	7.4%	0.086	1	3.7%	0.056 J	5	18.5%	0.064
Bromacil	H	Upstream	0.033	25	92.6%	0.220	22	81.5%	0.068	2	7.4%	0.040
		Downstream		9	33.3%	0.071	1	3.7%	0.022 J	ND		
Chlorpropham	H	Upstream	0.033	ND			1	3.7%	0.038	ND		
		Downstream		ND			8	29.6%	1.5 E	5	18.5%	0.330 J
Cycloate	H	Upstream	0.033	ND			ND			ND		
		Downstream		ND			1	3.7%	0.073 J	1	3.7%	0.990
Dicamba I	H	Upstream	0.063	5	18.5%	0.380	3	11.1%	0.150	6	22.2%	0.048 J
		Downstream		4	14.8%	0.250 J	3	11.1%	0.053 J	5	18.5%	0.067

Chemical Name	Type	Site	ALPQL	2009 n=27			2010 n=27			2011 n=27		
				# Det	Freq	Max	# Det	Freq	Max	# Det	Freq	Max
Dichlobenil	H	Upstream	0.033	25	92.6%	0.095	25	92.6%	0.097	23	85.2%	0.190
		Downstream		14	51.9%	0.110	15	55.6%	0.052	16	59.3%	0.074
Diuron	H	Upstream	0.043	ND			8	29.6%	0.130 J	13	48.1%	0.013
		Downstream		1	3.7%	0.140	11	40.7%	3.4 E	16	59.3%	0.705
Eptam	H	Upstream	0.033	ND			1	3.7%	0.027 E	1	3.7%	0.068
		Downstream		3	11.1%	0.360	4	14.8%	0.210	3	11.1%	0.140
Linuron	H	Upstream	0.050	ND			ND			ND		
		Downstream		ND			1	3.7%	0.014 J	1	3.7%	0.023 J
MCPA	H	Upstream	0.063	2	7.4%	0.092	2	7.4%	0.06 J	1	3.7%	0.042 J
		Downstream		5	18.5%	1.10	7	25.9%	0.300	9	33.3%	1.4
Mecoprop (MCPP)	H	Upstream	0.063	6	22.2%	0.210	4	14.8%	0.120	9	33.3%	0.120
		Downstream		4	14.8%	0.260	2	7.4%	0.026 J	3	11.1%	0.053 J
Metolachlor	H	Upstream	0.033	1	3.7%	0.021	1	3.7%	0.041 J	ND		
		Downstream		14	51.9%	1.9 E	18	66.7%	0.190	23	85.2%	6.2
Metribuzin	H	Upstream	0.033	ND			ND			ND		
		Downstream		1	3.7%	0.200	ND			ND		
Picloram	H	Upstream	0.063	16	59.3%	0.220 J	2	7.4%	0.12 J	ND		
		Downstream		ND			ND			ND		
Prometon	H	Upstream	0.033	ND			3	11.1%	0.130	3	11.1%	0.052
		Downstream		ND			3	11.1%	0.046	ND		
Simazine	H	Upstream	0.033	ND			ND			1	3.7%	0.048
		Downstream		ND			ND			ND		
Tebuthiuron	H	Upstream	0.033	12	44.4%	0.044 J	4	14.8%	0.054 J	4	14.8%	0.035
		Downstream		ND			ND			ND		
Triclopyr	H	Upstream	0.063	8	29.6%	0.360	11	40.7%	0.110	6	22.2%	0.390
		Downstream		6	22.2%	0.480	10	37.0%	0.092	5	18.5%	0.370
Trifluralin	H	Upstream	0.034	ND			ND			ND		
		Downstream		1	3.7%	0.019 J	1	3.7%	0.015 J	ND		

Table H-4. Summary of pesticide detections in Indian Slough, 2009-2011. Concentrations reported as µg/L.

Chemical Name	Type	ALPQL	2009 n=27			2010 n=27			2011 n=27		
			# Det	Freq	Max	# Det	Freq	Max	# Det	Freq	Max
Carbaryl	I-C	0.017	ND			1	3.7%	0.015 J	ND		
Carbofuran	I-C	0.017	1	3.7%	0.021	5	18.5%	0.033	ND		
Diazinon	I-OP	0.033	3	11.1%	0.034	ND			ND		
Ethoprop	I-OP	0.033	ND			1	3.7%	0.290	ND		
Imidacloprid	I-N	0.019	2	7.4%	0.024	2	7.4%	0.020	1	3.7%	0.008 J
Malathion	I-OP	0.033	1	3.7%	0.900	ND			ND		
Methomyl	I-C	0.036	1	3.7%	0.074	ND			ND		
4-Nitrophenol	D-M	0.063	1	3.7%	0.026 J	ND			ND		
Chlorothalonil	F	0.033	ND			1	3.7%	0.024 J	ND		
Metalaxyl	F	0.033	1	3.7%	0.036	ND			ND		
Pentachlorophenol	WP	0.063	2	7.4%	0.018 J	6	22.2%	0.028 J	7	25.9%	0.026 J
2,4-D	H	0.063	9	33.3%	1.1	11	40.7%	3.0	12	44.4%	0.780
Atrazine	H	0.034	5	18.5%	0.200	ND			1	3.7%	0.034 J
Bentazon	H	0.063	6	22.2%	0.033 J	1	3.7%	0.035 J	6	22.2%	0.076
Bromacil	H	0.033	19	70.4%	0.110	24	88.9%	0.650	23	85.2%	0.570
Chlorpropham	H	0.033	ND			1	3.7%	0.110	2	7.4%	0.270
Dicamba I	H	0.063	1	3.7%	0.010 J	3	11.1%	0.200	5	18.5%	0.073
Dichlobenil	H	0.033	18	66.7%	0.490	17	63.0%	0.130	15	55.6%	0.78
Diphenamid	H	0.033	16	59.3%	0.034	12	44.4%	0.026 J	11	40.7%	0.032
Diuron	H	0.043	ND			8	29.6%	3.6 E	21	77.8%	2.94 J
Eptam	H	0.033	ND			3	11.1%	0.069	1	3.7%	0.082
Hexazinone	H	0.051	12	44.4%	0.500	15	55.6%	0.120	4	14.8%	0.130
MCPA	H	0.063	3	11.1%	0.093	ND			1	3.7%	0.061 J
Mecoprop (MCPP)	H	0.063	1	3.7%	0.031 J	2	7.4%	0.330	1	3.7%	0.037 J
Metolachlor	H	0.033	6	22.2%	0.170	9	33.3%	0.195	11	40.7%	0.062
Metribuzin	H	0.033	ND			1	3.7%	0.210	ND		
Napropamide	H	0.051	ND			1	3.7%	0.440	ND		
Prometon	H	0.033	ND			2	7.4%	0.055	ND		
Simazine	H	0.033	ND			ND			1	3.7%	0.064
Tebuthiuron	H	0.033	19	70.4%	0.071	5	18.5%	0.049	14	51.9%	0.075 J
Triclopyr	H	0.063	8	29.6%	0.710	14	51.9%	0.640	7	25.9%	0.690

Table H-5. Summary of pesticide detections in Browns Slough, 2009-2011. Concentrations reported as µg/L.

Chemical Name	Type	ALPQL	2009 n=27			2010 n=27			2011 n=27		
			# Det	Freq	Max	# Det	Freq	Max	# Det	Freq	Max
Carbofuran	I-C	0.017	1	3.7%	0.026	6	22.2%	0.097	ND		
Diazinon	I-OP	0.033	ND			ND			1	3.7%	0.080
Imidacloprid	I-N	0.019	ND			5	18.5%	0.020	5	18.5%	0.077 J
4-Nitrophenol	D-M	0.063	ND			ND			1	3.7%	0.100 J
Captan	F	0.033	ND			ND			1	3.7%	0.900
Metalaxyl	F	0.033	ND			1	3.7%	0.064 J	1	3.7%	0.061
Pentachlorophenol	WP	0.063	1	3.7%	0.130	ND			1	3.7%	0.015 J
2,4-D	H	0.063	4	14.8%	0.140	4	14.8%	0.370	3	11.1%	0.065
Atrazine	H	0.034	ND			ND			1	3.7%	0.030 J
Bentazon	H	0.063	1	3.7%	0.100	4	14.8%	0.250	10	37.0%	0.120
Cycloate	H	0.033	ND			ND			1	3.7%	0.073
DCPA	H	0.063	13	48.1%	0.910	20	74.1%	0.250	19	70.4%	2.8
Dicamba I	H	0.063	2	7.4%	0.040 J	2	7.4%	0.160	1	3.7%	0.012 J
Dichlobenil	H	0.033	5	18.5%	0.011 J	6	22.2%	0.014 J	3	11.1%	0.038
Diuron	H	0.043	ND			3	11.1%	0.190 J	23	85.2%	1.07 J
Eptam	H	0.033	2	7.4%	0.840	4	14.8%	0.050	6	22.2%	0.290
MCPA	H	0.063	ND			5	18.5%	0.410	3	11.1%	0.130
Metolachlor	H	0.033	7	25.9%	0.400	9	33.3%	0.590 J	11	40.7%	0.310
Metribuzin	H	0.033	2	7.4%	0.049	ND			ND		
Simazine	H	0.033	7	25.9%	0.085	4	14.8%	0.072	2	7.4%	0.086 J
Tebuthiuron	H	0.033	ND			1	3.7%	0.056 J	ND		
Triclopyr	H	0.063	1	3.7%	0.038 J	2	7.4%	0.055 J	ND		

Table H-6. Summary of pesticide detections in the Samish River, 2009-2011. Concentrations reported as µg/L.

Chemical Name	Type	ALPQL	2009 n=27			2010 n=27			2011 n=27		
			# Det	Freq	Max	# Det	Freq	Max	# Det	Freq	Max
Ethoprop	I-OP	0.033	ND			1	3.7%	0.054 J	ND		
Methomyl Oxime	D-C	0.036	ND			ND			1	3.7%	0.034 J
Pentachlorophenol	WP	0.063	1	3.7%	0.015 J	ND			1	3.7%	0.013 J
2,4-D	H	0.063	3	11.1%	0.125	3	11.1%	0.120	1	3.7%	0.240
Dicamba I	H	0.063	2	7.4%	0.016 J	2	7.4%	0.013 J	1	3.7%	0.084
Dichlobenil	H	0.033	6	22.2%	0.013 J	2	7.4%	0.019 J	1	3.7%	0.011 J
Hexazinone	H	0.051	1	3.7%	0.071	ND			ND		
MCPA	H	0.063	2	7.4%	0.085	ND			ND		
Metolachlor	H	0.033	3	11.1%	0.020 J	ND			ND		
Triclopyr	H	0.063	2	7.4%	0.059 J	1	3.7%	0.050 J	ND		

Table H-7. Summary of pesticide detections in Spring Creek, 2009-2011. Concentrations reported as ug/L.

Chemical Name	Type	Site	ALPQL	2009 US=14 DS=27			2010 US=14 DS=27			2011 US=14 DS=27		
				# Det	Freq	Max	# Det	Freq	Max	# Det	Freq	Max
Carbaryl	I-C	Upstream	0.017	1	7.1%	0.031	2	14.3%	0.027	2	14.3%	0.025
		Downstream		1	3.7%	0.046	6	22.2%	0.021	4	14.8%	0.022
Carbofuran	I-C	Upstream	0.017	ND			1	7.1%	0.005 J	ND		
		Downstream		ND						ND		
Chlorpyrifos	I-OP	Upstream	0.034	2	14.3%	0.033	1	7.1%	0.020 J	2	14.3%	0.054
		Downstream		6	22.2%	0.076	3	11.1%	0.061	5	18.5%	0.110
Diazinon	I-OP	Upstream	0.033	3	21.4%	0.077	1	7.1%	0.12	ND		
		Downstream		3	11.1%	0.060	1	3.7%	0.021 J	1	3.7%	0.055
Imidacloprid	I-N	Upstream	0.019	ND			7	50.0%	0.007	ND		
		Downstream		ND			11	40.7%	0.006 J	ND		
Imidan	I-OP	Upstream	0.047	ND						ND		
		Downstream		1	3.70%	0.059				ND		
Methiocarb	I-C	Upstream	0.021	ND						ND		
		Downstream		ND						1	3.7%	0.003 J
Methomyl	I-C	Upstream	0.036	ND						1	7.1%	0.009 J
		Downstream		ND						1	3.7%	0.008 J
4,4'-DDE	D-OC	Upstream	0.034	1	7.1%	0.011 J	ND			ND		
		Downstream		ND			ND			ND		
Endosulfan Sulfate	D-OC	Upstream	0.034	ND						ND		
		Downstream		1	3.7%	0.022 J				ND		
Oxamyl oxime	D-C	Upstream	0.022	ND			1	7.1%	0.019 J	ND		
		Downstream		ND			1	3.7%	0.026	ND		
Pentachlorophenol	WP	Upstream	0.063	ND						3	21.4%	0.017 J
		Downstream		1	3.7%	0.008 J				ND		
2,4-D	H	Upstream	0.063	5	35.7%	0.084	5	35.7%	0.050 J	4	28.6%	0.092
		Downstream		18	66.7%	0.120	19	70.4%	0.130	14	51.9%	0.130
Atrazine	H	Upstream	0.034	5	35.7%	0.025 J	2	14.3%	0.028 J	3	21.4%	0.030 J
		Downstream		2	7.4%	0.027 J	2	7.4%	0.027 J	3	11.1%	0.035
Bentazon	H	Upstream	0.063	5	35.7%	0.040 J	2	14.3%	0.051 J	3	21.4%	0.032 J
		Downstream		2	7.4%	0.028 J	2	7.4%	0.035 J	ND		
Bromacil	H	Upstream	0.033	ND			ND			ND		
		Downstream		15	55.6%	0.059	4	14.8%	0.030 J	5	18.5%	0.070
Dicamba I	H	Upstream	0.063	3	21.4%	0.046 J	2	14.3%	0.019 J	4	28.6%	0.020 J
		Downstream		8	29.6%	0.051 J	6	22.2%	0.017 J	6	22.2%	0.049 J
Dichlobenil	H	Upstream	0.033	4	28.6%	0.013 J	1	7.1%	0.010 J	ND		
		Downstream		8	29.6%	0.012 J	2	7.4%	0.012 J	1	3.7%	0.011 J
Diuron	H	Upstream	0.043	ND			2	14.3%	0.015	1	7.1%	0.018 J
		Downstream		ND			2	7.4%	0.060 J	6	22.2%	0.084
Eptam	H	Upstream	0.033	ND						1	7.1%	0.020 J
		Downstream		ND			ND			1	3.7%	0.056
MCPA	H	Upstream	0.063	1	7.1%	0.027 J	1	7.1%	0.025 J	ND		
		Downstream		2	7.4%	0.030 J	1	3.7%	0.024 J	3	11.1%	0.042 J
Metolachlor	H	Upstream	0.033	ND						1	7.1%	0.031 J
		Downstream		ND						1	3.7%	0.023 J
Norflurazon	H	Upstream	0.034	3	21.4%	0.066	ND			2	14.3%	0.045
		Downstream		5	18.5%	0.062	1	3.7%	0.030 J	ND		
Oryzalin	H	Upstream	0.116	4	28.6%	0.310	1	7.1%	1.0 J	2	14.3%	0.290
		Downstream		2	7.4%	0.540 J	ND			ND		
Pendimethalin	H	Upstream	0.034	3	21.4%	0.027 J	ND			ND		
		Downstream		9	33.3%	0.046	ND			ND		
Prometon	H	Upstream	0.033	ND			ND			ND		
		Downstream		ND			1	3.7%	0.009 J	2	7.4%	0.034
Propoxur	H	Upstream	0.036	1	7.1%	0.064	ND			ND		
		Downstream		1	7.1%	0.099	ND			ND		
Simazine	H	Upstream	0.033	1	7.1%	0.015 J	ND			ND		
		Downstream		3	21.4%	0.045	ND			ND		
Terbacil	H	Upstream	0.034	ND			ND			ND		
		Downstream		ND			ND			1	3.7%	0.043

Table H-8. Summary of pesticide detections in Marion Drain, 2009-2011.
Concentrations reported as µg/L.

Chemical Name	Type	ALPQL	2009 n=34			2010 n=34			2011 n=34		
			# Det	Freq	Max	# Det	Freq	Max	# Det	Freq	Max
Carbaryl	I-C	0.017	ND			5	14.7%	0.016 J	1	2.9%	0.017
Chlorpyrifos	I-OP	0.034	10	29.4%	0.040	5	14.7%	0.027 J	ND		
Disulfoton sulfone	I-OP	0.101	4	11.8%	0.046 J	3	8.8%	0.045 J	ND		
Ethoprop	I-OP	0.033	8	23.5%	0.610	2	5.9%	0.110	7	20.6%	0.910
Fipronil	I-Pyra	0.101	ND			ND			1	2.9%	0.018 J
Imidacloprid	I-N	0.019	1	2.9%	0.041	17	50.0%	0.009 J	2	5.9%	0.190
Malathion	I-OP	0.033	2	5.9%	0.045	2	5.9%	0.062	3	8.8%	0.270
Methomyl	I-C	0.036	ND			5	14.7%	0.043	3	8.8%	1.21
Oxamyl	I-C	0.037	ND			ND			6	17.6%	0.036
Propargite	I-SE	0.051	ND			1	2.9%	0.110 J	2	5.9%	0.870
Disulfoton Sulfoxide	D-OP	0.112	5	14.7%	0.160 J	2	5.9%	0.110 J	1	2.9%	0.024 J
Chlorothalonil	F	0.033	ND			ND			1	2.9%	1.1
Metalaxyl	F	0.033	ND			ND			1	2.9%	0.120
Pentachlorophenol	WP	0.063	ND			ND			1	2.9%	0.010 J
2,4-D	H	0.063	19	55.9%	0.092	20	58.8%	0.081	12	35.3%	0.160
Atrazine	H	0.034	1	2.9%	0.022 J	1	2.9%	0.041	8	23.5%	0.042
Bentazon	H	0.063	15	44.1%	0.280	10	29.4%	0.250	13	38.2%	0.260
Bromacil	H	0.033	4	11.8%	0.042	3	8.8%	0.052	ND		
Bromoxynil	H	0.063	7	20.6%	0.073	5	14.7%	0.076	4	11.8%	0.049 J
Chlorpropham	H	0.033	1	2.9%	0.049	ND			ND		
Clopyralid	H	0.063	ND			ND			9	26.5%	0.046 J
Dicamba I	H	0.063	18	52.9%	0.030 J	18	52.9%	0.032 J	17	50.0%	0.049 J
Diuron	H	0.043	ND			6	17.6%	0.210	21	61.8%	0.122
Eptam	H	0.033	1	2.9%	0.067	1	2.9%	0.028 J	1	2.9%	0.100
MCPA	H	0.063	4	11.8%	0.026 J	6	17.6%	0.066	4	11.8%	0.072
Metolachlor	H	0.033	3	8.8%	0.120	3	8.8%	0.034	ND		
Metribuzin	H	0.033	ND			ND			1	2.9%	0.075
Pendimethalin	H	0.034	10	29.4%	0.080 J	12	35.3%	0.099 J	8	23.5%	0.094
Simazine	H	0.033	1	2.9%	0.023 J	2	5.9%	0.081	ND		
Terbacil	H	0.034	26	76.5%	0.680	25	73.5%	0.580	24	70.6%	0.720
Triclopyr	H	0.063	ND			ND			1	2.9%	0.120
Trifluralin	H	0.034	10	29.4%	0.026	8	23.5%	0.030 J	8	23.5%	0.060

Table H-9. Summary of pesticide detections in Sulphur Creek Wasteway, 2009-2011. Concentrations reported as µg/L.

Chemical Name	Type	ALPQL	2009 n=27			2010 n=27			2011 n=27		
			# Det	Freq	Max	# Det	Freq	Max	# Det	Freq	Max
4,4'-DDT	I-OC	0.033	ND			ND			1	3.7%	0.029 J
Carbaryl	I-C	0.017	5	18.5%	0.039	11	40.7%	0.040	5	18.5%	0.098
Chlorpyrifos	I-OP	0.034	5	18.5%	0.280	4	14.8%	0.096	6	22.2%	0.130
DDVP	I-OP	0.051	ND			1	3.7%	0.0685	ND		
Diazinon	I-OP	0.033	4	14.8%	0.087	1	3.7%	0.033	ND		
Dimethoate	I-OP	0.033	1	3.7%	0.120	ND			ND		
Imidacloprid	I-N	0.019	ND			14	51.9%	0.042	2	7.4%	0.108 J
Methiocarb	I-C	0.021	1	3.7%	0.269	ND			ND		
Methomyl	I-C	0.036	ND			2	7.4%	0.004 J	ND		
Oxamyl	I-C	0.037	ND			1	3.7%	0.003 J	2	7.4%	0.044
4,4'-DDE	D-OC	0.034	3	11.1%	0.022 J	ND			ND		
Disulfoton Sulfoxide	D-OP	0.112	ND			1	3.7%	0.026 J	ND		
Methomyl Oxime	D-C	0.036	ND			ND			1	3.7%	0.034 J
2,4-D	H	0.063	21	77.8%	0.230	23	85.2%	0.440	23	85.2%	1.4
Acetochlor	H	0.101	ND			2	7.4%	0.041 J	ND		
Atrazine	H	0.034	1	3.7%	0.046	ND			8	29.6%	0.060
Bentazon	H	0.063	4	14.8%	0.037 J	2	7.4%	0.052 J	4	14.8%	0.048 J
Bromacil	H	0.033	18	66.7%	0.067	12	44.4%	0.048	16	59.3%	0.380
DCPA	H	0.063	8	29.6%	0.033	6	22.2%	0.047	7	25.9%	0.056 J
Dicamba I	H	0.063	18	66.7%	0.072	12	44.4%	0.026 J	18	66.7%	0.170
Dichlobenil	H	0.033	9	33.3%	0.012 J	3	11.1%	0.009 J	ND		
Diuron	H	0.043	ND			7	25.9%	0.540 J	19	70.4%	0.543
Hexazinone	H	0.051	3	11.1%	0.110	3	11.1%	0.410	1	3.7%	0.050
MCPA	H	0.063	5	18.5%	0.0885	3	11.1%	0.037 J	3	11.1%	0.120
Metribuzin	H	0.033	1	3.7%	0.420	ND			1	3.7%	0.110
Monuron	H	0.010	MEL added Monuron analysis in 2011						2	7.4%	0.050
Norflurazon	H	0.034	1	3.7%	0.044	ND			ND		
Pendimethalin	H	0.034	3	11.1%	0.043	1	3.7%	0.055 J	4	14.8%	0.064
Prometon	H	0.033	ND			ND			1	3.7%	0.028 J
Simazine	H	0.033	1	3.7%	0.690 J	1	3.7%	0.049	ND		
Terbacil	H	0.034	7	25.9%	0.120	3	11.1%	0.095	3	11.1%	0.096
Trifluralin	H	0.034	5	18.5%	0.032 J	2	7.4%	0.025 J	1	3.7%	0.026 J

Table H-10. Summary of pesticide detections in Peshastin Creek, 2009-2011. Concentrations reported as µg/L.

Chemical Name	Type	ALPQL	2009 n=27			2010 n=27			2011 n=27		
			# Det	Freq	Max	# Det	Freq	Max	# Det	Freq	Max
Endosulfan I	I-OC	0.051	2	7.4%	0.040 J	1	3.7%	0.045 J	ND		
3-Hydroxycarbofuran	D-C	0.036	ND			1	3.7%	0.004 J	ND		
Fipronil Sulfide	D-Pyra	0.101	1	3.7%	0.015 J	ND			ND		
Fipronil Sulfone	D-Pyra	0.101	1	3.7%	0.016 J	ND			ND		
Fenarimol	F	0.033	ND			ND			1	3.7%	0.055
Pentachlorophenol	WP	0.063	ND			ND			ND		
Diuron	H	0.043	ND			1	3.7%	0.120 J	ND		
Simazine	H	0.033	1	3.7%	0.014 J	1	3.7%	0.047	ND		
Simetryn	H	0.101	1	3.7%	0.055 J	ND			ND		

Table H-11. Summary of pesticide detections in Mission Creek, 2009-2011. Concentrations reported as µg/L.

Chemical Name	Type	ALPQL	2009 n=27			2010 n=27			2011 n=27		
			# Det	Freq	Max	# Det	Freq	Max	# Det	Freq	Max
Carbaryl	I-C	0.017	ND			2	7.4%	0.007 J	ND		
Chlorpyrifos	I-OP	0.034	ND			ND			1	3.7%	0.032
Endosulfan I	I-OC	0.051	1	3.7%	0.024 J	ND			ND		
Imidacloprid	I-D	0.019	ND			ND			1	3.7%	0.076 J
3-Hydroxycarbofuran	D-C	0.036	1	3.7%	0.051	ND			ND		
Pentachlorophenol	WP	0.063	ND			ND			ND		
Piperonyl butoxide	Sy	0.101	1	3.7%	0.095 J	1	3.7%	0.660	1	3.7%	0.082 J

Table H-12. Summary of pesticide detections in the Wenatchee River, 2009-2011. Concentrations reported as µg/L.

Chemical Name	Type	ALPQL	2009 n=27			2010 n=27			2011 n=27		
			# Det	Freq	Max	# Det	Freq	Max	# Det	Freq	Max
Carbaryl	I-C	0.017	ND			1	3.7%	0.006 J	ND		
Chlorpyrifos	I-OP	0.034	1	3.7%	0.038	1	3.7%	0.025 J	1	3.7%	0.035
Endosulfan I	I-OC	0.051	1	3.7%	0.061	ND			ND		
Pentachlorophenol	WP	0.063	1	3.7%	0.014 J	ND			ND		
2,4-D	H	0.063	1	3.7%	0.018 J	1	3.7%	0.040 J	ND		
Dicamba I	H	0.063	ND			1	3.7%	0.017 J	ND		
Diuron	H	0.043	ND			1	3.7%	0.027 J	1	3.7%	0.012 J

Table H-13. Summary of pesticide detections in Brender Creek, 2009-2011. Concentrations reported as µg/L.

Chemical Name	Type	ALPQL	2009 n=27			2010 n=27			2011 n=27		
			# Det	Freq	Max	# Det	Freq	Max	# Det	Freq	Max
2,4'-DDT	I-OC	0.033	2	7.4%	0.019 J	ND			1	3.7%	0.022 J
4,4'-DDT	I-OC	0.033	20	74.1%	0.037	15	55.6%	0.045	21	77.8%	0.051
Carbaryl	I-C	0.017	ND			5	18.5%	0.028	6	22.2%	0.211
Chlorpyrifos	I-OP	0.034	6	22.2%	0.083	4	14.8%	0.120	5	18.5%	0.034
Diazinon	I-OP	0.033	ND			3	11.1%	0.230	ND		
Endosulfan I	I-OC	0.051	5	18.5%	0.100	2	7.4%	0.054	ND		
Endosulfan II	I-OC	0.051	6	22.2%	0.058 J	3	11.1%	0.035 J	ND		
Imidacloprid	I-N	0.019	1	3.7%	0.022 J	9	33.3%	0.037	1	3.7%	0.025
Methiocarb	I-C	0.021	1	3.7%	0.033	ND			ND		
2,4'-DDE	D-OC	0.033	2	7.4%	0.009 J	ND			ND		
3-Hydroxycarbofuran	D-C	0.036	1	3.7%	0.106	ND			ND		
4,4'-DDD	D-OC	0.034	13	48.1%	0.030 J	10	37.0%	0.027	10	37.0%	0.032 J
4,4'-DDE	D-OC	0.034	25	92.6%	0.047	15	55.6%	0.045	19	70.4%	0.053
Endosulfan Sulfate	D-OC	0.034	21	77.8%	0.098	21	77.8%	0.100 J	15	55.6%	0.072
Pentachlorophenol	WP	0.063	ND			5	18.5%	0.020	3	11.1%	0.024 J
Piperonyl butoxide	Sy	0.101	1	3.7%	0.070 J	ND			1	3.7%	0.740
2,4-D	H	0.063	ND			ND			1	3.7%	0.032 J
Dicamba I	H	0.063	1	3.7%	0.012 J	ND			1	3.7%	0.009 J
Dichlobenil	H	0.033	10	37.0%	0.030 J	1	3.7%	0.004 J	4	14.8%	0.020 J
Diuron	H	0.043	ND			9	33.3%	0.860	1	3.7%	0.130 J
Norflurazon	H	0.034	7	25.9%	0.048	6	22.2%	0.470	9	33.3%	0.340
Pendimethalin	H	0.034	2	7.4%	0.048	2	7.4%	0.048	1	3.7%	0.047
Simazine	H	0.033	1	3.7%	0.096	ND			ND		

Table H-14. Summary of pesticide detections in the Entiat River, 2009-2011. Concentrations reported as µg/L.

Chemical Name	Type	ALPQL	2009 n=27			2010 n=27			2011 n=27		
			# Det	Freq	Max	# Det	Freq	Max	# Det	Freq	Max
4,4'-DDT	I-OC	0.034	ND			1	3.7%	0.021 J	ND		
Carbaryl	I-C	0.017	ND			2	7.4%	0.017 J	2	7.4%	0.008 J
Chlorpyrifos	I-OP	0.034	1	3.7%	0.023 J	ND			ND		
Endosulfan I	I-OC	0.051	1	3.7%	0.024 J	ND			ND		
Imidacloprid	I-N	0.019	ND			1	3.7%	0.006 J	ND		
Piperonyl butoxide	Sy	0.101	3	11.1%	0.100	1	3.7%	0.280	ND		
2,4-D	H	0.063	ND			2	7.4%	0.095 J	1	3.7%	0.055 J

Appendix I. Pesticide Calendars

To determine if water quality concentrations were healthy for aquatic life, monitoring data were compared to EPA pesticide registration toxicity criteria and EPA National Recommended Water Quality Criteria (NRWQC), referred to as assessment criteria in this report. Data were also compared to numeric Washington State water quality standards, referred to as water quality standards. Refer to Appendix G, *Assessment Criteria and Water Quality Standards*, in this report for information on assessment criteria development.

For this report, pesticide registration toxicity and risk assessment criteria, NRWQC, and the water quality standards were reviewed for changes and additions to numeric criteria. While the NRWQC and water quality standards numeric criteria did not change since the last report, additional pesticide numeric criteria were added based on pesticide registration toxicity and risk assessment criteria. Assessment criteria were added for 4-nitrophenol, and chronic assessment criteria (either fish or invertebrate, or both) were added for bromacil, carbaryl, eptam, methiocarb, terbacil, and triclopyr. Pesticide calendars from the 2009 and 2010 Data Summary reports (Sargeant et al., 2010 and 2011) may differ from the up-to-date calendars below.

Table I-1 presents the color codes used in Tables I-2 to I-49 (calendars) to compare detected pesticide concentrations to assessment criteria. In the calendars, the number below the months indicate sample week. Each square in a calendar represents the period when a sample was taken.

Table I-1. Color codes for comparison to assessment criteria in the pesticide calendars.

	No pesticide residue detected.
	Analysis not completed.
	Pesticide residue detected. Assessment criteria not available.
	Magnitude of detection below regulatory or toxicological criteria or standard.
	Magnitude of detection above an EPA[1] acute or chronic invertebrate registration criteria.
	Magnitude of detection above a WAC[2] or NRWQC[3] acute or chronic regulatory standard.
	Magnitude of detection above Endangered Species Level of Concern for fish, which is $1/20^{th}$ of the acute toxicity criteria.

[1] EPA: United States Environmental Protection Agency
[2] WAC: Washington Administrative Code
[3] NRWQC: EPA's National Recommended Water Quality Criteria

Detection of a pesticide concentration above an assessment criteria does not indicate exceedance of (not meeting) the regulatory criteria. The temporal component of the criteria must also be exceeded. The Washington State Department of Agriculture (WSDA) advises pesticide user groups and other stakeholders on the results of this study and also determines if assessment criteria are exceeded. If an exceedance is determined, WSDA advises stakeholders of appropriate measures to reduce pesticide concentrations.

For additional information on pesticide assessment criteria, contact the WSDA, Natural Resources Assessment Section, toll free at (877) 301-4555, #6 or (360) 902-2067, or e-mail: nras@agr.wa.gov. Their web site is http://agr.wa.gov/PestFert/natresources/SWM/.

Cedar-Sammamish Basin

Thornton Creek

Twenty-two types of pesticides and degradate compounds were detected in Thornton Creek from 2009 to 2011 (Tables I-2 - I-4). In March 2009, a detection of the insecticide methiocarb was above the chronic assessment criteria for invertebrates. In June 2011, there was one detection of 4,4'-DDD, a degradate of the legacy insecticide DDT, that was above chronic NRWQC and chronic water quality standards for DDT (and metabolites).

Table I-2. Thornton Creek (downstream) 2009 – Freshwater Criteria.

Month		**March**				**April**				**May**				**June**					**July**				**August**					**Sept**
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
2,4,6-Trichlorophenol	D-M								0.510																			
2,4-D	H									0.110	0.037	0.130	0.019									0.020						0.040
3-Hydroxycarbofuran	D-C									0.054		0.076																
4-Nitrophenol	D-M			0.120																								
Carbaryl	I-C					0.025																						
Carbofuran	I-C					0.031																						
Chlorothalonil	F					0.028																						
Dicamba I	H										0.010																	
Dichlobenil	H	0.017	0.023	0.046	0.017	0.010	0.025	0.014	0.012	0.053	0.017	0.049	0.015	0.020	0.020	0.011	0.012	0.014	0.037	0.018	0.014	0.027	0.024	0.030	0.028	0.024	0.026	0.051
Diuron	H				0.057																							
Mecoprop (MCPP)	H			0.041						0.042		0.086																
Methiocarb	I-C	0.099	0.215																									
Methomyl	I-C	0.065																										
Methomyl Oxime	D-C											0.079																
Oxamyl oxime	D-C					0.028																						
Pentachlorophenol	WP												0.007													0.015		0.024
Prometon	H							0.075	0.039																			
Propoxur	I-C																0.053											
Triclopyr	H									0.080		0.040																0.044
Total Suspended Solids	NA	3.0	7.0	17.0	5.0	7.0	6.0	6.0	6.0	25.0	4.0	11.0	7.0	10.0	5.0	11.0	4.0	3.0	4.0	4.0	4.0	3.0	3.0	3.0	2.0	3.0	3.0	4.0

C: Carbamate, D: Degradate, F: Fungicide, H: Herbicide, I: Insecticide, M: Multiple, NA: Not applicable, WP: Wood preservative

Table I-3. Thornton Creek (downstream) 2010 – Freshwater Criteria.

Month		**March**				**April**				**May**				**June**					**July**				**August**				**Sept**	
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
2,4-D	H				0.073				0.110	0.056										0.095						0.087	0.033	0.067
Carbaryl	I-C								0.005																			
Dichlobenil	H	0.017	0.008	0.013	0.027	0.011	0.009	0.009	0.044	0.014	0.010		0.008	0.021	0.012	0.014	0.014	0.007	0.001	0.002		0.012	0.012	0.016	0.012	0.015	0.008	
Diuron	H								0.039					0.053												0.028		
Imidacloprid	I-N											0.005		0.005							0.004	0.003	0.003					
MCPA	H																										0.031	
Mecoprop (MCPP)	H								0.050																		0.022	
Pentachlorophenol	WP		0.018	0.032			0.019	0.021	0.031					0.021				0.018									0.024	0.049
Propoxur	I-C								0.008																			
Triclopyr	H													0.035						0.063						0.064	0.150	0.210
Total Suspended Solids	NA	6.0	2.0	13.0	9.0	5.0	6.0	6.0	15.0	7.0	5.0	8.0	18.0	5.0	6.0	9.0	6.0	4.0	4.0	8.0	11.0	7.0	5.0	5.0	6.0	4.0	5.0	12.0

C: Carbamate, H: Herbicide, I: Insecticide, N: Neonicotinoid, NA: Not applicable, WP: Wood preservative

Table I-4. Thornton Creek (downstream) 2011 - Freshwater Criteria.

Month		**March**				**April**				**May**					**June**				**July**				**August**					**Sept**
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
2,4-D	H							0.065		0.045					X		0.046					0.160						
4,4'-DDD	D-OC																	0.061										
4-Nitrophenol	D-M	0.390													X													
Dicamba I	H								0.037	0.021					X		0.012											
Dichlobenil	H	0.020	0.020	0.010	0.042		0.017	0.020	0.320	0.021	0.013	0.025	0.020	0.017	0.011	0.008	0.008	0.009		0.011	0.012	0.022	0.012		0.005	0.005		
Diuron	H	0.007			0.016	0.007		0.009				0.007	0.007									0.020					0.016	
MCPA	H								0.170						X													
Mecoprop (MCPP)	H							0.038		0.038					X													
Pentachlorophenol	WP		0.017	0.014		0.016			0.036						X													
Prometon	H				0.150	0.032																						
Triclopyr	H			0.022											X													
Total Suspended Solids	NA	8.0	7.0	8.0	67.0	7.0	4.0	10.0	105.0	5.5	6.0	7.0	13.0	11.0	7.0	6.0	5.0	8.0	4.0	5.0	5.0	12.0	3.0	4.0	4.0	3.0	4.0	4.0

D: Degradate, H: Herbicide, M: Multiple, NA: Not applicable, OC: Organochlorine, WP: Wood preservative

Green-Duwamish Basin

Longfellow Creek

Twenty-three types of pesticides and degradate compounds were detected in Longfellow Creek from 2009 to 2011 (Tables I-5 - I-7). Early March 2009 detections of the insecticide methiocarb exceeded the chronic assessment criteria for invertebrates.

Table I-5. Longfellow Creek 2009 - Freshwater Criteria.

Month		March				April				May				June					July				August					Sept
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
2,4,6-Trichlorophenol	D-M			0.510																								
2,4-D	H									0.110	0.038	0.085				0.058	0.110							0.042	0.022		0.027	0.035
3,5-Dichlorobenzoic Acid	D-M			0.520																								
Dichlobenil	H		0.046	0.010	0.016	0.013	0.047	0.014	0.014	0.130	0.019	0.025	0.013	0.012	0.011	0.008	0.010	0.009	0.022	0.011	0.011	0.023	0.021	0.021	0.030	0.025	0.030	0.033
MCPA	H											0.025																
Mecoprop (MCPP)	H									0.051	0.009																	
Methiocarb	I-C	0.117	0.200																									
Pentachlorophenol	WP		0.028							0.037	0.009																	0.020
Triclopyr	H		0.095							0.110	0.024	0.071				0.014	0.098					0.015		0.047	0.048	0.034	0.052	0.074
Total Suspended Solids	NA	13.0	20.0	3.0	3.0	2.0	7.0	3.0	3.0	38.0	2.0	5.0	4.0	4.5	16.0	4.0	3.0	6.0	3.0	18.0	2.0	2.0	2.0	1.0	< 1	3.0	2.0	1.0

C: Carbamate, D: Degradate, H: Herbicide, I: Insecticide, M: Multiple, NA: Not applicable, WP: Wood preservative

Table I-6. Longfellow Creek 2010 - Freshwater Criteria.

Month		March				April				May				June					July				August				Sept	
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
2,4-D	H				0.057		0.036	0.032	0.540	0.150	0.068										0.024		0.030		0.130	0.042	0.038	0.086
Carbaryl	I-C								0.003																			
Carbofuran	I-C												0.003															
Dicamba I	H								0.076																			
Dichlobenil	H	0.017	0.011		0.054	0.027	0.017	0.021	0.210	0.078	0.026	0.008	0.010	0.024	0.010		0.014	0.006	0.002			0.013	0.011	0.015	0.012	0.011		0.017
Diuron	H								0.030																			
Imidacloprid	I-N		0.007									0.005	0.006		0.005						0.004	0.005	0.003	0.006			0.004	
Mecoprop (MCPP)	H								0.160	0.055																		
Metalaxyl	F				0.042																							
Methomyl	I-C												0.004															
Oxamyl	I-C												0.004															
Oxamyl oxime	D-C			0.013																								
Pentachlorophenol	WP		0.018						0.035							0.017				0.033	0.016							
Prometon	H							0.110																				
Triclopyr	H	0.034	0.033	0.031	0.080			0.049	0.140	0.092	0.049			0.070	0.053	0.031	0.036	0.031			0.031		0.037		0.080	0.052	0.048	0.150
Total Suspended Solids	NA	3.0	2.0	2.0	7.0	8.0	2.0	< 3	17.0	6.0	5.0	4.0	4.0	4.0	4.0	4.0	3.0	4.0	2.0	9.0	2.0	3.0	2.0	4.0	2.0	9.0	2.0	3.0

C: Carbamate, D: Degradate, F: Fungicide, H: Herbicide, I: Insecticide, N: Neonicotinoid, NA: Not applicable, WP: Wood preservative

Table I-7. Longfellow Creek 2011 - Freshwater Criteria.

Month		**March**				**April**				**May**					**June**				**July**				**August**					**Sept**
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
2,4-D	H								0.180									0.045			0.059	0.087						
4-Nitrophenol	D-M	0.270																										
Chlorothalonil	F	0.028																										
Diazinon	I-OP	0.038																										
Dicamba I	H															0.009						0.021						
Dichlobenil	H	0.023	0.026	0.013	0.026		0.021	0.020	0.046	0.010	0.008	0.023	0.022	0.015		0.009	0.012		0.011		0.016	0.017	0.010			0.006	0.008	
Diuron	H		0.006																									
Fipronil	I-Py						0.050																					
Imidacloprid	I-N																				0.005							
Mecoprop (MCPP)	H								0.085												0.045							
Pentachlorophenol	WP		0.014	0.012	0.013																							
Prometon	H												0.032															
Triclopyr	H		0.036	0.027		0.038																						
Total Suspended Solids	NA	29.0	43.0	5.0	2.0	6.0	1.0	2.0	187.0	2.0	2.0	5.0	2.0	7.5	4.0	3.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.0	1.0	2.0	2.0

D: Degradate, F: Fungicide, H: Herbicide, I: Insecticide, M: Multiple, N: Neonicotinoid, NA: Not applicable, OP: Organophosphate, Py: Pyrethroid, WP: Wood preservative

Skagit-Samish Basin

Big Ditch

A total of 37 pesticides and degradates were detected in Big Ditch from 2009-2011 (Tables I-8 – I-13). Of these, 29 were identified at the upstream Big Ditch site, and 31 were found at the downstream Big Ditch site.

In 2009, the upstream Big Ditch site had a methiocarb detection that was above the chronic invertebrate assessment criteria as well as a malathion detection that did not meet the Endangered Species Level of Concern (ESLOC) for fish, EPA's chronic NRWQC, and chronic invertebrate assessment criteria. In 2009, at the downstream Big Ditch site, two detections of metolachlor were above the chronic invertebrate assessment criteria. One of the detections was also above the chronic plant assessment criterion.

In 2010, there were no pesticide detections at either Big Ditch sites that exceeded assessment criteria or water quality standards.

In 2011, at the upstream Big Ditch site, three detections of bifenthrin, a pyrethroid insecticide, did not meet (exceeded) the ESLOC for fish and the chronic invertebrate assessment criteria. Two of these bifenthrin detections were on consecutive weeks in early July. In 2011, at the downstream Big Ditch site, one detection of bifenthrin did not meet the ESLOC for fish and the chronic invertebrate assessment criteria as well as a detection of metolachlor that was above the chronic invertebrate and plant assessment criteria.

Comparison of Upstream Big Ditch to Downstream Big Ditch

During 2009-2011, both Big Ditch sites were sampled weekly on the same day. During 2009-2011, 23 pesticides were detected in common at the two sites: bifenthrin, 2,4-D, 3-hydroxycarbofuran, 4-nitrophenol, bromacil, carbaryl, carbofuran, chlorothalonil, chlorpropham, dicamba, dichlobenil, diuron, eptam, imidacloprid, MCPA, mecoprop (MCPP), metalaxyl, methiocarb, metolachlor, pentachlorophenol, piperonyl butoxide, prometon, and triclopyr. Eight pesticides were detected only at the upstream site: malathion, oxamyl, methomyl oxime, picloram, simazine, and tebuthiuron. Eight pesticides were detected only at the downstream site: atrazine, bentazon, cycloate, ethoprop, fipronil, linuron, metribuzin, and trifluralin.

Table I-8. Upstream Big Ditch 2009 – Freshwater Criteria.

Month		March				April				May				June					July				August					Sept
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
2,4-D	H			0.270			0.088			0.220	1.200	0.840					0.510			0.023		0.480						
3-Hydroxycarbofuran	D-C																				0.054							
4-Nitrophenol	D-M			0.150																								
Bromacil	H	0.140	0.120		0.100	0.120	0.074	0.120	0.140		0.070	0.170	0.100	0.190	0.180	0.170	0.145	0.220	0.170	0.210	0.190	0.110	0.130	0.088	0.150	0.120	0.120	0.120
Chlorothalonil	F											0.017																
Dicamba I	H		0.022				0.028			0.035	0.380	0.042																
Dichlobenil	H	0.016	0.019	0.050	0.013	0.014	0.095	0.025	0.021	0.071	0.067	0.055	0.017	0.016	0.013	0.010	0.011	0.010		0.020	0.015	0.027	0.037	0.028	0.026	0.022	0.028	
Imidacloprid	I-N								0.107	0.082	0.026		0.029	1.740	0.091	0.025		0.026	0.071		0.025			0.057				
Malathion	I-OP											0.940																
MCPA	H									0.077	0.092																	
Mecoprop (MCPP)	H	0.110	0.150	0.210						0.051	0.200	0.120																
Metalaxyl	F								0.330		0.051			0.075					1.300				0.075	0.096				
Methiocarb	I-C	0.095	0.110																									
Metolachlor	H											0.021																
Pentachlorophenol	WP											0.018									0.009	0.027						0.021
Picloram	H	0.120				0.057			0.220				0.087	0.060	0.130	0.180	0.210	0.210	0.087	0.067	0.063		0.150	0.065	0.040		0.035	
Tebuthiuron	H		0.031			0.023		0.032	0.044					0.030			0.029	0.036	0.044	0.039	0.035				0.037	0.032		
Triclopyr	H						0.043			0.160	0.210	0.260					0.350			0.021		0.360						0.051
Total Suspended Solids	NA	10.0	6.0	118.0	7.0	4.0	14.0	5.0	3.0	16.5	15.0	59.0	6.0	9.0	11.0	9.0	7.0	13.0	8.0	14.0	19.0	10.5	10.0	37.0	3.0	8.0	6.0	28.0

C: Carbamate, D: Degradate, F: Fungicide, H: Herbicide, I: Insecticide, M: Multiple, N: Neonicotinoid, NA: Not applicable, OP: Organophosphate, WP: Wood preservative

Table I-9. Downstream Big Ditch 2009 – Freshwater Criteria.

Month		March				April				May				June					July				August					Sept
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
2,4-D	H						0.210			0.950	1.100	0.370						0.024		0.021					0.045			0.037
3-Hydroxycarbofuran	D-C									0.074																		
4-Nitrophenol	D-M										0.110																	
Atrazine	H							0.076		0.860	0.150																	
Bentazon	H							0.086				0.040																
Bromacil	H		0.047		0.045			0.069	0.071			0.062	0.046	0.025											0.043		0.026	
Carbaryl	I-C						0.024																					
Carbofuran	I-C											0.102																
Chlorothalonil	F																0.014	0.072										
Dicamba I	H									0.125	0.250	0.089	0.012															
Dichlobenil	H	0.013	0.018	0.009	0.012	0.010	0.110	0.016	0.013	0.110	0.073	0.032	0.011											0.019	0.022			
Diuron	H				0.140																							
Eptam	H					0.360	0.130	0.200																				
Ethoprop	I-OP									0.160	0.740	0.310																
MCPA	H					0.093	0.190	1.100		0.155		0.060																
Mecoprop (MCPP)	H	0.029								0.083	0.260	0.052																
Metalaxyl	F																											0.160
Methiocarb	I-C	0.075	0.085																									
Metolachlor	H	0.035	0.054	0.084	0.059	0.160	0.500	0.058	0.085	1.200	0.400	1.900	0.059	0.023	0.018													
Metribuzin	H											0.200																
Pentachlorophenol	WP									0.052	0.036	0.015																
Triclopyr	H						0.097			0.480	0.220	0.140													0.046			0.040
Trifluralin	H			0.019																								
Total Suspended Solids	NA	29.5	24.0	35.0	38.0	22.0	19.0	8.0	12.0	11.0	31.0	7.5	5.0	12.0	13.0	4.0	4.0	5.0	10.0	3.0	3.0	2.0	< 1	< 1	< 1	3.0	4.0	2.0

C: Carbamate, D: Degradate, F: Fungicide, H: Herbicide, I: Insecticide, M: Multiple, NA: Not applicable, OP: Organophosphate, WP: Wood preservative

Table I-10. Upstream Big Ditch 2010 – Freshwater Criteria.

Month		March				April				May				June					July				August				Sept	
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
2,4-D	H			0.063	0.045		0.160		0.120	0.170			0.052	0.170		0.235								0.058				0.073
Bromacil	H	0.045	0.050		0.055	0.043		0.059			0.048	0.037	0.035	0.060	0.021	0.061	0.068	0.058	0.042	0.033	0.050	0.057	0.062	0.051	0.050	0.055	0.057	
Carbaryl	I-C								0.005																			
Carbofuran	I-C												0.003															
Chlorpropham	H																						0.038					
Dicamba I	H								0.026					0.016		0.150												
Dichlobenil	H	0.029	0.022	0.067	0.046	0.013	0.022	0.012	0.056	0.097	0.011	0.009	0.010	0.062	0.020	0.022	0.015	0.007	0.002		0.006	0.011	0.011	0.015	0.021	0.012	0.007	
Diuron	H								0.032				0.017	0.062	0.041	0.074								0.041			0.130	0.089
Eptam	H										0.027																	
Imidacloprid	I-N		0.017			0.009	0.012	0.016	0.072	0.095	0.093	0.387	0.079	0.023	0.133	0.016	0.012	0.018	0.215	0.095	0.035	0.303	0.033	0.009	0.879		0.005	
MCPA	H								0.041							0.060												
Mecoprop (MCPP)	H								0.048	0.120				0.026														0.040
Metalaxyl	F										0.060				0.049					0.250	0.190	1.000			0.083			
Methiocarb	I-C	0.003																										
Metolachlor	H															0.041												
Oxamyl	I-C																0.003	0.004		0.003								
Pentachlorophenol	WP	0.025	0.019						0.032	0.025			0.021	0.024	0.021	0.020												
Picloram	H											0.061						0.120										
Piperonyl butoxide	Sy									0.120																		
Prometon	H	0.130		0.046										0.040														
Tebuthiuron	H																	0.054				0.035				0.036	0.047	
Triclopyr	H			0.040	0.051				0.077	0.070			0.063	0.110	0.042	0.043	0.030							0.043				0.066
Total Suspended Solids	NA	12.0	3.0	12.0	5.0	3.0	3.0	4.0	8.0	15.0	3.0	6.0	7.0	9.0	4.0	4.0	4.0	8.0	7.0	5.0	4.0	11.0	9.0	6.0	16.0	8.0	5.5	7.0

C: Carbamate, F: Fungicide, H: Herbicide, I: Insecticide, N: Neonicotinoid, NA: Not applicable, Sy: Synergist, WP: Wood preservative

Table I-11. Downstream Big Ditch 2010 – Freshwater Criteria.

Month		March				April				May				June					July				August				Sept	
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
2,4-D	H		0.057	0.086	0.098			0.077		0.110			0.140	0.160	0.110	0.033												0.041
3-Hydroxycarbofuran	D-C													0.004														
Atrazine	H		0.054														0.059											
Bentazon	H				0.056																							
Bromacil	H											0.022																
Carbaryl	I-C					0.012																						
Carbofuran	I-C					0.067						0.005	0.005	0.584	0.018	0.008	0.004											
Chlorpropham	H	0.770	1.500	0.690	0.260	0.056	0.250	0.067	0.024																			
Cycloate	H													0.073														
Dicamba I	H	0.053	0.026													0.026												
Dichlobenil	H		0.024	0.009	0.037		0.012		0.010	0.052	0.006	0.007	0.006	0.032	0.016	0.011	0.009										0.006	0.009
Diuron	H						1.500	1.300	0.230	3.400	0.115	0.160	0.100	1.100	0.098	0.290		0.012										
Eptam	H						0.080	0.081			0.210		0.024															
Ethoprop	I-OP													0.200														
Fipronil	I-Py													0.037														
Imidacloprid	I-N								0.034	0.166	0.055	0.055	0.024	0.024	0.023	0.014	0.027	0.022	0.007		0.003		0.008					
Linuron	H																											0.014
MCPA	H			0.250	0.110		0.270		0.029				0.300	0.092	0.034													
Mecoprop (MCPP)	H							0.026	0.022																			
Metalaxyl	F									0.096				0.110														
Methiocarb	I-C	0.002				0.060																						
Metolachlor	H	0.036	0.045	0.036	0.065	0.028	0.049	0.027	0.056	0.066	0.042	0.110	0.060	0.190	0.074	0.081	0.040	0.024										0.029
Pentachlorophenol	WP	0.022		0.022	0.031				0.021	0.029			0.020		0.022	0.019											0.026	0.026
Prometon	H												0.046														0.034	0.042
Triclopyr	H				0.064					0.058			0.089	0.092	0.052	0.031	0.086	0.034									0.026	0.040
Trifluralin	H										0.015																	
Total Suspended Solids	NA	7.0	13.0	10.0	10.0	6.0	9.0	9.0	11.0	12.0	8.5	25.0	8.0	11.0	9.0	6.0	4.0	4.5	5.0	4.0	2.0	2.0	2.0	< 1	2.0	2.0	2.0	1.0

C: Carbamate, D: Degradate, F: Fungicide, H: Herbicide, I: Insecticide, N: Neonicotinoid, NA: Not applicable, OP: Organophosphate, Py: Pyrethroid, WP: Wood preservative

Table I-12. Upstream Big Ditch 2011 – Freshwater Criteria.

Month		**March**				**April**				**May**					**June**				**July**				**August**					**Sept**
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
2,4-D	H				0.099	0.044			0.720	0.069	0.082	0.230		0.084							0.043	0.089						
Bifenthrin	I-Py								0.110										0.057	0.032								
Bromacil	H																	0.021		0.040								
Carbaryl	I-C																				0.008							
Dicamba I	H								0.048	0.018	0.023	0.025		0.033								0.017						
Dichlobenil	H	0.045	0.034	0.020	0.150	0.062	0.067	0.041	0.190	0.074	0.042	0.042	0.019	0.026	0.011		0.013		0.015	0.015	0.022	0.020	0.013		0.005	0.008	0.005	
Diuron	H													0.006		0.008	0.009		0.013	0.008	0.011	0.013	0.007	0.008	0.008	0.011	0.009	0.009
Eptam	H												0.068															
Imidacloprid	I-N	0.015	0.055		0.025	0.008	0.013	0.005	0.026	0.008		0.008		0.006							0.008		0.066		0.024	0.065		0.962
MCPA	H											0.042																
Mecoprop (MCPP)	H				0.038	0.020			0.120	0.043	0.032	0.043		0.030							0.040	0.042						
Metalaxyl	F				0.180		0.087						0.100										0.071					
Methiocarb	I-C												0.015															
Methomyl Oxime	D-C													0.034														
Pentachlorophenol	WP	0.019	0.017	0.014	0.042	0.025			0.074			0.017		0.019	0.019			0.029			0.031							
Piperonyl butoxide	Sy												1.800		0.051													
Prometon	H							0.024	0.052	0.017																		
Simazine	H				0.048																							
Tebuthiuron	H																		0.035	0.032			0.034					0.028
Triclopyr	H	0.037			0.042	0.035			0.390		0.063			0.059														
Total Suspended Solids	NA	9.0	8.0	5.0	60.0	13.0	4.0	4.0	72.0	4.0	3.0	5.5	4.0	4.0	3.0	5.0	4.0	27.0	9.0	7.0	5.0	6.0	10.0	5.0	7.0	7.0	12.0	7.0

C: Carbamate, D: Degradate, F: Fungicide, H: Herbicide, I: Insecticide, N: Neonicotinoid, NA: Not applicable, Py: Pyrethroid, Sy: Synergist, WP: Wood preservative

Table I-13. Downstream Big Ditch 2011 – Freshwater Criteria.

Month		**March**				**April**				**May**					**June**				**July**				**August**					**Sept**
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
2,4-D	H				0.160	0.089				0.580	0.087	0.190					0.077				0.039						0.099	
Atrazine	H																				0.025	0.064						
Bentazon	H							0.064	0.064		0.048			0.059		0.040												
Bifenthrin	I-Py								0.042																			
Chlorpropham	H	0.130	0.330	0.170	0.150		0.033																					
Cycloate	H									0.990																		
Dicamba I	H									0.067	0.024			0.025							0.012	0.023						
Dichlobenil	H	0.013	0.023	0.008	0.030	0.058	0.031	0.019	0.014	0.074	0.027	0.024	0.012	0.019	0.009		0.006		0.010									
Diuron	H	0.041	0.705	0.223	0.664	0.416	0.103	0.047	0.033	0.084	0.072	0.174	0.029	0.034		0.015	0.017	0.011										
Eptam	H													0.069	0.036	0.140												
Ethoprop	I-OP																0.080											
Imidacloprid	I-N		0.016	0.008	0.031		0.016			0.024		0.031	0.003	0.014								0.015						
Linuron	H																0.023											
MCPA	H				1.400	1.400	0.110		0.300	0.170	0.070						0.150	0.100			0.036							
Mecoprop (MCPP)	H				0.038	0.020				0.053																		
Metalaxyl	F						0.076			0.047																		
Metolachlor	H	0.054	0.058	0.051	0.052	0.044	0.041	0.050	0.080	6.200	0.076	0.068	0.110	0.290	0.180	0.097	0.350	0.024	0.036		0.087	0.062	0.025				0.069	0.037
Pentachlorophenol	WP	0.017	0.022	0.021	0.023	0.031			0.021					0.023														
Piperonyl butoxide	Sy												0.500															
Triclopyr	H				0.024	0.030				0.370											0.042						0.066	
Total Suspended Solids	NA	10.0	49.0	20.0	22.0	57.0	9.0	11.0	6.0	12.0	17.0	16.0	10.0	8.0	5.0	4.0	10.0	5.0	5.0	6.0	7.0	8.0	7.0	4.0	4.0	7.0	3.0	1.0

F: Fungicide, H: Herbicide, I: Insecticide, N: Neonicotinoid, NA: Not applicable, OP: Organophosphate, Py: Pyrethroid, Sy: Synergist, WP: Wood preservative

Indian Slough

A total of 31 pesticides and degradates were detected in Indian Slough from 2009-2011 (Tables I-14 - I-16).

In March 2009, there was a single detection of malathion that did not meet the ESLOC for fish, EPA's chronic NRWQC, and the chronic invertebrate assessment criteria.

Table I-14. Indian Slough 2009 – Freshwater Criteria.

Month		March				April				May				June					July				August					Sept
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
2,4-D	H						0.092		0.065	0.130	1.100	0.240						0.210		0.050			0.056		0.085			
4-Nitrophenol	D-M																			0.026								
Atrazine	H							0.200	0.080	0.049	0.058	0.039																
Bentazon	H													0.023				0.033	0.025	0.023	0.021		0.017					
Bromacil	H	0.055	0.060	0.059	0.055	0.044	0.086	0.048	0.067	0.044	0.097	0.110	0.041	0.033		0.037		0.084		0.052		0.028			0.060		0.022	
Carbofuran	I-C						0.021																					
Diazinon	I-OP										0.019				0.017											0.034		
Dicamba I	H																			0.010								
Dichlobenil	H	0.013	0.027	0.037	0.015	0.013	0.490	0.019	0.013	0.020	0.085	0.110	0.012	0.009	0.011		0.006			0.013	0.009				0.031			
Diphenamid	H	0.020						0.021						0.017	0.018	0.018	0.017	0.030	0.012	0.034	0.032		0.020	0.016	0.013	0.018	0.015	0.020
Hexazinone	H						0.500				0.210	0.240	0.071	0.070	0.064	0.068	0.051	0.065		0.063	0.057				0.065			
Imidacloprid	I-N		0.024								0.023																	
Malathion	I-OP			0.900																								
MCPA	H								0.093	0.091		0.035																
Mecoprop (MCPP)	H						0.031																					
Metalaxyl	F																						0.036					
Methomyl	I-C	0.074																										
Metolachlor	H												0.170	0.022					0.037	0.051	0.029				0.037			
Pentachlorophenol	WP			0.018							0.018																	
Tebuthiuron	H			0.040	0.036	0.046		0.059	0.071	0.037			0.039	0.039	0.037	0.033	0.035	0.051	0.052	0.044	0.044	0.038	0.036		0.049			0.058
Triclopyr	H									0.059	0.710	0.230						0.120		0.014			0.028	0.020	0.160			
Total Suspended Solids	NA	23.0	15.0	12.5	12.0	9.0	15.0	9.0	12.0	9.0	16.0	9.0	9.0	6.0	6.0	2.0	4.0	5.0	4.0	5.0	5.0	3.0	< 2	2.0	4.0	11.0	3.0	2.5

C: Carbamate, D: Degradate, F: Fungicide, H: Herbicide, I: Insecticide, M: Multiple, N: Neonicotinoid, NA: Not applicable, OP: Organophosphate, WP: Wood preservative

Table I-15. Indian Slough 2010 – Freshwater Criteria.

Month		March				April				May				June					July				August				Sept	
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
2,4-D	H	0.120	0.049						0.051	0.250		0.040	0.044	0.440					0.073					0.043			3.000	1.600
Bentazon	H		0.035																									
Bromacil	H	0.037				0.031	0.037	0.040	0.082	0.120	0.035	0.029	0.035	0.205	0.140	0.080	0.060	0.047	0.032	0.027	0.036	0.041	0.042	0.038	0.035	0.041	0.650	0.310
Carbaryl	I-C													0.015														
Carbofuran	I-C									0.004			0.004	0.033	0.006	0.004												
Chlorothalonil	F														0.024													
Chlorpropham	H									0.110																		
Dicamba I	H																							0.019			0.200	0.073
Dichlobenil	H	0.009	0.022	0.026	0.039	0.011	0.009		0.018	0.130	0.006	0.006		0.037	0.075	0.011	0.007						0.009				0.007	0.026
Diphenamid	H					0.017	0.022				0.006	0.007	0.005			0.025	0.026	0.022			0.014		0.017			0.014	0.022	
Diuron	H								0.038	0.280				3.600	0.260	0.440		0.012									0.310	1.000
Eptam	H											0.036	0.022	0.069														
Ethoprop	I-OP													0.290														
Hexazinone	H	0.079		0.085		0.069	0.110			0.084	0.073	0.060	0.058	0.110	0.061	0.120	0.120	0.065	0.045		0.050							
Imidacloprid	I-N													0.020	0.007													
Mecoprop (MCPP)	H																										0.330	0.140
Metolachlor	H				0.038									0.195	0.018	0.043							0.029		0.015	0.015	0.028	0.079
Metribuzin	H													0.210														
Napropamide	H													0.440														
Pentachlorophenol	WP		0.023		0.028	0.019			0.023						0.023	0.019												
Prometon	H									0.036																	0.055	
Tebuthiuron	H																					0.040		0.039	0.040	0.045	0.049	
Triclopyr	H	0.089	0.029		0.043				0.053	0.175			0.036	0.230	0.083	0.037	0.040		0.062	0.033							0.530	0.640
Total Suspended Solids	NA	15.0	10.0	9.0	7.0	9.0	7.0	10.0	6.0	11.0	9.0	8.0	7.0	10.0	6.0	6.0	7.0	9.0	7.0	6.0	3.0	22.0	4.0	4.0	4.0	2.0	3.0	5.0

C: Carbamate, F: Fungicide, H: Herbicide, I: Insecticide, N: Neonicotinoid, NA: Not applicable, OP: Organophosphate, WP: Wood preservative

Table I-16. Indian Slough 2011 – Freshwater Criteria.

Month		March				April				May					June				July				August					Sept
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
2,4-D	H							0.092		0.190	0.078	0.780		0.062			0.110		0.250		0.640	0.230	0.050			0.100	0.130	
Atrazine	H												0.034															
Bentazon	H															0.045							0.059	0.067	0.065		0.063	0.076
Bromacil	H	0.044	0.039	0.039	0.080	0.077	0.039	0.047	0.046	0.047	0.040	0.094	0.058	0.067	0.061	0.035	0.071	0.031	0.057	0.050	0.570	0.100	0.087	0.053				
Chlorpropham	H						0.140	0.270																				
Dicamba I	H													0.015			0.054				0.023					0.007	0.073	
Dichlobenil	H		0.017		0.026	0.035	0.025	0.020	0.013	0.048	0.014	0.021		0.014			0.016		0.010		0.014	0.009					0.005	
Diphenamid	H	0.024							0.020				0.027			0.008		0.008	0.028	0.031	0.031		0.030				0.032	0.030
Diuron	H	0.018	0.048	0.020	0.168	0.376	0.024	0.022		0.034	0.030	2.940	0.061	0.145		0.013	0.022	0.009	0.010	0.006	0.106	0.020			0.007	0.011		
Eptam	H															0.082												
Hexazinone	H	0.071						0.084					0.130		0.084													
Imidacloprid	I-N											0.008																
MCPA	H												0.061															
Mecoprop (MCPP)	H																0.037											
Metolachlor	H		0.041		0.034	0.062	0.018	0.018		0.037		0.055							0.026	0.028	0.046				0.035			
Pentachlorophenol	WP	0.018	0.015	0.017		0.026		0.021	0.020					0.023														
Simazine	H				0.064																							
Tebuthiuron	H						0.034	0.035	0.040				0.051	0.051		0.075				0.045	0.052	0.048	0.050		0.035	0.045	0.039	0.040
Triclopyr	H									0.190							0.110		0.170		0.690	0.250	0.092				0.052	
Total Suspended Solids	NA	6.0	5.0	9.0	12.0	43.0	< 4	5.0	9.0	4.0	< 4	6.0	6.5	6.0	7.0	8.0	6.0	6.0	4.0	9.0	7.0	5.0	7.0	5.0	4.0	5.0	5.0	4.0

H: Herbicide, I: Insecticide, N: Neonicotinoid, NA: Not applicable, WP: Wood preservative

Browns Slough

A total of 22 pesticides and degradates were detected in Browns Slough from 2009-2011 (Tables I-17 - I-19). No detections were above assessment criteria or water quality standards.

Table I-17. Browns Slough 2009 – Freshwater and Marine Criteria.

Month		March				April				May				June					July				August					Sept
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
2,4-D	H							0.061		0.140	0.056				0.051													
Bentazon	H														0.100													
Carbofuran	I-C										0.026																	
DCPA	H	0.520	0.420	0.049	0.900	0.910	0.150	0.360	0.080	0.072		0.120	0.025				0.015			0.025								
Dicamba I	H									0.040					0.018													
Dichlobenil	H					0.005	0.010			0.011			0.007		0.007													
Eptam	H								0.840	0.086																		
Metolachlor	H						0.400	0.075	0.130	0.090	0.048	0.036			0.018													
Metribuzin	H												0.030	0.049														
Pentachlorophenol	WP										0.130																	
Simazine	H	0.046	0.085		0.043	0.022	0.034				0.025	0.026																
Triclopyr	H										0.038																	
Total Suspended Solids	NA	9.0	14.0	9.0	9.0	9.0	15.0	13.0	11.0	7.0	7.0	5.0	8.0	4.0	7.0	4.0	8.0	9.0	9.0	8.0	18.0	8.0	8.0	13.0	5.0	5.0	7.0	7.0

C: Carbamate, H: Herbicide, I: Insecticide, NA: Not applicable, WP: Wood preservative

Table I-18. Browns Slough 2010 – Freshwater and Marine Criteria.

Month		March				April				May				June					July				August				Sept	
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
2,4-D	H											0.063		0.043							0.047	0.370						
Bentazon	H	0.096	0.084											0.250		0.110												
Carbofuran	I-C												0.004	0.097	0.023	0.015	0.006	0.004										
DCPA	H	0.100	0.091	0.075	0.120	0.091	0.250	0.230	0.047	0.100	0.041	0.046	0.050	0.110	0.072	0.200	0.045	0.098	0.051	0.049				0.032				
Dicamba I	H																				0.022	0.160						
Dichlobenil	H	0.013	0.014	0.008			0.010							0.009														0.010
Diuron	H								0.031					0.190		0.042												
Eptam	H							0.037				0.050	0.030	0.034														
Imidacloprid	I-N													0.020	0.008	0.004			0.007	0.008								
MCPA	H							0.410	0.066			0.066	0.033	0.044														
Metalaxyl	F													0.064														
Metolachlor	H							0.130	0.021	0.015		0.011	0.008	0.590	0.028	0.046	0.035											
Simazine	H			0.037		0.072	0.034							0.031														
Terbacil	H													0.056														
Triclopyr	H						0.055							0.042														
Total Suspended Solids	NA	4.0	7.0	17.0	8.0	8.0	6.0	15.0	5.0	6.0	6.0	6.0	7.0	5.0	5.0	5.0	4.0	6.0	6.0	6.5	5.0	2.0	5.0	8.0	4.0	8.0	4.0	10.0

C: Carbamate, F: Fungicide, H: Herbicide, I: Insecticide, N: Neonicotinoid, NA: Not applicable

Table I-19. Browns Slough 2011 – Freshwater and Marine Criteria.

Month		March				April				May					June				July				August					Sept
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
2,4-D	H					0.054				0.065	0.051																	
4-Nitrophenol	D-M					0.100																						
Atrazine	H																					0.030						
Bentazon	H			0.065		0.120		0.059		0.054	0.069			0.071		0.047	0.037					0.120		0.063				
Captan	F				0.900																							
Cycloate	H												0.073															
DCPA	H	0.130	0.160	0.160	1.400	0.180	0.110	0.440	0.064	0.200	0.250	2.800	0.082	0.069		0.027	0.049	0.270	0.220		0.040			0.077				
Diazinon	I-OP																										0.080	
Dicamba I	H																	0.012										
Dichlobenil	H				0.012										0.038						0.012							
Diuron	H	0.030	0.224	0.081	0.516	1.070	0.055	0.038	0.019	0.017	0.050	0.334	0.041	0.028	0.016	0.014	0.010	0.011	0.010		0.007	0.009		0.009	0.006		0.007	
Eptam	H									0.051			0.290	0.180	0.080	0.250	0.053											
Imidacloprid	I-N			0.021	0.071	0.077					0.015	0.064																
MCPA	H								0.110		0.130									0.035								
Metalaxyl	F																							0.061				
Metolachlor	H					0.028			0.210	0.310	0.100	0.079	0.150	0.058	0.010	0.180	0.016		0.027									
Pentachlorophenol	WP					0.015																						
Simazine	H	0.078	0.086																									
Total Suspended Solids	NA	3.0	7.0	3.0	23.0	48.0	4.0	4.0	4.0	4.0	6.0	11.0	3.0	4.0	6.0	3.0	3.0	< 2	3.0	4.0	8.0	4.0	11.0	5.0	5.0	8.0	8.0	8.0

D: Degradate, F: Fungicide, H: Herbicide, I: Insecticide, M: Multiple, N: Neonicotinoid, NA: Not applicable, OP: Organophosphate, WP: Wood preservative

Samish River

A total of 10 pesticides and degradates were detected in the Samish River from 2009-2011 (Tables I-20 - I-22). No detections were above assessment criteria or water quality standards.

Table I-20. Samish River 2009 – Freshwater Criteria.

Month		March				April				May				June					July				August					Sept
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
2,4-D	H									0.068	0.125										0.021							
Dicamba I	H									0.014	0.016																	
Dichlobenil	H		0.010	0.005			0.010			0.010	0.013		0.007															
Hexazinone	H										0.071																	
MCPA	H										0.085					0.019												
Metolachlor	H			0.015							0.020					0.012												
Pentachlorophenol	WP																											0.015
Triclopyr	H									0.038	0.059																	
Total Suspended Solids	NA	8.0	13.0	18.0	8.0	20.0	60.0	14.0	9.0	20.0	89.0	16.0	12.0	6.0	8.0	7.0	3.0	3.0	2.0	3.0	4.0	4.0	4.5	2.0	4.0	4.0	8.0	4.0
H: Herbicide, NA: Not applicable, WP: Wood preservative																												

Table I-21. Samish River 2010 – Freshwater Criteria.

Month		March				April				May				June					July				August				Sept	
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
2,4-D	H																0.022	0.031										0.120
Dicamba I	H																0.010	0.013										
Dichlobenil	H									0.019				0.010														
Ethoprop	I-OP													0.054														
Triclopyr	H																											0.050
Total Suspended Solids	NA	8.0	7.0	10.5	17.0	10.5	11.0	8.0	12.0	151.0	12.0	10.0	6.0	51.0	18.0	13.0	9.0	5.0	5.0	2.0	4.0	5.0	3.0	5.0	4.0	4.0	7.0	8.0
H: Herbicide, I: Insecticide, NA: Not applicable, OP: Organophosphate																												

Table I-22. Samish River 2011 – Freshwater Criteria.

Month		March				April				May					June				July				August					Sept
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
2,4-D	H																							0.240				
Dicamba I	H																							0.084				
Dichlobenil	H							0.011																				
Methomyl Oxime	D-C									0.034																		
Pentachlorophenol	WP					0.013																						
Total Suspended Solids	NA	12.0	25.0	17.0	117.0	68.0	26.0	23.0	15.0	40.0	31.0	42.0	13.0	10.0	10.0	9.0	4.0	4.5	4.0	3.0	5.0	5.0	5.5	5.0	4.0	3.0	3.0	3.0
C: Carbamate, D: Degradate, H: Herbicide, NA: Not applicable, WP: Wood preservative																												

Lower Yakima Basin

Spring Creek

A total of 20 pesticides and degradates were detected in Spring Creek from 2009-2011 (Tables I-23 - I-28). Of these, 15 were detected at the upstream Spring Creek site, and 15 were detected at the downstream Spring Creek site.

In April 2009, at the upstream Spring Creek site, there was one detection of 4,4'-DDE, a degradate of the legacy insecticide DDT, that was above the chronic water quality standard for DDT (and metabolites). In April 2011, there was also a single chlorpyrifos detection that was above EPA's chronic NRWQC and the chronic invertebrate assessment criteria, as well as the chronic water quality standard. No other detections were above assessment criteria.

Multiple chlorpyrifos detections occurred in 2009, 2010, and 2011 at the downstream Spring Creek site that did not meet EPA's chronic NRWQC and the chronic invertebrate assessment criteria, as well as the chronic water quality standard. Exceedances generally occurred in late March or early April. In 2009, chlorpyrifos detections did not meet chronic criteria during three consecutive weeks; in 2010, during one week; and in 2011, during two consecutive weeks.

Comparison of Upstream Spring Creek to Downstream Spring Creek

During 2009-2011, the upstream Spring Creek site was sampled every other week, and the downstream site was sampled weekly. Nine pesticides and degradates were detected in common at the two sites: 2,4-D, atrazine, bentazon, carbaryl, chlorpyrifos, diazinon, dicamba I, dichlobenil, MCPA, and norflurazon. Oryzalin, pendimethalin, propoxur, simazine, and 4,4'-DDE were detected only at the upstream site, and bromacil, diuron, imidacloprid, oxamyl oxime, and prometon were detected only at the downstream site.

Table I-23. Upstream Spring Creek 2009 – Freshwater Criteria.

Month		**March**				**April**				**May**				**June**					**July**				**August**					**Sept**
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
2,4-D	H									0.084		0.020								0.079		0.046						0.028
4,4'-DDE	D-OC							0.011																				
Atrazine	H	0.023				0.015												0.025				0.024						0.020
Bentazon	H	0.035		0.040								0.025		0.016														0.029
Carbaryl	I-C					0.031																						
Chlorpyrifos	I-OP					0.029		0.033																				
Diazinon	I-OP															0.069				0.077		0.027						
Dicamba I	H									0.046										0.010								0.017
Dichlobenil	H					0.004		0.013		0.009										0.009								
MCPA	H									0.027																		
Norflurazon	H					0.030										0.025				0.066								
Oryzalin	H							0.300		0.150						0.086				0.310								
Pendimethalin	H									0.027		0.022				0.021												
Propoxur	I-C																							0.064				
Simazine	H					0.015																						
Total Suspended Solids	NA	7.0		4.0		8.0		27.0		68.0		19.0		27.0		59.0		25.0		29.0		18.0		12.0		7.0		4.0

C: Carbamate, D: Degradate, H: Herbicide, I: Insecticide, NA: Not applicable, OC: Organochlorine, OP: Organophosphate

Table I-24. Downstream Spring Creek 2009 – Freshwater Criteria.

Month		**March**				**April**				**May**				**June**					**July**				**August**					**Sept**
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
2,4-D	H									0.110	0.038	0.057	0.021	0.026	0.038	0.038	0.072	0.100	0.055	0.120	0.033	0.061	0.021		0.024	0.024	0.020	0.038
Atrazine	H	0.025	0.027																									
Bentazon	H			0.028																			0.012					
Bromacil	H	0.036	0.041	0.040	0.023	0.019	0.034	0.046	0.043	0.020		0.022								0.055	0.059		0.035		0.039		0.024	
Carbaryl	I-C					0.046																						
Chlorpyrifos	I-OP				0.045	0.076	0.046	0.028	0.024	0.020																		
Diazinon	I-OP																0.013			0.060		0.024						
Dicamba I	H									0.051		0.011								0.009	0.007		0.007		0.011		0.012	0.017
Dichlobenil	H					0.005	0.009	0.012	0.009	0.009	0.009		0.006							0.009								
Endosulfan Sulfate	D-OC		0.022																									
Imidan	I-OP																											0.059
MCPA	H									0.024																	0.030	
Norflurazon	H	0.033	0.060	0.034												0.023				0.062								
Oryzalin	H						0.540			0.120																		
Pendimethalin	H		0.024				0.044	0.046		0.030	0.032	0.032	0.028	0.032		0.021												
Pentachlorophenol	WP										0.008																	
Propoxur	I-C																						0.099					
Simazine	H	0.024	0.045	0.020																								
Total Suspended Solids	NA	5.0	3.0	1.0	14.0	12.0	8.0	9.0	25.0	30.0	50.0	20.0	28.0	19.0	49.0	11.0	5.0	2.0	3.0	17.0	8.0	14.0	5.0	7.0	7.0	8.0	8.0	7.0

C: Carbamate, D: Degradate, H: Herbicide, I: Insecticide, NA: Not applicable, OC: Organochlorine, OP: Organophosphate, WP: Wood preservative

Table I-25. Upstream Spring Creek 2010 – Freshwater Criteria.

Month		March				April				May				June					July				August				Sept	
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
2,4-D	H									0.040		0.050				0.037		0.038		0.050								
Atrazine	H													0.028		0.027												
Bentazon	H	0.051		0.047																								
Carbaryl	I-C									0.027		0.024																
Carbofuran	I-C																	0.005										
Chlorpyrifos	I-OP					0.020																						
Diazinon	I-OP																					0.120						
Dicamba I	H									0.019		0.017																
Dichlobenil	H					0.010																						
Diuron	H									0.150				0.045														
Imidacloprid	I-N											0.005		0.007		0.005		0.006		0.004		0.006		0.004				
MCPA	H											0.025																
Oryzalin	H					1.000																						
Oxamyl oxime	D-C			0.019																								
Total Suspended Solids	NA	7.0		10.0		23.0		29.0		16.0		143.0		46.0		19.0		50.0		17.0		22.0		15.0		6.0		10.0

C: Carbamate, D: Degradate, H: Herbicide, I: Insecticide, N: Neonicotinoid, NA: Not applicable, OP: Organophosphate

Table I-26. Downstream Spring Creek 2010 – Freshwater Criteria.

Month		March				April				May				June					July				August				Sept	
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
2,4-D	H				0.031	0.031		0.100	0.032	0.041		0.047	0.027			0.022	0.051	0.047	0.130	0.038	0.029	0.046	0.041		0.065	0.097	0.050	0.110
Atrazine	H													0.027												0.012		
Bentazon	H		0.035				0.032																					
Bromacil	H																				0.030	0.029		0.026			0.024	
Carbaryl	I-C								0.010	0.015	0.021	0.016	0.005	0.007														
Chlorpyrifos	I-OP			0.034	0.061	0.033																						
Diazinon	I-OP																					0.021						
Dicamba I	H									0.017		0.015	0.014						0.015	0.010				0.014				
Dichlobenil	H		0.005		0.012																							
Diuron	H									0.053				0.060														
Imidacloprid	I-N											0.005		0.006	0.005	0.004	0.005	0.005				0.005	0.005	0.004		0.003	0.003	
MCPA	H											0.024																
Norflurazon	H											0.030																
Oxamyl oxime	D-C			0.026																								
Prometon	H								0.009																			
Total Suspended Solids	NA	2.0	2.0	2.0	30.0	14.0	3.0	9.0	7.0	11.0	13.0	30.0	18.0	8.0	7.0	2.0	2.0	2.0	7.0	4.0	5.0	12.0	12.0	13.0	12.0	3.0	3.0	2.0

C: Carbamate, D: Degradate, H: Herbicide, I: Insecticide, N: Neonicotinoid, NA: Not applicable, OP: Organophosphate

Table I-27. Upstream Spring Creek 2011 – Freshwater Criteria.

Month		March				April				May					June				July				August					Sept
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
2,4-D	H					0.092						0.085								0.039						0.059		
Atrazine	H	0.030												0.027								0.022						
Bentazon	H	0.032		0.029														0.027										
Carbaryl	I-C											0.025				0.006												
Chlorpyrifos	I-OP					0.054		0.026																				
Dicamba I	H									0.018		0.020								0.006		0.016						
Diuron	H											0.018																
Eptam	H															0.020												
Methomyl	I-C																							0.009				
Metolachlor	H																	0.031										
Norflurazon	H									0.028		0.045																
Oryzalin	H					0.290						0.170																
Pentachlorophenol	WP											0.014		0.014		0.017												
Total Suspended Solids	NA	3.0		4.0		54.0		76.5		27.0		56.5		57.0		42.0		60.0		22.0		20.0		21.0		18.0		11.0

C: Carbamate, H: Herbicide, I: Insecticide, NA: Not applicable, OP: Organophosphate, WP: Wood preservative

Table I-28. Downstream Spring Creek 2011 – Freshwater Criteria.

Month		March				April				May					June				July				August					Sept
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
2,4-D	H					0.054			0.090	0.044	0.080	0.130				0.044		0.045		0.043	0.037		0.100		0.046	0.040	0.044	0.045
Atrazine	H	0.035																	0.023		0.029							
Bromacil	H											0.033											0.070	0.059	0.037		0.027	
Carbaryl	I-C										0.006	0.022	0.020					0.011										
Chlorpyrifos	I-OP				0.050	0.110	0.036	0.021															0.036					
Diazinon	I-OP																						0.055					
Dicamba I	H									0.030	0.037	0.049								0.005	0.012	0.016						
Dichlobenil	H						0.011																					
Diuron	H		0.009				0.008		0.010	0.009		0.084	0.007															
Eptam	H														0.056													
MCPA	H									0.032	0.042	0.024																
Methiocarb	I-C																			0.003								
Methomyl	I-C																							0.008				
Metolachlor	H																	0.023										
Prometon	H			0.034	0.022																							
Terbacil	H											0.043																
Total Suspended Solids	NA	6.0	1.0	1.0	31.0	37.0	6.0	16.0	17.0	21.0	12.0	62.0	17.0	17.0	20.0	13.0	5.5	5.0	10.0	12.0	16.0	6.0	8.0	7.0	6.0	4.0	4.0	5.0

C: Carbamate, H: Herbicide, I: Insecticide, NA: Not applicable, OP: Organophosphate

Marion Drain

A total of 32 pesticides and degradates were detected in Marion Drain during 2009-2011 (Tables I-29 - I-31).

In April 2009, chlorpyrifos was detected once above EPA’s chronic invertebrate assessment criteria.

In May 2010, a malathion detection was above the chronic invertebrate assessment criterion.

In July 2011, a malathion detection did not meet the ESLOC for fish and EPA’s chronic NRWQC. In August 2011, a malathion detection was above the chronic invertebrate assessment criterion. In addition, in 2011, ethoprop and methomyl were detected once above EPA’s chronic invertebrate assessment criteria. These single-event detections did not exceed the 21-day time component of the chronic invertebrate criteria.

Table I-29. Marion Drain 2009 – Freshwater Criteria.

Month		March				April				May				June					July				August					Sept				October			
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
2,4-D	H								0.032	0.079	0.041	0.032	0.020	0.021	0.078	0.029	0.023	0.055	0.048	0.043	0.033		0.032	0.092	0.031	0.028	0.030	0.034							
Atrazine	H																	0.022																	
Bentazon	H													0.062	0.064	0.130	0.140	0.110	0.130	0.140	0.260	0.260	0.280	0.180	0.140	0.078	0.069	0.075							
Bromacil	H						0.026	0.028	0.042		0.020																								
Bromoxynil	H								0.065	0.073	0.039	0.030	0.017	0.010	0.008																				
Chlorpropham	H																									0.049									
Chlorpyrifos	I-OP				0.026	0.029	0.040		0.038		0.018			0.020	0.008													0.016	0.015			0.016			
Dicamba I	H								0.020	0.030	0.015	0.014			0.010	0.011	0.009	0.009	0.010	0.010	0.010	0.008	0.011	0.021	0.014	0.012	0.013	0.016							
Disulfoton sulfone	I-OP																										0.034	0.046	0.044		0.031				
Disulfoton Sulfoxide	D-OP																						0.035					0.038	0.160		0.032	0.018			
Eptam	H											0.067																							
Ethoprop	I-OP											0.033															0.480	0.610	0.380	0.130	0.088	0.082	0.070		
Imidacloprid	I-N														0.041																				
Malathion	I-OP																		0.029	0.045															
MCPA	H									0.026		0.020	0.009	0.013																					
Metolachlor	H																					0.091	0.120		0.037										
Pendimethalin	H								0.080	0.065	0.053	0.074	0.062	0.061	0.040	0.034	0.023	0.028																	
Simazine	H		0.023																																
Terbacil	H							0.051	0.070	0.590	0.140	0.200	0.115	0.100	0.089	0.110	0.120	0.120	0.069	0.067	0.680	0.290	0.063	0.045	0.033	0.045	0.066	0.260	0.220	0.250	0.360	0.230	0.053		
Trifluralin	H									0.016	0.019	0.024	0.026	0.024	0.022	0.015	0.015	0.017	0.009																
Total Suspended Solids	NA	15.0	12.0	12.0	22.0	24.0	40.0	12.0	30.5	19.0	19.0	20.0	25.0	23.0	7.0	7.0	5.0	4.0	3.0	2.0	2.0	3.0	4.0	7.0	24.0	26.0	10.0	8.0	8.0	9.5	14.0	6.0	4.0	13.0	12.0

D: Degradate, H: Herbicide, I: Insecticide, N: Neonicotinoid, NA: Not applicable, OP: Organophosphate

Table I-30. Marion Drain 2010 – Freshwater Criteria.

Month		**March**				**April**				**May**				**June**					**July**				**August**				**Sept**					**October**			
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
2,4-D	H							0.045	0.051	0.064	0.034	0.056	0.029	0.037		0.040	0.033	0.042	0.038	0.050	0.048	0.079	0.059	0.040	0.045	0.043	0.081	0.032							
Atrazine	H									0.041																									
Bentazon	H																0.051	0.073	0.160	0.250	0.150	0.230	0.094	0.170	0.130			0.097							
Bromacil	H									0.052							0.051	0.026																	
Bromoxynil	H							0.051	0.076	0.050	0.032	0.035																							
Carbaryl	I-C								0.009	0.011	0.016						0.008	0.007																	
Chlorpyrifos	I-OP																										0.023		0.027		0.022	0.020	0.020		
Dicamba I	H								0.017	0.019	0.016	0.023	0.011	0.011		0.011	0.019	0.011	0.013	0.014	0.029	0.027	0.032	0.016	0.014	0.011		0.015							
Disulfoton sulfone	I-OP																								0.023		0.044		0.045						
Disulfoton Sulfoxide	D-OP																								0.011		0.110								
Diuron	H								0.030	0.210	0.016	0.097		0.033		0.037																			
Eptam	H										0.028																								
Ethoprop	I-OP																									0.057	0.110								
Imidacloprid	I-N		0.004						0.004			0.006	0.006	0.005	0.005	0.005	0.006	0.004	0.005	0.004		0.005	0.006	0.005	0.006	0.006	0.009								
Malathion	I-OP											0.062	0.044																						
MCPA	H							0.066		0.032		0.036	0.022				0.025				0.026														
Methomyl	I-C												0.004						0.003	0.003		0.043				0.004									
Metolachlor	H													0.034		0.032		0.023																	
Pendimethalin	H							0.099	0.075	0.087	0.075	0.098	0.039	0.042	0.032	0.064	0.049	0.037		0.025															
Propargite	I-SE															0.110																			
Simazine	H									0.081				0.023																					
Terbacil	H							0.200	0.160	0.420	0.097	0.160	0.050	0.064	0.059	0.180	0.190	0.080	0.032	0.270	0.220	0.087	0.050	0.043		0.034	0.057	0.270	0.580	0.505	0.150	0.038	0.170		
Trifluralin	H							0.020		0.030	0.023	0.023	0.015	0.028	0.012	0.027																			
Total Suspended Solids	NA	6.0	10.0	16.0	10.0	16.0	47.0	48.0	19.0	16.5	13.0	12.0	21.0	23.0	23.0	9.0	4.0	5.0	1.0	3.0	5.0	3.0	26.0	6.0	2.0	5.0	11.0	9.0	8.0	11.0	17.0	4.0	9.0	5.0	9.0

C: Carbamate, D: Degradate, H: Herbicide, I: Insecticide, N: Neonicotinoid, NA: Not applicable, OP: Organophosphate, SE: Sulfite Ester

Table I-31. Marion Drain 2011 – Freshwater Criteria.

Month		March				April				May					June				July				August					Sept				October			
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
2,4-D	H									0.064	0.067	0.092		0.054		0.095				0.051	0.098	0.054	0.110	0.160	0.032	0.130									
Atrazine	H										0.022	0.040	0.031	0.042			0.010		0.020	0.020	0.022														
Bentazon	H															0.033	0.047	0.099	0.130	0.185	0.140	0.077	0.260	0.210	0.073	0.067	0.051	0.076							
Bromoxynil	H								0.033	0.049	0.029			0.036																					
Carbaryl	I-C												0.017																						
Chlorothalonil	F																				1.100														
Clopyralid	H													0.046		0.024	0.023	0.023		0.019	0.027	0.030	0.015	0.018											
Dicamba I	H								0.020	0.035	0.032	0.049	0.016	0.015	0.012	0.012	0.011	0.013	0.015	0.017	0.016	0.020	0.009	0.007	0.009										
Disulfoton Sulfoxide	D-OP																						0.024												
Diuron	H		0.024	0.008	0.008	0.023	0.033		0.033	0.059	0.042	0.114	0.025	0.122	0.022	0.021	0.015	0.013	0.011	0.040	0.011	0.020			0.008		0.008								
Eptam	H												0.100																						
Ethoprop	I-OP																										0.310	0.910	0.435	0.400	0.140	0.140	0.044		
Fipronil	I-Py																	0.018																	
Imidacloprid	I-N																	0.190			0.003														
Malathion	I-OP														0.047						0.270		0.060												
MCPA	H									0.041	0.072	0.057		0.041																					
Metalaxyl	F																				0.120														
Methomyl	I-C																	0.007			1.210			0.021											
Metribuzin	H												0.075																						
Oxamyl	I-C																0.036	0.030	0.009	0.016	0.019		0.007												
Pendimethalin	H									0.051	0.049		0.089	0.094	0.062	0.078	0.050	0.030																	
Pentachlorophenol	WP					0.010																													
Propargite	I-SE																				0.870		0.089												
Terbacil	H									0.260	0.150	0.220	0.094	0.230	0.056	0.085	0.059	0.075	0.052	0.720	0.260	0.110	0.200	0.074	0.130	0.050	0.033	0.360	0.485	0.540	0.660	0.310	0.075		
Triclopyr	H						0.120																												
Trifluralin	H										0.016		0.052	0.060	0.019	0.018	0.020	0.013	0.029																
Total Suspended Solids	NA	5.0	7.0	8.0	12.5	35.0	34.0	33.0	14.0	9.0	23.0	193.0	49.0	45.0	42.0	31.0	23.0	1.0	2.0	1.0	5.5	6.0	< 1	3.0	7.0	7.0	10.0	2.0	2.0	3.0	7.0	10.0	20.0	15.0	10.0

C: Carbamate, D: Degradate, F: Fungicide, H: Herbicide, I: Insecticide, N: Neonicotinoid, NA: Not applicable, OP: Organophosphate, Py: Pyrethroid, SE: Sulfite Ester, WP: Wood preservative

Sulphur Creek Wasteway

A total of 32 pesticides and degradates were detected in Sulphur Creek Wasteway during 2009-2011 (Tables I-32 - I-34).

During March and April 2009-2011, there were consecutive weeks of chlorpyrifos detections that did not meet (exceeded) EPA's chronic NRWQC, the chronic invertebrate assessment criteria, and the chronic water quality standard. Of the eight exceedances during 2009-2011, one April 2009 detection also did not meet the ESLOC for fish.

In 2009, there were three detections of 4,4'-DDE and, in 2011, a single detection of 4,4'-DDT that were above the chronic NRWQC and the chronic water quality standard for DDT (and metabolites). In 2009, a single methiocarb detection was above the chronic assessment criteria. In 2010, a detection of DDVP was above the chronic invertebrate assessment criteria.

Table I-32. Sulphur Creek Wasteway 2009 – Freshwater Criteria.

Month		March				April				May				June					July				August					Sept
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
2,4-D	H							0.032	0.074	0.170	0.041	0.051	0.077	0.028	0.055	0.097	0.230	0.110	0.052	0.062	0.049	0.074	0.050	0.055	0.061	0.071	0.040	0.041
4,4'-DDE	D-OC			0.022	0.021				0.005																			
Atrazine	H																	0.046										
Bentazon	H	0.028	0.037																		0.015		0.012					
Bromacil	H	0.047	0.054	0.021	0.017	0.019	0.038	0.044	0.045		0.027	0.025					0.023	0.067	0.036	0.043			0.024		0.039	0.027	0.021	
Carbaryl	I-C	0.030	0.024				0.026				0.039							0.022										
Chlorpyrifos	I-OP				0.050	0.280	0.046	0.030			0.020																	
DCPA	H	0.019				0.032				0.018			0.005				0.013							0.023	0.030	0.033		
Diazinon	I-OP																			0.031		0.027		0.025				0.087
Dicamba I	H							0.013	0.048	0.072	0.014	0.022	0.009		0.008	0.011	0.008		0.021	0.015	0.011	0.023	0.017	0.019	0.016	0.012		0.021
Dichlobenil	H						0.012	0.009		0.011	0.010		0.007		0.007		0.007	0.007			0.009							
Dimethoate	I-OP										0.120																	
Hexazinone	H							0.110	0.099		0.047																	
MCPA	H									0.032					0.014				0.089			0.012	0.012					
Methiocarb	I-C	0.269																										
Metribuzin	H																0.420											
Norflurazon	H								0.044																			
Pendimethalin	H	0.043					0.039					0.024																
Simazine	H																0.690											
Terbacil	H							0.120				0.039	0.024	0.033					0.039	0.045	0.039							
Trifluralin	H											0.018	0.021	0.022			0.015				0.032							
Total Suspended Solids	NA	18.0	7.0	94.0	83.0	23.0	32.0	41.0	67.0	98.0	36.0	38.0	44.0	66.0	64.0	31.0	47.0	13.0	25.0	16.0	10.0	28.0	22.0	20.0	27.0	11.0	44.0	81.0

C: Carbamate, D: Degradate, H: Herbicide, I: Insecticide, NA: Not applicable, OC: Organochlorine, OP: Organophosphate

Table I-33. Sulphur Creek Wasteway 2010 – Freshwater Criteria.

Month		March				April				May				June					July				August				Sept	
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
2,4-D	H				0.041	0.036	0.028	0.073	0.074	0.068	0.120	0.093	0.040	0.057	0.031	0.058	0.210	0.054	0.038	0.440	0.100	0.087		0.050	0.110	0.270	0.350	0.210
Acetochlor	H									0.032				0.041														
Bentazon	H	0.052	0.049																									
Bromacil	H	0.048	0.047			0.018	0.024			0.020		0.028		0.044		0.045	0.041	0.036		0.017	0.024							
Carbaryl	I-C								0.023	0.015	0.013	0.040	0.005	0.009		0.011	0.007	0.012	0.009					0.004				
Chlorpyrifos	I-OP			0.096	0.053	0.028	0.024																					
DCPA	H		0.044							0.031							0.029	0.047	0.038	0.033								
DDVP	I-OP																	0.069										
Diazinon	I-OP																										0.033	
Dicamba I	H									0.026	0.024	0.024			0.015		0.015	0.013	0.015	0.021	0.017			0.017	0.019			0.018
Dichlobenil	H		0.004											0.005									0.009					
Disulfoton Sulfoxide	D-OP																											0.026
Diuron	H								0.030	0.097	0.051	0.260		0.540		0.083	0.044											
Hexazinone	H	0.062									0.410			0.057														
Imidacloprid	I-N			0.005								0.005	0.005	0.006	0.005	0.004	0.005	0.042			0.004	0.004	0.003	0.003	0.003		0.003	
MCPA	H								0.029	0.029		0.037																
Methomyl	I-C											0.004	0.004															
Oxamyl	I-C																			0.003								
Pendimethalin	H							0.055																				
Simazine	H													0.049														
Terbacil	H																	0.036								0.025		0.095
Trifluralin	H										0.017					0.025												
Total Suspended Solids	NA	10.0	7.0	251.0	48.0	56.0	49.0	94.0	160.0	45.0	26.0	39.0	53.0	60.0	39.0	9.0	27.0	15.0	16.0	15.0	17.0	8.0	41.0	16.0	18.0	17.0	18.0	21.0

C: Carbamate, D: Degradate, H: Herbicide, I: Insecticide, N: Neonicotinoid, NA: Not applicable, OP: Organophosphate

Table I-34. Sulphur Creek Wasteway 2011 – Freshwater Criteria.

Month		**March**				**April**				**May**					**June**				**July**				**August**					**Sept**
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
2,4-D	H	0.130	0.086		0.150			0.078	0.130	0.140	0.270	1.400		0.081	0.095	0.084	0.066	0.062	0.080	0.120	0.068	0.100	0.086	0.100	0.230	0.072	0.067	0.041
4,4'-DDT	I-OC											0.029																
Atrazine	H											0.060		0.024				0.015	0.021	0.026	0.024	0.023	0.022					
Bentazon	H																0.034						0.048		0.041			0.035
Bromacil	H		0.380				0.030	0.034		0.011	0.013	0.048	0.036	0.035	0.020			0.023	0.035	0.038		0.032	0.037	0.026		0.031		
Carbaryl	I-C										0.005	0.096	0.098	0.017						0.005								
Chlorpyrifos	I-OP			0.029	0.110	0.130	0.037	0.030				0.048																
DCPA	H		0.056								0.027			0.027			0.031	0.031		0.048				0.044				
Dicamba I	H							0.021	0.029	0.051	0.036	0.170		0.018	0.014	0.011	0.012	0.011	0.008	0.016	0.018	0.025	0.016	0.012	0.007	0.009		
Diuron	H		0.157	0.030	0.059	0.015		0.018	0.543	0.025	0.019	0.249	0.023	0.050	0.018	0.016	0.023	0.010	0.007	0.012	0.008						0.007	
Hexazinone	H		0.050																									
Imidacloprid	I-N								0.023									0.108										
MCPA	H									0.077	0.044	0.120																
Methomyl Oxime	D-C																	0.034										
Metribuzin	H											0.110																
Monuron	H								0.050		0.010																	
Oxamyl	I-C													0.010			0.044											
Pendimethalin	H								0.064	0.029	0.023			0.050														
Prometon	H			0.028																								
Terbacil	H											0.096								0.034	0.049							
Trifluralin	H		0.026																									
Total Suspended Solids	NA	3.0	4.0	130.0	75.0	57.0	14.0	13.0	118.0	30.0	14.0	116.0	37.0	39.0	32.0	19.5	29.0	13.0	11.0	23.0	25.0	20.0	19.0	17.0	21.0	18.0	8.0	10.0

C: Carbamate, D: Degradate, H: Herbicide, I: Insecticide, N: Neonicotinoid, NA: Not applicable, OC: Organochlorine, OP: Organophosphate

Wenatchee and Entiat Basins

Peshastin Creek

A total of eight pesticides and degradates were detected in Peshastin Creek during 2009-2011 (Tables I-35 - I-37). Endosulfan was detected above the ESLOC for fish once in April 2009 and once in March 2010.

Table I-35. Peshastin Creek 2009 – Freshwater Criteria.

Month		March				April				May				June					July				August					Sept
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
Endosulfan I	I-OC					0.040	0.013																					
Fipronil Sulfide	D-Py									0.015																		
Fipronil Sulfone	D-Py									0.016																		
Simazine	H				0.014																							
Simetryn	H																											0.055
Total Suspended Solids	NA	2.0	< 1	3.0	3.0	25.0	14.0	52.0	4.0	4.5	6.0	67.0	13.0	11.0	7.0	4.0	1.5	1.0	2.0	1.0	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.0

D: Degradate, H: Herbicide, I: Insecticide, NA: Not applicable, OC: Organochlorine, Py: Pyrethroid

Table I-36. Peshastin Creek 2010 – Freshwater Criteria.

Month		March				April				May				June					July				August				Sept	
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
3-Hydroxycarbofuran	D-C					0.004																						
Diuron	H																											0.120
Endosulfan I	I-OC			0.045																								
Simazine	H																											0.047
Total Suspended Solids	NA	2.0	2.0	1.0	7.0	2.0	< 3	39.0	9.5	2.0	2.0	55.0	5.0	12.0	10.0	12.0	5.0	3.5	2.0	2.0	1.0	1.0	4.0	2.0	1.0	< 1	6.0	42.0

C: Carbamate, D: Degradate, H: Herbicide, I: Insecticide, NA: Not applicable, OC: Organochlorine

Table I-37. Peshastin Creek 2011 – Freshwater Criteria.

Month		March				April				May					June				July				August					Sept
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
Fenarimol	F									0.055																		
Total Suspended Solids	NA	< 1	1.0	3.0	164.0	26.0	3.0	2.0	2.0	2.0	5.0	42.0	14.0	5.0	15.0	7.0	7.0	4.0	3.0	1.0	2.0	2.0	1.0	1.0	1.0	2.0	< 1	< 1

F: Fungicide, NA: Not applicable

Mission Creek

During 2009-2011, seven pesticides and degradates were detected in Mission Creek (Tables I-38 - I-40). In April 2011, a single detection of chlorpyrifos did not meet the ESLOC for fish, EPA's acute and chronic assessment criteria, the acute and chronic NRWQC, and acute and chronic water quality standards.

.

Table I-38. Mission Creek 2009 – Freshwater Criteria.

Month		March				April				May				June					July				August					Sept
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
3-Hydroxycarbofuran	D-C																					0.051						
Endosulfan I	I-OC					0.024																						
Piperonyl butoxide	Sy					0.095																						
Total Suspended Solids	NA	6.0	3.0	11.0	10.0	73.0	42.0	85.0	13.0	23.0	13.0	71.0	14.0	11.0	16.0	17.0	8.0	6.0	8.0	8.0	5.0	20.0	5.0	5.0	3.0	2.0	< 1	41.0

C: Carbamate, D: Degradate, I: Insecticide, NA: Not applicable, OC: Organochlorine, Sy: Synergist

Table I-39. Mission Creek 2010 – Freshwater Criteria.

Month		March				April				May				June					July				August				Sept	
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
Carbaryl	I-C								0.007				0.006															
Piperonyl butoxide	Sy			0.660																								
Total Suspended Solids	NA	7.0	4.0	2.0	25.0	8.0	3.0	268.0	105.0	10.0	10.0	143.0	24.0	22.5	427.0	95.0	32.0	30.0	12.0	9.0	8.0	5.0	6.0	2.0	2.0	2.0	3.0	4180.0

C: Carbamate, I: Insecticide, NA: Not applicable, Sy: Synergist

Table I-40. Mission Creek 2011 – Freshwater Criteria.

Month		March				April				May					June				July				August					Sept
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
Chlorpyrifos	I-OP					0.320																						
Imidacloprid	I-N																									0.076		
Piperonyl butoxide	Sy					0.082																						
Total Suspended Solids	NA	6.0	12.0	89.0	157.0	142.0	18.0	9.0	6.0	4.0	10.0	563.0	88.0	49.0	37.0	27.0	9.0	7.0	6.0	5.0	3.0	6.0	3.0	2.0	2.0	2.0	1.0	< 1

I: Insecticide, N: Neonicotinoid, NA: Not applicable, OP: Organophosphate, Sy: Synergist

Wenatchee River

During 2009-2011, seven pesticides were detected in the Wenatchee River (Tables I-41 - I-43). In April 2009, there was a single detection of endosulfan that exceeded the ESLOC for fish.

Table I-41. Wenatchee River 2009 – Freshwater Criteria.

Month		**March**				**April**				**May**				**June**					**July**				**August**					**Sept**
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
2,4-D	H																									0.018		
Chlorpyrifos	I-OP						0.038																					
Endosulfan I	I-OC					0.061																						
Pentachlorophenol	WP															0.014												
Total Suspended Solids	NA	2.0	1.0	2.0	2.0	6.0	7.0	46.0	4.0	7.0	4.0	37.0	12.0	13.0	14.5	6.0	5.0	4.0	5.0	3.0	3.5	3.0	2.0	8.0	9.0	2.0	3.0	3.0

H: Herbicide, I: Insecticide, NA: Not applicable, OC: Organochlorine, OP: Organophosphate, WP: Wood preservative

Table I-42. Wenatchee River 2010 – Freshwater Criteria.

Month		**March**				**April**				**May**				**June**					**July**				**August**				**Sept**	
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
2,4-D	H																											0.040
Carbaryl	I-C													0.006														
Chlorpyrifos	I-OP					0.025																						
Dicamba I	H																											0.017
Diuron	H																											0.027
Total Suspended Solids	NA	2.0	2.0	2.0	4.0	3.0	4.0	25.5	6.0	6.0	3.0	70.0	8.0	12.0	18.0	17.0	15.0	10.0	4.0	6.0	6.0	3.0	9.0	3.0	2.0	2.0	2.0	30.0

C: Carbamate, H: Herbicide, I: Insecticide, NA: Not applicable, OP: Organophosphate

Table I-43. Wenatchee River 2011 – Freshwater Criteria.

Month		**March**				**April**				**May**					**June**				**July**				**August**					**Sept**
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
Chlorpyrifos	I-OP					0.035																						
Diuron	H				0.012																							
Total Suspended Solids	NA	< 1	1.0	3.0	6.0	18.0	6.0	4.0	4.0	4.0	< 2	60.0	43.0	27.0	24.0	17.0	16.0	8.5	12.0	9.0	8.0	7.0	8.0	4.0	4.0	3.0	3.0	2.0

H: Herbicide, I: Insecticide, NA: Not applicable, OP: Organophosphate

Brender Creek

During 2009-2011, a total of 23 pesticides and pesticide degradates were detected in Brender Creek (Tables I-44 - I-46).

In April and May 2009, there were four sample events where total endosulfan did not meet (exceeded) the ESLOC for fish; three of these four events also did not meet EPA's chronic NRWQC and the chronic water quality standard. Two endosulfan sulfate detections did not meet the ESLOC for fish as well. During March 2010, a total endosulfan detection did not meet the ESLOC for fish, EPA's chronic NRWQC, and the chronic water quality standard. In April 2010, and again in May 2011, an endosulfan sulfate detection did not meet the ESLOC for fish.

In April 2009, during two consecutive sampling weeks, chlorpyrifos did not meet EPA's chronic NRWQC, the chronic invertebrate assessment criteria, and the chronic water quality standard. In April 2010, a single chlorpyrifos detection did not meet EPA's acute and chronic NRWQC, the acute and chronic invertebrate assessment criteria, and the acute and chronic water quality standard.

In September 2010, a single detection of diazinon did not meet EPA's chronic and acute NRWQC and the chronic invertebrate assessment criteria.

DDT and DDT degradates (DDE and DDD) were found consistently during 2009-2011. All detections did not meet the total DDT chronic NRWQC and the chronic water quality standard. The chronic water quality standard is based on a 24-hour average concentration.

Table I-44. Brender Creek 2009 – Freshwater Criteria.

Month		March				April				May				June					July				August					Sept
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
2,4'-DDE	D-OC							0.009															0.007					
2,4'-DDT	D-OC																0.012		0.019									
3-Hydroxycarbofuran	D-C																								0.106			
4,4'-DDD	D-OC		0.023	0.023	0.023			0.019		0.014	0.013	0.013					0.012		0.025			0.029	0.029	0.030		0.030		
4,4'-DDE	D-OC	0.024	0.021	0.033	0.029	0.026	0.021	0.016	0.047	0.020	0.006	0.006			0.007	0.013	0.046	0.024	0.043	0.043	0.016	0.004	0.028	0.026	0.019	0.030	0.037	0.026
4,4'-DDT	I-OC	0.030	0.025	0.027	0.035		0.023	0.020	0.037	0.025	0.021	0.019			0.024	0.014	0.024	0.025	0.028	0.036		0.023	0.027	0.029				0.022
Total DDT	I-OC	0.054	0.069	0.083	0.087	0.026	0.044	0.064	0.084	0.059	0.04	0.038			0.031	0.027	0.094	0.049	0.115	0.079	0.016	0.056	0.091	0.085	0.019	0.06	0.037	0.048
Chlorpyrifos	I-OP					0.034	0.055	0.083	0.034	0.022	0.020																	
Dicamba I	H																										0.012	
Dichlobenil	H	0.010	0.010	0.005			0.009	0.008	0.010	0.010			0.007						0.030		0.009							
Endosulfan I	I-OC					0.100	0.027	0.018	0.058	0.036																		
Endosulfan II	I-OC					0.049	0.023		0.055	0.058	0.030	0.021																
Total Endosulfan	I-OC					0.149	0.050	0.018	0.113	0.094	0.030	0.021																
Endosulfan Sulfate	D-OC		0.022	0.022	0.021	0.048	0.044	0.044	0.098	0.084	0.050	0.043	0.032	0.029	0.028	0.027	0.030	0.029	0.035	0.031		0.034	0.031	0.031				
Imidacloprid	I-N																			0.022								
Methiocarb	I-C														0.033													
Norflurazon	H		0.031										0.028	0.048	0.039	0.032	0.028						0.045					
Piperonyl butoxide	Sy					0.070																						
Simazine	H													0.096														
Total Suspended Solids	NA	31.0	12.0	33.0	22.0	11.0	24.0	12.0	75.0	52.0	52.0	19.0	13.0	8.0	16.0	15.0	64.0	19.0	116.0	56.0	15.0	10.0	54.0	85.0	7.0	66.0	47.0	53.0

C: Carbamate, D: Degradate, H: Herbicide, I: Insecticide, N: Neonicotinoid, NA: Not applicable, OC: Organochlorine, OP: Organophosphate, Sy: Synergist

Table I-45. Brender Creek 2010 – Freshwater Criteria.

Month		March				April				May				June					July				August				September	
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
4,4'-DDD	D-OC									0.018						0.025	0.027	0.020	0.023	0.024				0.014		0.012	0.013	0.027
4,4'-DDE	D-OC								0.042	0.042	0.026					0.043	0.029	0.012	0.006	0.014	0.024	0.021	0.038	0.011		0.024	0.033	0.045
4,4'-DDT	I-OC									0.028	0.023	0.023	0.017		0.020	0.045	0.041	0.023	0.024	0.027	0.024			0.026		0.021	0.026	0.045
Total DDT	I-OC								0.042	0.088	0.049	0.023	0.017		0.020	0.113	0.097	0.055	0.053	0.065	0.048	0.021	0.038	0.051		0.057	0.072	0.117
Carbaryl	I-C									0.028	0.017		0.005	0.006														0.006
Chlorpyrifos	I-OP					0.024	0.120	0.029	0.027																			
Diazinon	I-OP								0.028																	0.019		0.230
Dichlobenil	H														0.004													
Diuron	H								0.031	0.180	0.024	0.860	0.025	0.038		0.070							0.067					0.047
Endosulfan I	I-OC			0.054	0.027																							
Endosulfan II	I-OC			0.029					0.029	0.035																		
Total Endosulfan	I-OC			0.083	0.027				0.029	0.035																		
Endosulfan Sulfate	D-OC			0.043	0.052	0.035	0.052	0.058	0.100	0.065	0.054	0.059	0.037	0.045	0.044	0.056	0.046	0.040	0.049	0.049				0.022		0.021	0.027	0.062
Imidacloprid	I-N											0.006		0.005								0.005	0.003	0.008	0.003	0.003	0.004	0.037
Norflurazon	H											0.470						0.049	0.022						0.032		0.040	0.120
Pendimethalin	H									0.041							0.048											
Pentachlorophenol	WP						0.016	0.016		0.020	0.015			0.015														
Total Suspended Solids	NA	11.0	13.0	7.0	7.0	7.0	44.0	14.0	249.0	108.0	53.5	50.5	25.0	7.0	36.0	83.0	68.0	25.0	30.0	54.0	37.0	25.0	103.0	21.0	12.0	31.0	143.0	125.0

C: Carbamate, D: Degradate, H: Herbicide, I: Insecticide, N: Neonicotinoid, NA: Not applicable, OC: Organochlorine, OP: Organophosphate, WP: Wood preservative

Table I-46. Brender Creek 2011 – Freshwater Criteria.

Month		March				April				May				June					July				August					Sept
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
2,4-D	H																			0.032								
2,4'-DDT	D-OC																								0.022			
4,4'-DDD	D-OC			0.018	0.019													0.011		0.027	0.027	0.032			0.023	0.025	0.023	0.023
4,4'-DDE	D-OC	0.015				0.043				0.052	0.030	0.028	0.041	0.041	0.040		0.026	0.040		0.038	0.034	0.053	0.036	0.011	0.030	0.032	0.030	0.032
4,4'-DDT	I-OC			0.023	0.030		0.021	0.034		0.030	0.022		0.032	0.029	0.028		0.025	0.028	0.029	0.035	0.033	0.051	0.035	0.026	0.024	0.028	0.025	0.027
Total DDT	I-OC	0.015		0.041	0.049	0.043	0.021	0.034		0.082	0.052	0.028	0.073	0.070	0.068		0.051	0.079	0.029	0.100	0.094	0.136	0.071	0.037	0.099	0.085	0.078	0.082
Carbaryl	I-C			0.028	0.008								0.004	0.010	0.032	0.211												
Chlorpyrifos	I-OP						0.034	0.031	0.030	0.023	0.011																	
Dicamba I	H																	0.009										
Dichlobenil	H	0.010	0.020		0.009				0.011																			
Diuron	H				0.130																							
Endosulfan Sulfate	D-OC				0.027		0.037			0.072	0.046	0.034	0.044	0.036	0.044	0.025	0.019	0.026	0.031			0.044			0.040	0.027		
Imidacloprid	I-N																			0.025								
Norflurazon	H		0.035										0.340		0.023	0.020	0.016	0.037							0.053	0.025	0.054	
Pendimethalin	H				0.047																							
Pentachlorophenol	WP					0.012		0.014															0.024					
Piperonyl butoxide	Sy					0.740																						
Total Suspended Solids	NA	5.0	11.0	92.0	106.0	65.0	37.0	16.0	9.5	109.0	58.0	85.0	79.0	35.0	47.0	20.0	35.0	64.0	26.0	63.0	101.0	95.0	53.0	14.0	24.0	51.0	35.0	89.0

C: Carbamate, D: Degradate, H: Herbicide, I: Insecticide, N: Neonicotinoid, NA: Not applicable, OC: Organochlorine, OP: Organophosphate, Sy: Synergist, WP: Wood preservative

Entiat River

During 2009-2011, eight pesticides were detected in the Entiat River (Tables I-47 - I-49).

In September 2010, there was one detection of DDT that was above EPA's chronic NRWQC and the chronic water quality standard. The chronic water quality standard is based on a 24-hour average concentration.

Table I-47. Entiat River 2009 – Freshwater Criteria.

Month		March				April				May				June					July				August					Sept
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
Chlorpyrifos	I-OP					0.023																						
Endosulfan I	I-OC					0.024																						
Piperonyl butoxide	Sy			0.068		0.083	0.100																					
Total Suspended Solids	NA	< 2	< 1	2.0	< 1	2.0	3.0	12.0	3.0	4.0	5.0	46.0	19.0	13.0	11.0	5.0	4.0	4.0	3.0	2.0	2.0	3.0	2.0	2.0	2.0	2.0	1.5	2.0

I: Insecticide, NA: Not applicable, OC: Organochlorine, OP: Organophosphate, Sy: Synergist

Table I-48. Entiat River 2010 – Freshwater Criteria.

Month		March				April				May				June					July				August				Sept	
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
2,4-D	H					0.040	0.095																					
4,4'-DDT	I-OC																										0.021	
Carbaryl	I-C								0.003		0.017																	
Imidacloprid	I-N														0.006													
Piperonyl butoxide	Sy		0.280																									
Total Suspended Solids	NA	3.0	4.0	2.0	4.0	3.0	4.0	21.0	7.0	4.0	5.0	31.0	8.0	11.0	7.0	31.0	13.0	8.0	7.0	6.0	4.0	3.0	5.0	3.0	3.0	2.0	2.0	2.0

C: Carbamate, H: Herbicide, I: Insecticide, N: Neonicotinoid, NA: Not applicable, OC: Organochlorine, Sy: Synergist

Table I-49. Entiat River 2011 – Freshwater Criteria.

Month		March				April				May					June				July				August					Sept
Calendar Week	Use	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
2,4-D	H																							0.055				
Carbaryl	I-C											0.004			0.008													
Total Suspended Solids	NA	1.0	1.0	2.0	4.0	13.0	3.0	3.0	3.0	5.0	16.0	35.0	25.0	8.0	67.5	20.0	15.0	12.0	8.0	8.0	7.0	5.0	5.0	4.0	2.0	2.0	3.0	2.0

C: Carbamate, H: Herbicide, I: Insecticide, NA: Not applicable

Appendix J. Tau Correlation Coefficients

The statistical test, Kendall's tau, was used to determine if there was a relationship between environmental factors such as rainfall, flow, and total suspended solids (TSS) and commonly detected pesticides. Kendall's tau is a non-parametric statistical correlation test capable of handling non-detect values and multiple detection limits. The tables below provide the tau coefficients which describe the "strength" of the correlation. Only significant correlations are included: two-tailed, $p< 0.05$. It is important to note that tau values are generally lower (by about 0.2) than values for traditional correlation coefficients like Pearson's r. For example, strong linear correlations of 0.9 or above correspond to tau values of about 0.7 or above. Negative tau values indicate an inverse relationship between environmental factors and the pesticide.

Rainfall events compared to pesticide concentrations include: day of sampling precipitation (24 hours, 12 A.M. to 12 A.M.); day of sampling precipitation and the previous day's precipitation (48 hours, 12 A.M. to 12 A.M.); day before sampling precipitation (24 hours, 12 A.M. to 12 A.M.); days before sampling precipitation (48 hours, 12 AM to 12 AM).

Table J-1. Tau coefficients for environmental factors and commonly detected pesticides in Thornton Creek, 2003-2011.

Pesticide	Flow	Day of sampling precipitation (24 hr)	Day of sampling and previous day's precipitation (48 hr)	Previous 24-hour precipitation	Previous 48-hour precipitation	TSS
Dichlobenil	0.16	0.19	0.23	0.21	0.21	0.16
2,4-D	0.26	0.29	0.29	0.23	0.10	0.26
Pentachlorophenol	0.19	0.17	0.19	0.16	0.14	0.19
MCPA	0.10	0.11	0.11	-		0.10
Mecoprop (MCPP)	0.18	0.21	0.21	0.15	0.10	0.18
Triclopyr	0.14	0.13	0.15	0.20	0.19	0.14
Prometon	0.11	-	-	-	0.12	0.11
Diuron	-	-	-	0.11	0.12	-
Dicamba	-	-	-	-	-	-
DCPA	-	-	-	-	-	-

Table J-2. Tau coefficients for environmental factors and commonly detected pesticides in Longfellow Creek, 2009-2011.

Pesticide	Flow	Day of sampling precipitation (24 hr)	Day of sampling and previous day's precipitation (48 hr)	Previous 24-hour precipitation	Previous 48-hour precipitation	TSS
2,4-D	-	0.17	0.25	0.30	0.20	-
Dicamba I	-	-	-	-	-	-
Dichlobenil	0.30	0.29	0.32	0.35	0.30	0.18
Imidacloprid	-	-	-	-	-	-
Mecoprop (MCPP)	0.19	0.23	0.20	0.19	-	0.19
Pentachlorophenol	-	0.14	0.15	0.18	-	-
Triclopyr	-	0.21	0.30	0.33	0.27	-

Table J-3. Tau coefficients for environmental factors and commonly detected pesticides in Big Ditch, 2006-2011 at the downstream site and 2007-2011 at the upstream site.

Pesticide	Flow	Day of sampling precipitation (24 hr)	Day of sampling and previous day's precipitation (48 hr)	Previous 24-hour precipitation	Previous 48-hour precipitation	TSS
Upstream Big Ditch						
2,4-D	0.27	0.31	0.33	0.39	0.29	0.09
Bromacil	-0.17	-	-	-0.17	-0.21	-
Dichlobenil	0.38	0.41	0.42	0.39	0.38	0.15
Diuron	-	-	-	-	-	-
Imidacloprid	0.17	0.19	0.17	-	-	-
Mecoprop (MCPP)	0.22	0.26	0.26	0.28	0.25	0.19
Metalaxyl	-0.14	-	-	-	-0.15	-
Pentachlorophenol	-0.14	-	-	-	-	-
Picloram	-0.22	-0.26	-0.33	-0.20	-0.20	-
Tebuthiuron	-0.16	-	-	-	-	0.18
Triclopyr	-	-	0.15	-	-	-
Downstream Big Ditch						
2, 4-D	0.12	0.15	0.21	0.25	0.29	0.17
Atrazine	-	0.18	0.20	0.24	0.20	-
Bentazon	-	-	-	-	-	0.12
Bromacil	-	0.15	-	0.18	-	-
Carbofuran	-	0.17	0.16	0.18	0.20	-
Chlorpropham	0.27	0.29	0.25	0.16	0.23	0.22
Dicamba I	-	0.17	0.25	0.20	0.19	-
Dichlobenil	0.16	0.22	0.27	0.26	0.34	0.17
Diuron	0.27	0.34	0.30	0.26	0.38	0.35
Eptam	-	-	-	-	-	-
Imidacloprid	-	-	0.21	0.23	0.20	0.23
MCPA	0.15	0.25	0.26	0.17	0.23	0.15
Mecoprop (MCPP)	-	0.17	0.17	0.16	0.15	0.09
Metalaxyl	-0.15	-	-	-	-	-
Metolachlor	-	0.28	0.30	0.23	0.25	0.14
Pentachlorophenol	-	-	-	-	-	-
Triclopyr	-	0.18	0.22	0.24	0.25	-

Table J-4. Tau coefficients for environmental factors and commonly detected pesticides in Browns Slough, 2006-2011.

Pesticide	Flow	Day of sampling precipitation (24 hr)	Day of sampling and previous day's precipitation (48 hr)	Previous 24-hour precipitation	Previous 48-hour precipitation	TSS
2,4-D	-	-	-	-	-	-
Bentazon	0.38	0.19	0.20	0.18	0.27	-0.17
DCPA	0.42	0.27	0.29	0.25	0.37	-
Dichlobenil	-	--	-	-	-	-
Diuron	0.38	0.14	0.14	0.15	0.22	-
Eptam	0.16	-	-	-	-	-
Metolachlor	0.16	0.16	0.22	0.16	0.15	-
Simazine	0.28	0.16	-	-	0.20	-

Table J-5. Tau coefficients for environmental factors and commonly detected pesticides in Indian Slough, 2006-2011.

Pesticide	Flow	Day of sampling precipitation (24 hr)	Day of sampling and previous day's precipitation (48 hr)	Previous 24-hour precipitation	Previous 48-hour precipitation	TSS
2,4-D	-	-	-	0.18	0.27	-
Bentazon	-	-	-	-	-0.09	-
Bromacil	0.25	0.24	0.29	0.28	0.31	0.21
Dicamba I	-	-	-	-	-	-
Dichlobenil	0.21	0.27	0.30	0.31	0.38	0.21
Diphenamid	-	-	-	0.08	0.05	0.06
Diuron	0.26	0.21	0.24	0.25	0.34	-
Hexazinone	0.21	0.14	0.16	-	-	0.14
Metolachlor	0.19	0.17	0.20	0.24	0.26	0.13
Pentachlorophenol	-	-	-	-	-	-
Tebuthiuron	-0.16	-	-0.15	-	-0.18	-0.14
Triclopyr	-	-	0.14	0.13	0.25	-

Table J-6. Tau coefficients for environmental factors and commonly detected pesticides in Spring Creek (upstream and downstream), 2003-2011.

Analyte	Flow	Day of sampling precipitation (24 hr)	Day of sampling and previous day's precipitation (48 hr)	Previous 24-hour precipitation	Previous 48-hour precipitation	TSS
Upstream Spring Creek						
2,4-D	0.19	0.15	0.15	0.17	0.17	0.24
Atrazine	-0.14	-	0.06	0.05	0.06	-0.23
Bentazon	-0.29	-	0.11	0.11	-	-0.35
Bromacil	-	-	-	-	-	-
Carbaryl	-	-	-	-	-	-
Chlorpyrifos	-	-	-	-	-	-
Diazinon	-	-	-	-	-	-
Dicamba I	-	-	-	-	-	-
Imidacloprid	-	-	-	-	-	-
Norflurazon	-	-	-	-	-	-
Oryzalin	0.23	-	-	-	0.32	-
Pendimethalin	-	-	-	-	-	-
Pentachlorophenol	-	0.05	-	-	-	-
Simazine	-	-	-	-	-	-
Downstream Spring Creek						
2,4-D	0.16	0.13	0.11	0.06	0.03	0.09
Atrazine	-0.23	0.04		-0.05		-0.14
Azinphos-methyl	-	-	-	0.15	-	-
Bentazon	-	-	-	-	-	-0.11
Bromacil	-	-	-	-	-	-0.10
Carbaryl	-	-	-	-	-	-
Chlorpyrifos	-	-	-	0.17	0.19	-
Diazinon	-	-	-	-	-	-
Dicamba I	-	-	-	-	-	-
Dichlobenil	-	-	-	-	-	-
Diuron	-	-	0.14	0.22	0.20	0.09
Imidacloprid	-	-	-	-	-	-
MCPA	-	0.13	0.11	0.12	0.09	-
Norflurazon	-	-	-	-	-	-
Pendimethalin	-	-	-	-	-	-
Simazine	-0.09	-	-	0.17	0.17	-

Table J-7. Tau coefficients for environmental factors and commonly detected pesticides in Marion Drain, 2003-2011.

Pesticide	Flow	Day of sampling precipitation (24 hr)	Day of sampling and previous day's precipitation (48 hr)	Previous 24-hour precipitation	Previous 48-hour precipitation	TSS
2,4-D	-0.05	-	0.08	0.08	0.04	-0.05
Atrazine	-0.07	-	0.10	0.12	0.12	-
Bentazon	-0.42	-	-0.13	-	-	-0.39
Bromacil	0.10	-	-	-	-	0.09
Chlorpyrifos		-	-	-	-	-
Dicamba I	0.04	-	-	-	-	-
Diuron	0.08	-	-	-	-	-
Ethoprop		-	-	-	-	-
Imidacloprid		-	-	-	-	-
Malathion		-	-	-	-	-
MCPA		-	0.09	0.12	0.12	-
Metolachlor		-	-	-	-	-
Pendimethalin	0.11	-	-	-	-	0.22
Simazine		-	-	0.08	-	-
Terbacil	-0.19	-	-	-	-	-0.17
Trifluralin		-	0.09	0.09	-	-

Table J-8. Tau coefficients for environmental factors and commonly detected pesticides in Sulphur Creek Wasteway, 2003-2011.

Pesticide	Flow	Day of sampling precipitation (24 hr)	Day of sampling and previous day's precipitation (48 hr)	Previous 24-hour precipitation	Previous 48-hour precipitation	TSS
2,4-D	0.05	0.07	0.09	-	0.03	-0.06
Atrazine	-	-	-	0.07	0.13	-
Azinphos-methyl	-	-	-	-	-	-
Bentazon	-0.11	-	-	-	-	-0.09
Bromacil	-	0.12	-	-		-0.14
Carbaryl	-	-	-	-	-	-
Chlorpyrifos	-	-	-	-	0.14	0.19
DCPA	-0.09	-	-	-	-	-0.09
Dicamba I	0.04	-	0.04	-	0.07	0.04
Dichlobenil	-	-	-	-	-	-
Diuron	-	0.17	0.21	0.23	0.20	0.19
Hexazinone	-	-	-	-	-	-
Imidacloprid	-	-	-	-	-	-
MCPA	-	-	-	-	0.10	-
Norflurazon	-	-	-	-	-	-
Terbacil	-	-	-	-	-	-
Trifluralin	-	-	-	-	-	-

Table J-9. Tau coefficients for environmental factors and commonly detected pesticides in Brender Creek, 2007-2011.

Pesticide	Flow	Day of sampling precipitation (24 hr)	Day of sampling and previous day's precipitation (48 hr)	Previous 24-hour precipitation	Previous 48-hour precipitation	TSS
4,4'-DDD	0.10	-	-	-	-	0.10
4,4'-DDE	0.41	0.13	0.14	0.13	0.26	0.49
4,4'-DDT	0.30	0.13	0.11	0.10	0.12	0.30
Total DDT	0.42	-	-	-	-	0.48
Chlorpyrifos	-	-	-	-	-	-
Dichlobenil	-	-	-	-	-	-
Endo I	-	-	-	-	-	-
Endo II	-	-	-	0.19	-	-
Endosulfan Sulfate	0.24	0.22	0.23	0.22	0.25	0.16
Norflurazon	-	-	-	-	-	-

Appendix K. Continuous Temperature Profiles

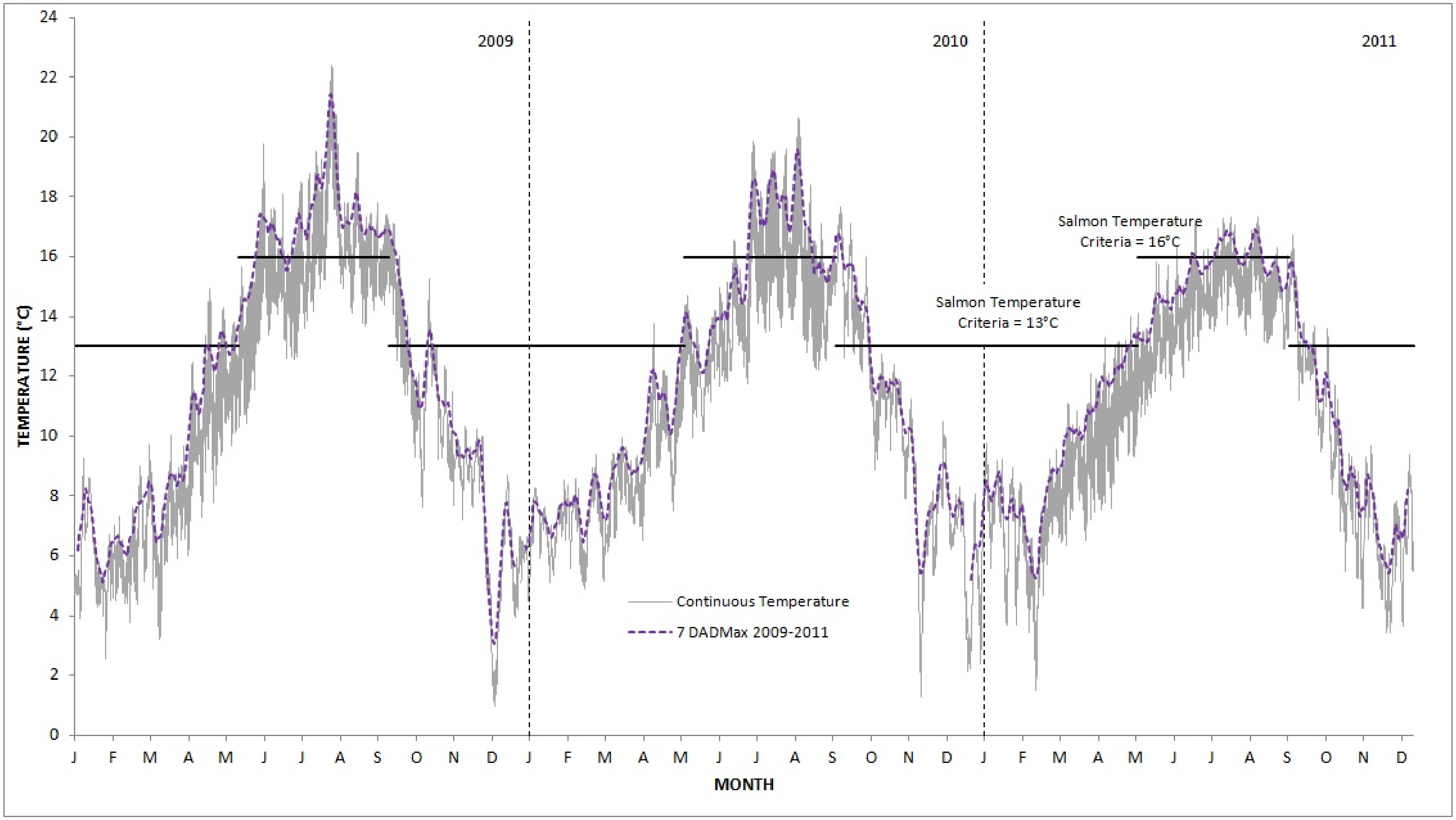


Figure K-1. Continuous temperature profile for downstream Thornton Creek, 2009-2011.

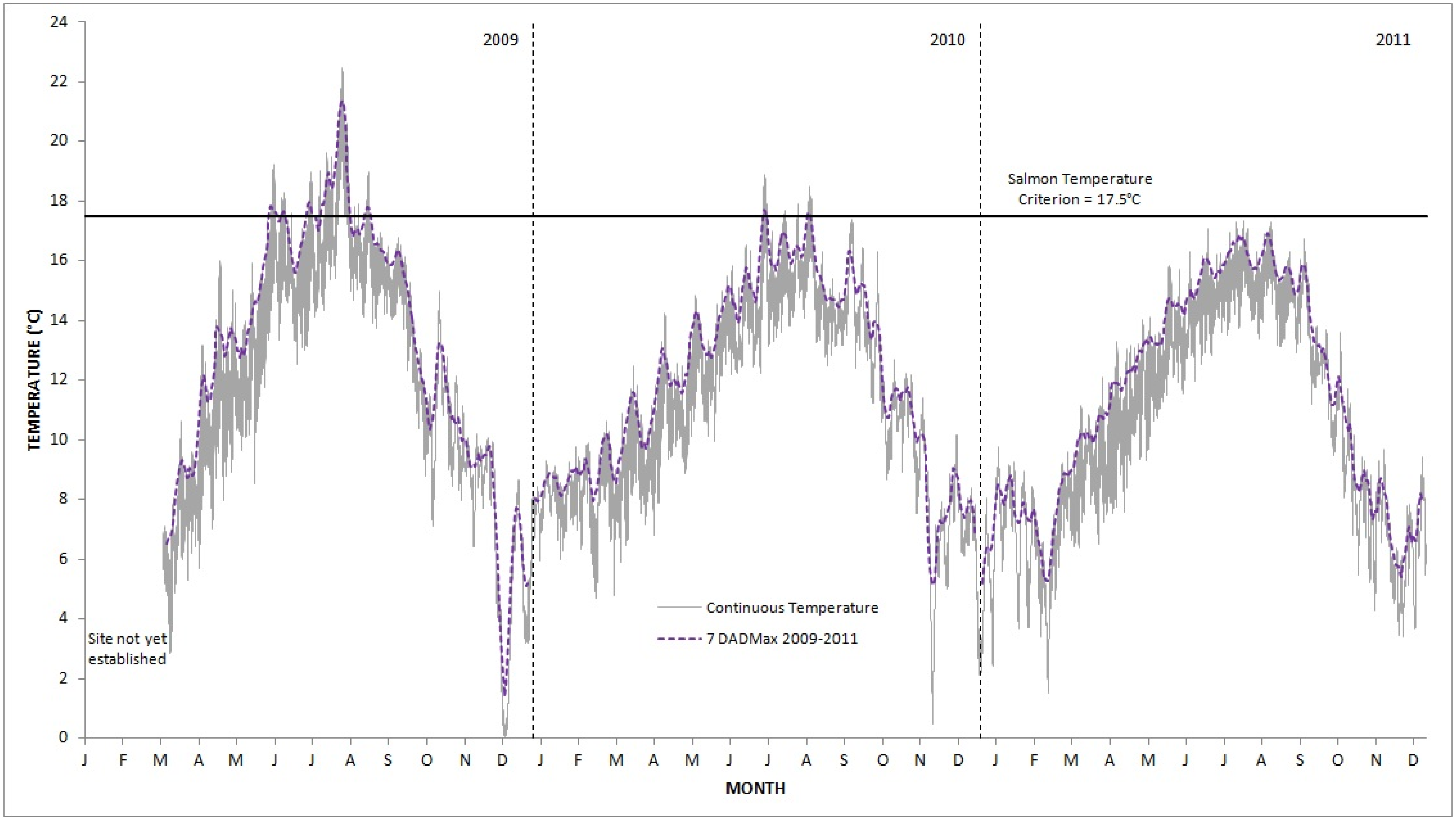


Figure K-2. Continuous temperature profile for Longfellow Creek, 2009-2011.

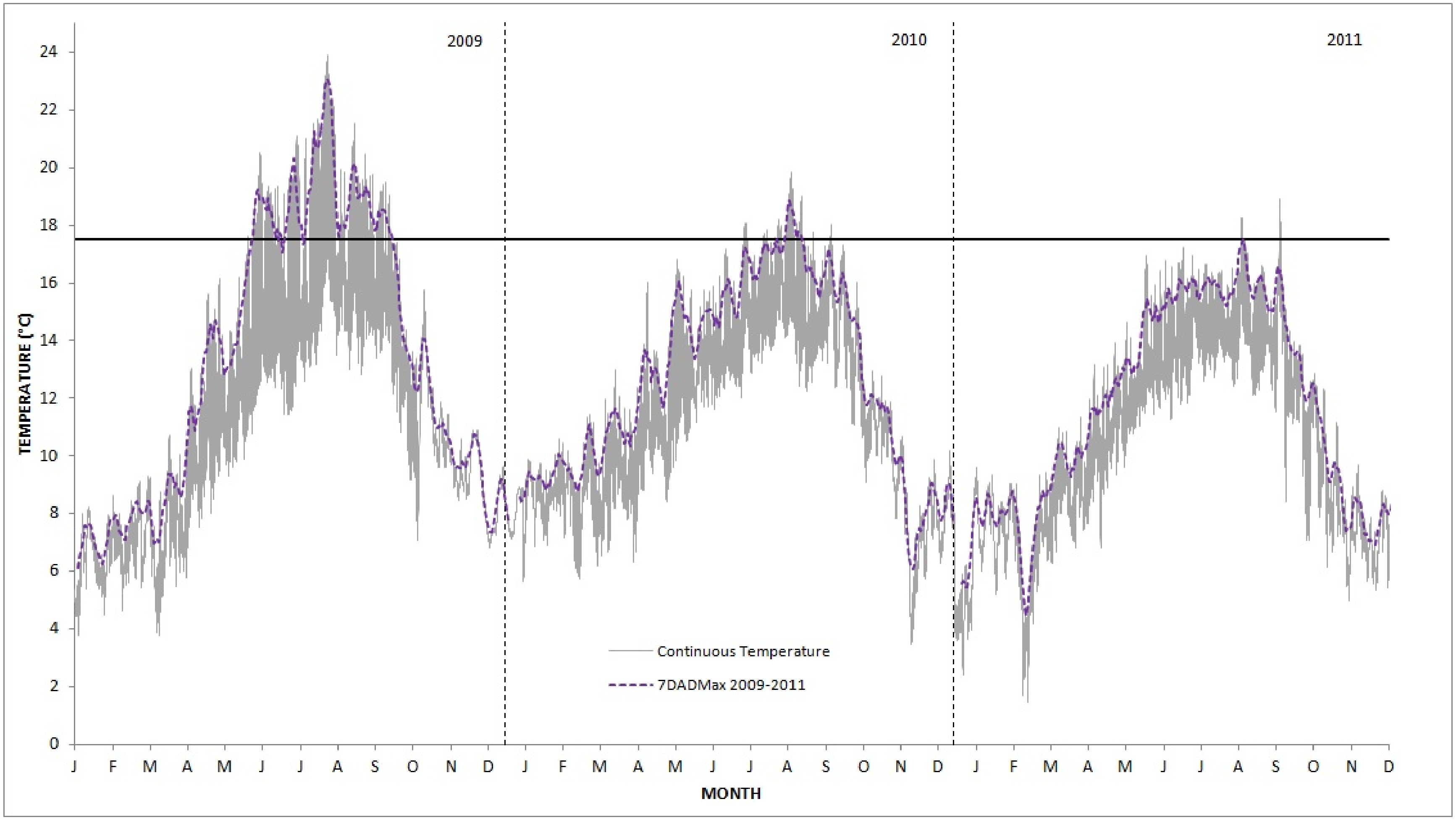


Figure K-3. Continuous temperature profile for upstream Big Ditch, 2009-2011.

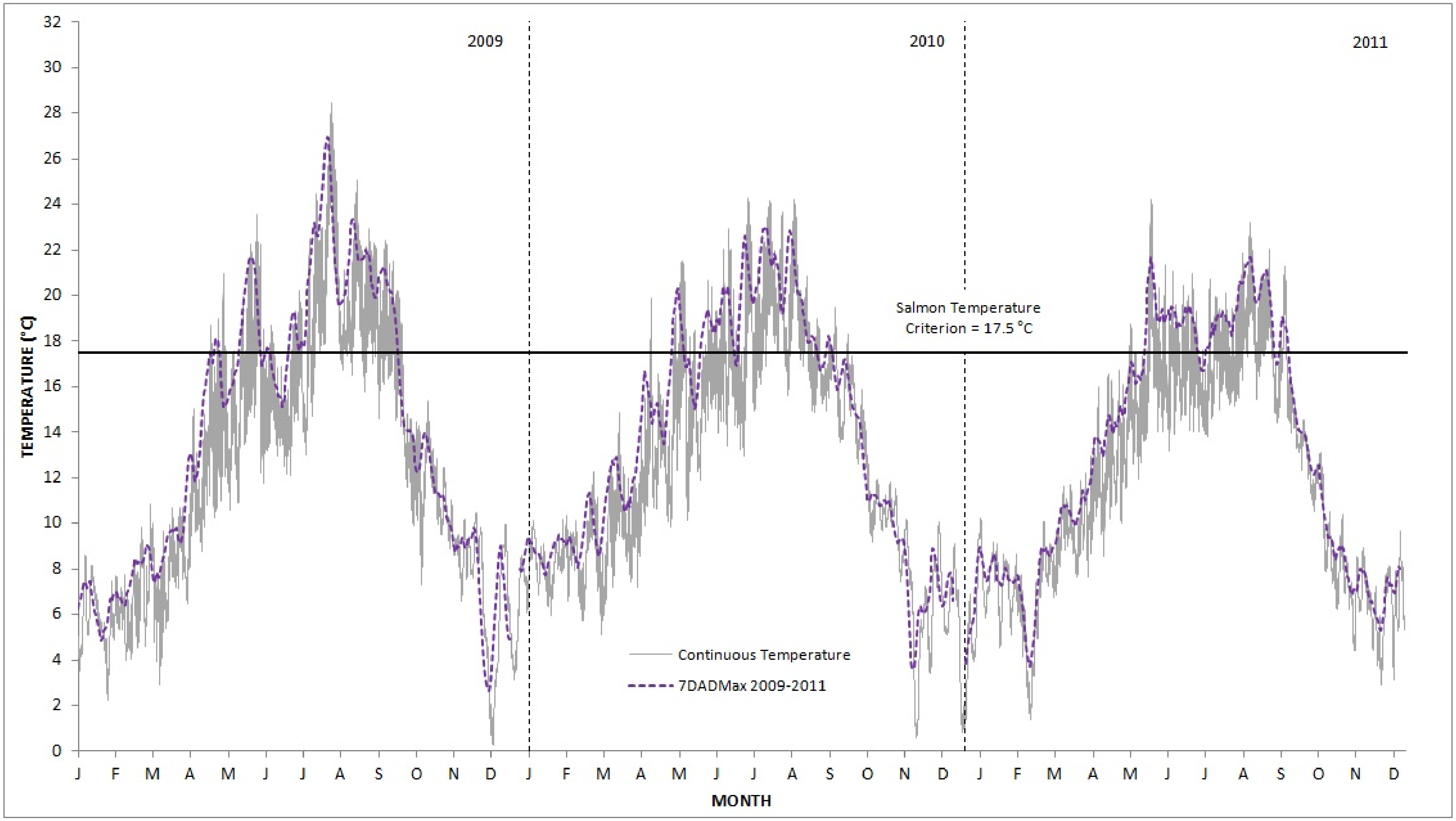


Figure K-4. Continuous temperature profile for downstream Big Ditch, 2009-2011.

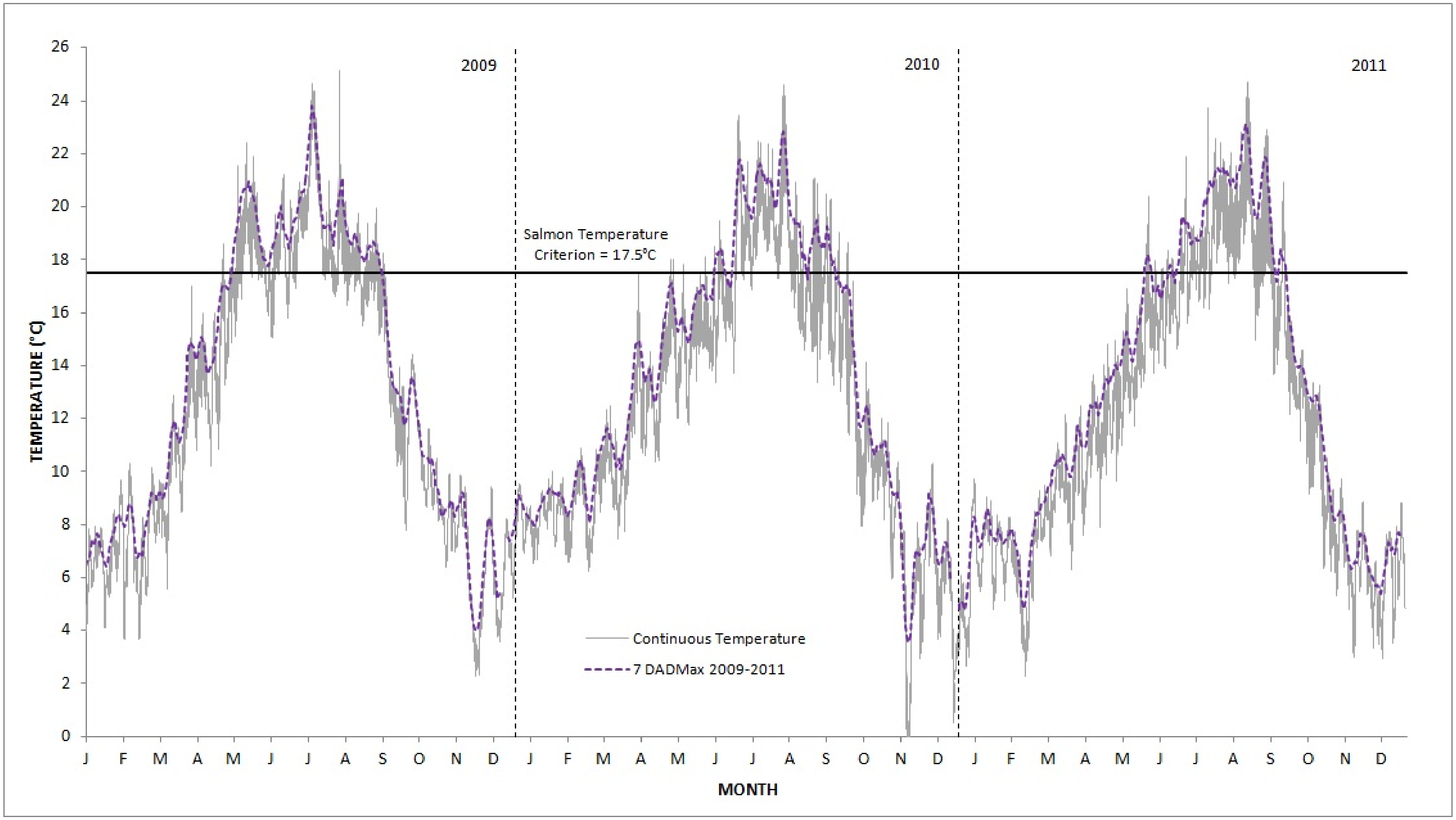


Figure K-5. Continuous temperature profile for Indian Slough, 2009-2011.

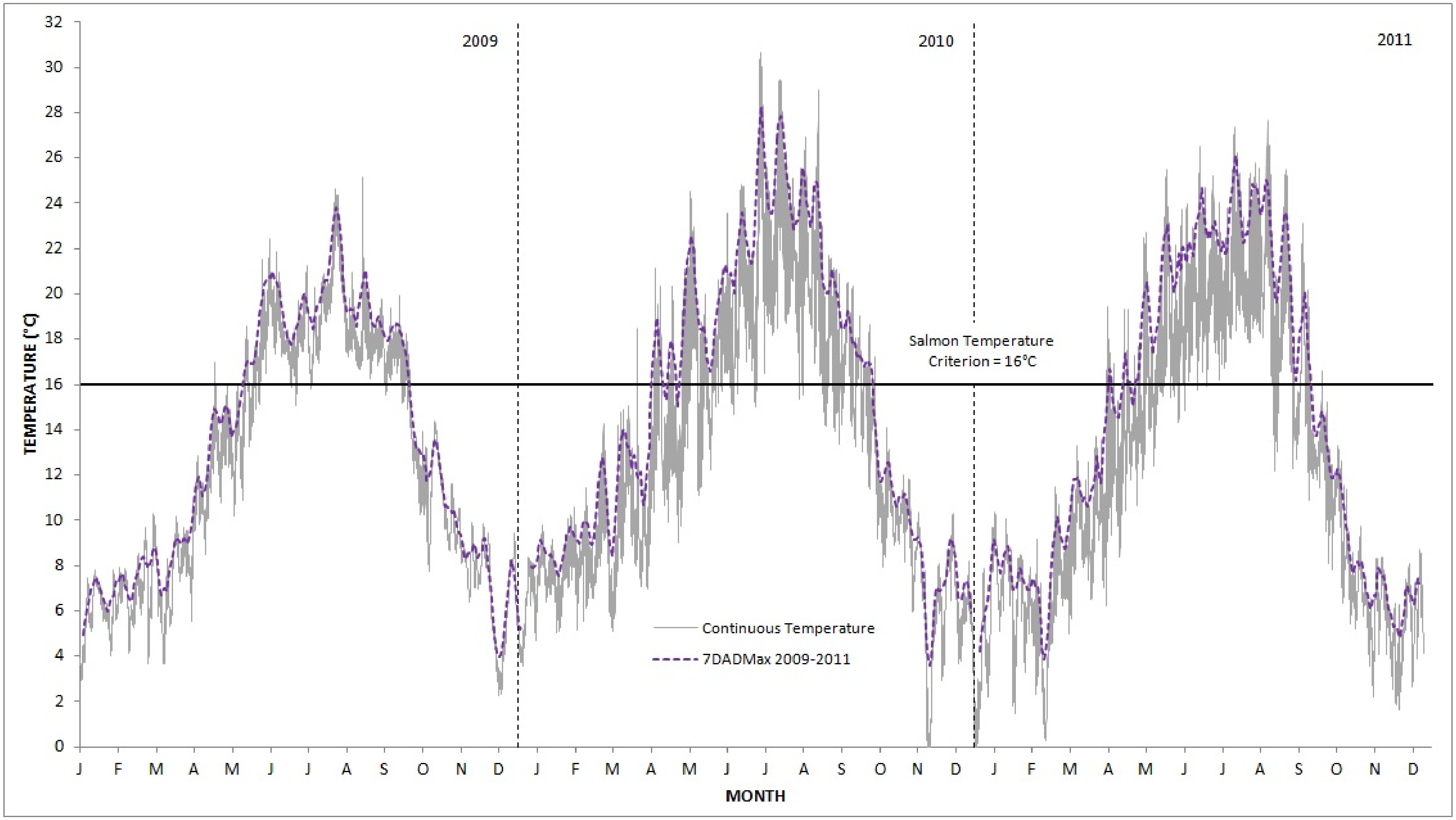


Figure K-6. Continuous temperature profile for Brown Slough, 2009-2011.

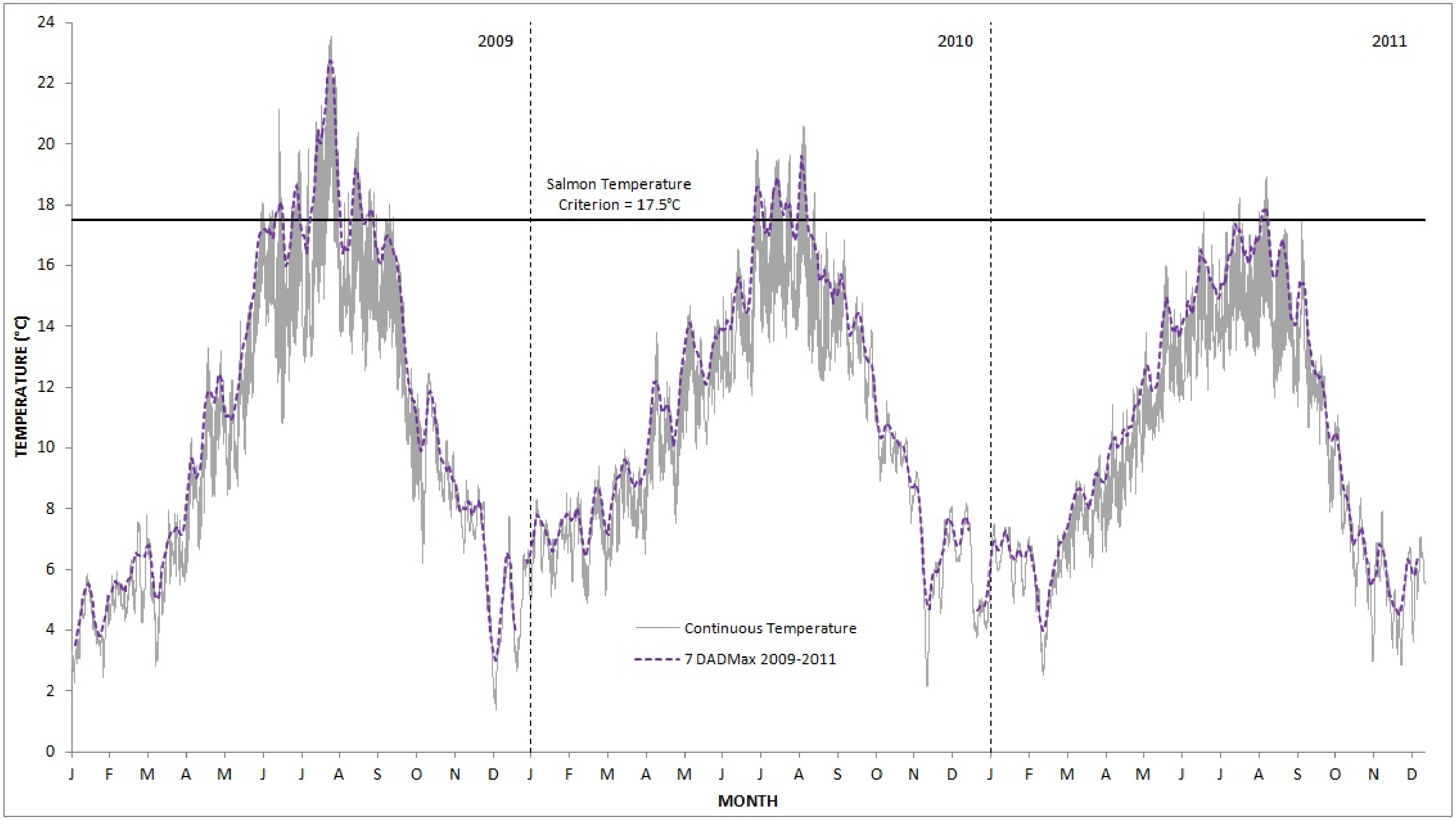


Figure K-7. Continuous temperature profile for the Samish River, 2009-2011.

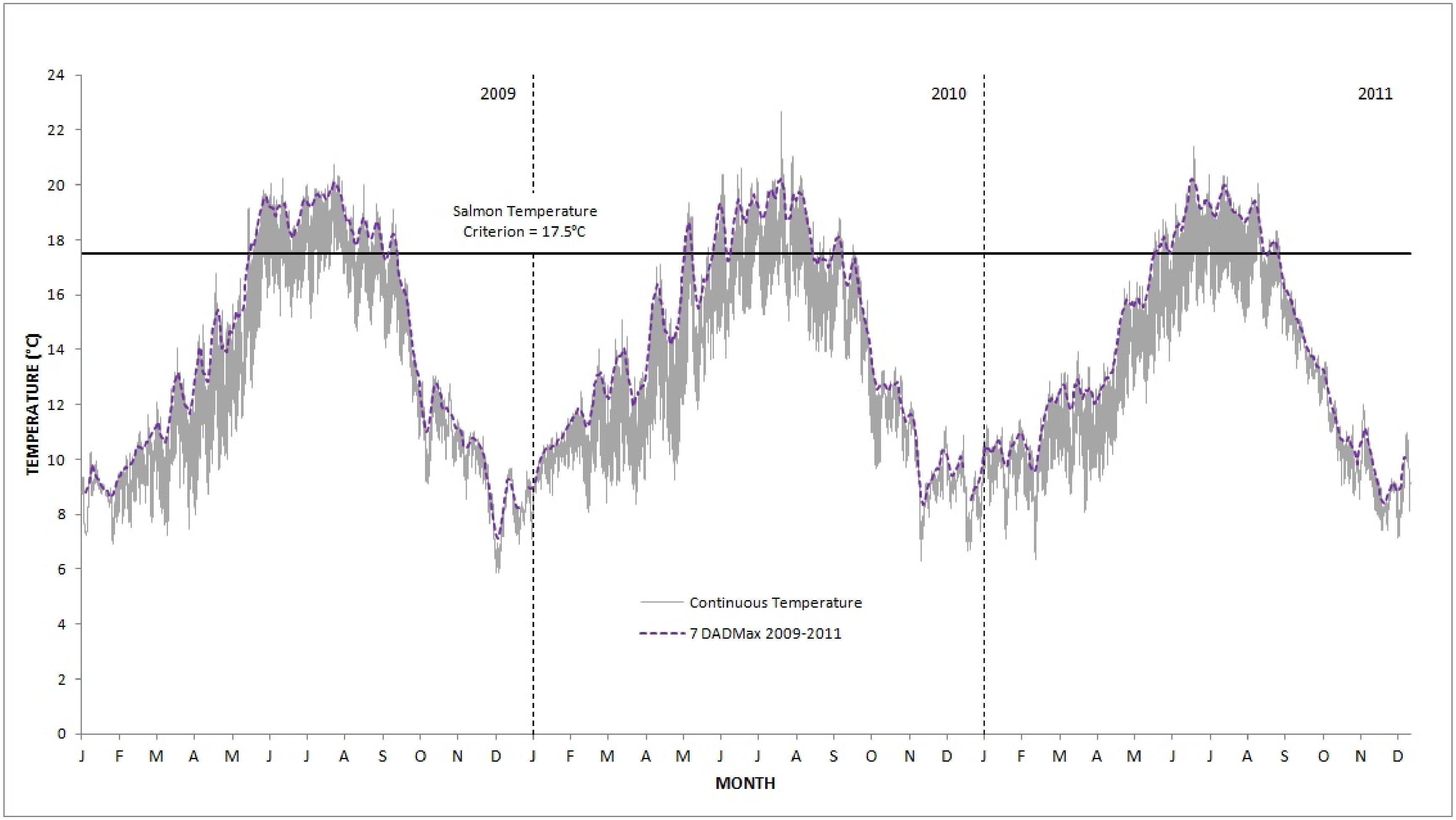


Figure K-8. Continuous temperature profile for upper Spring Creek, 2009-2011.

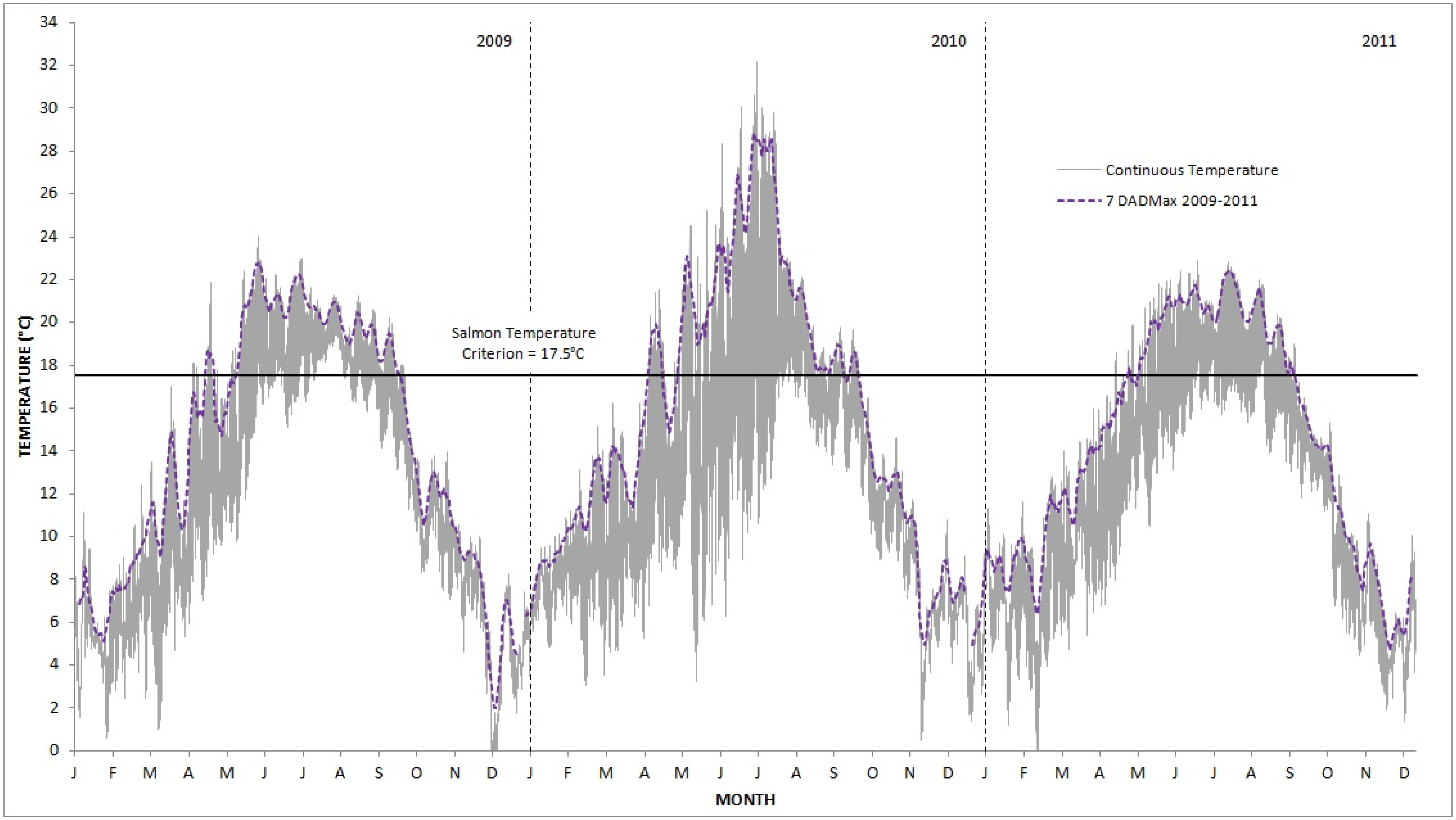


Figure K-9. Continuous temperature profile for downstream Spring Creek, 2009-2011.

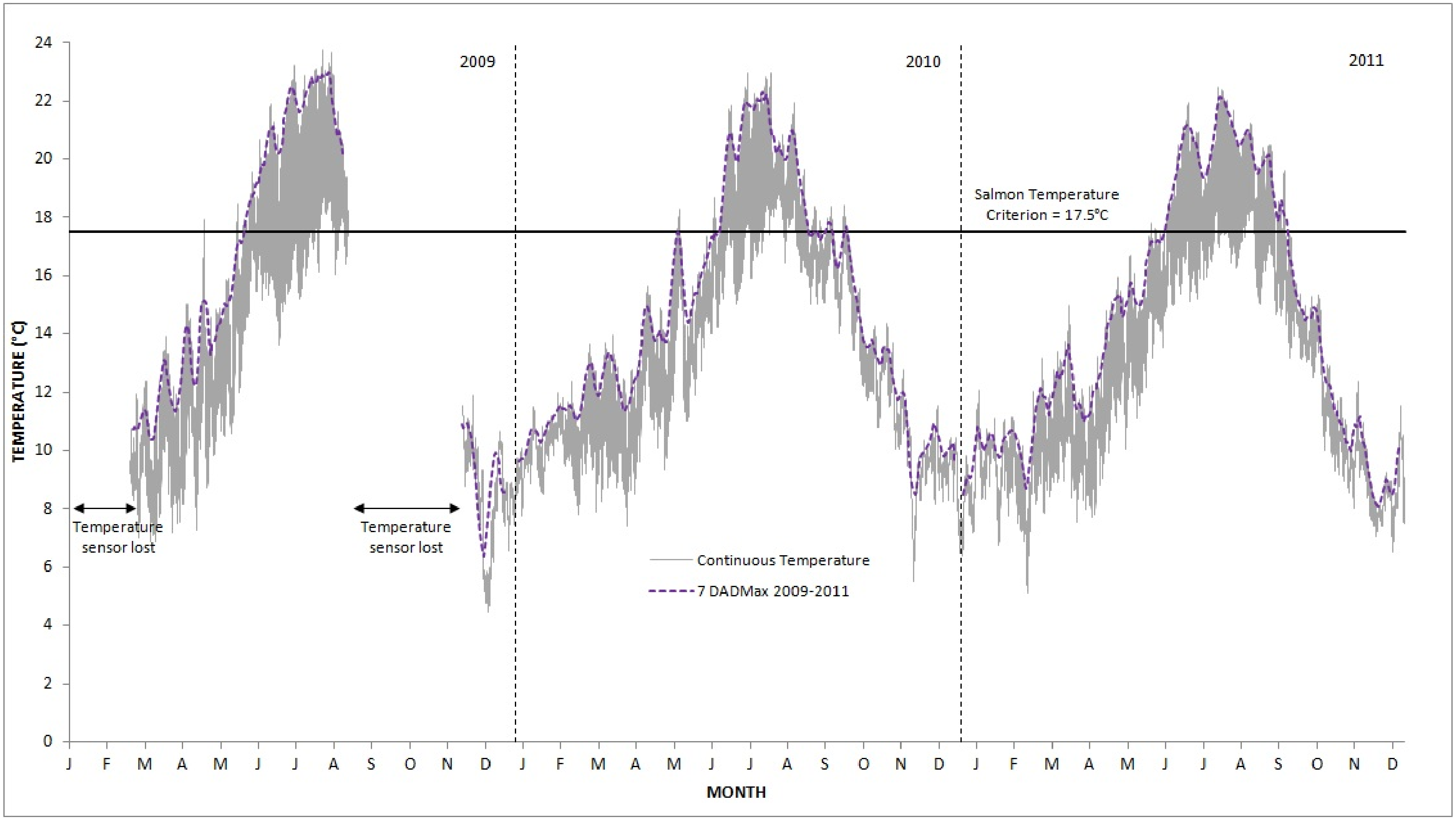


Figure K-10. Continuous temperature profile for Marion Drain, 2009-2011.

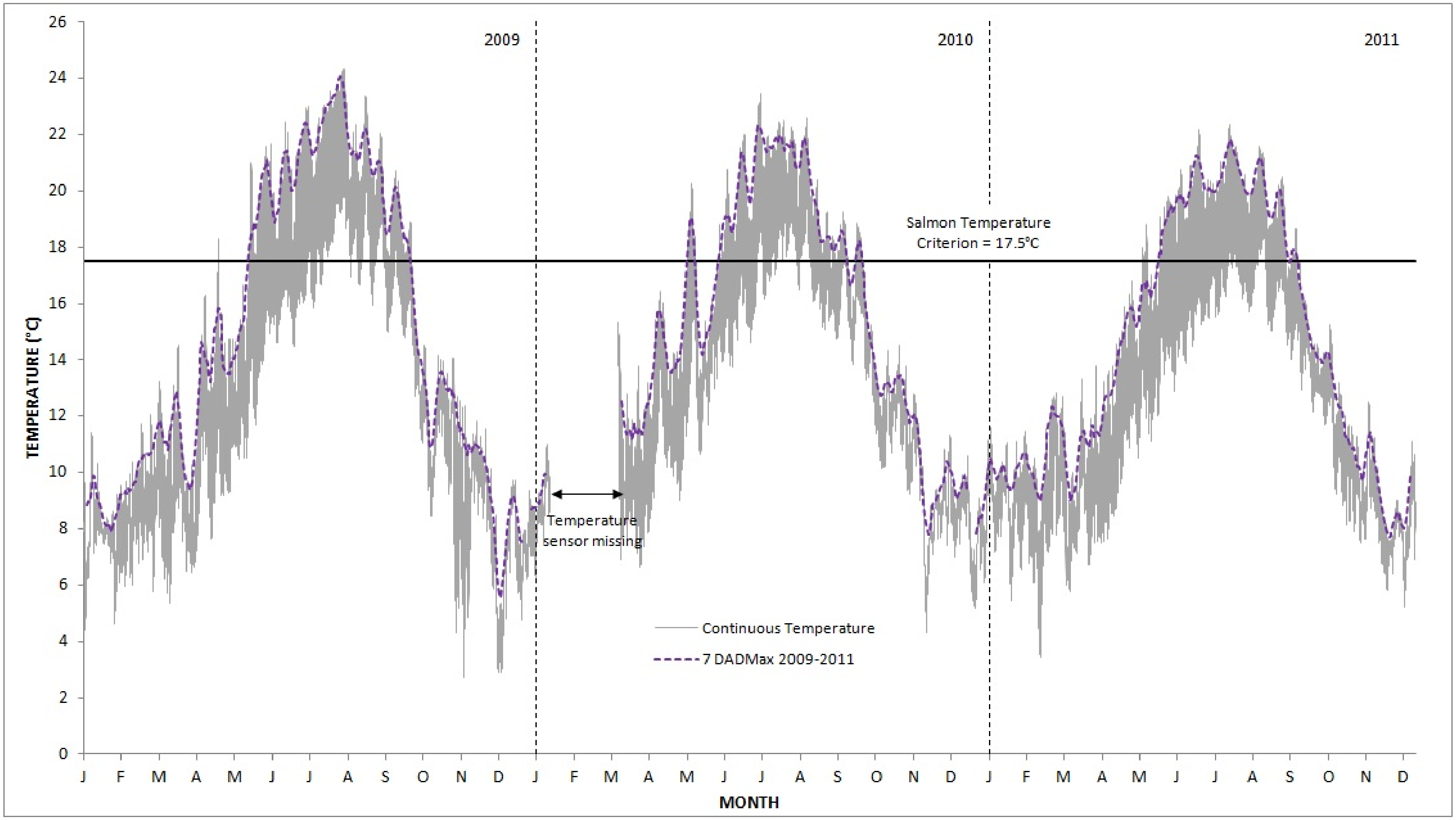


Figure K-11. Continuous temperature profile for Sulphur Creek Wasteway, 2009-2011.

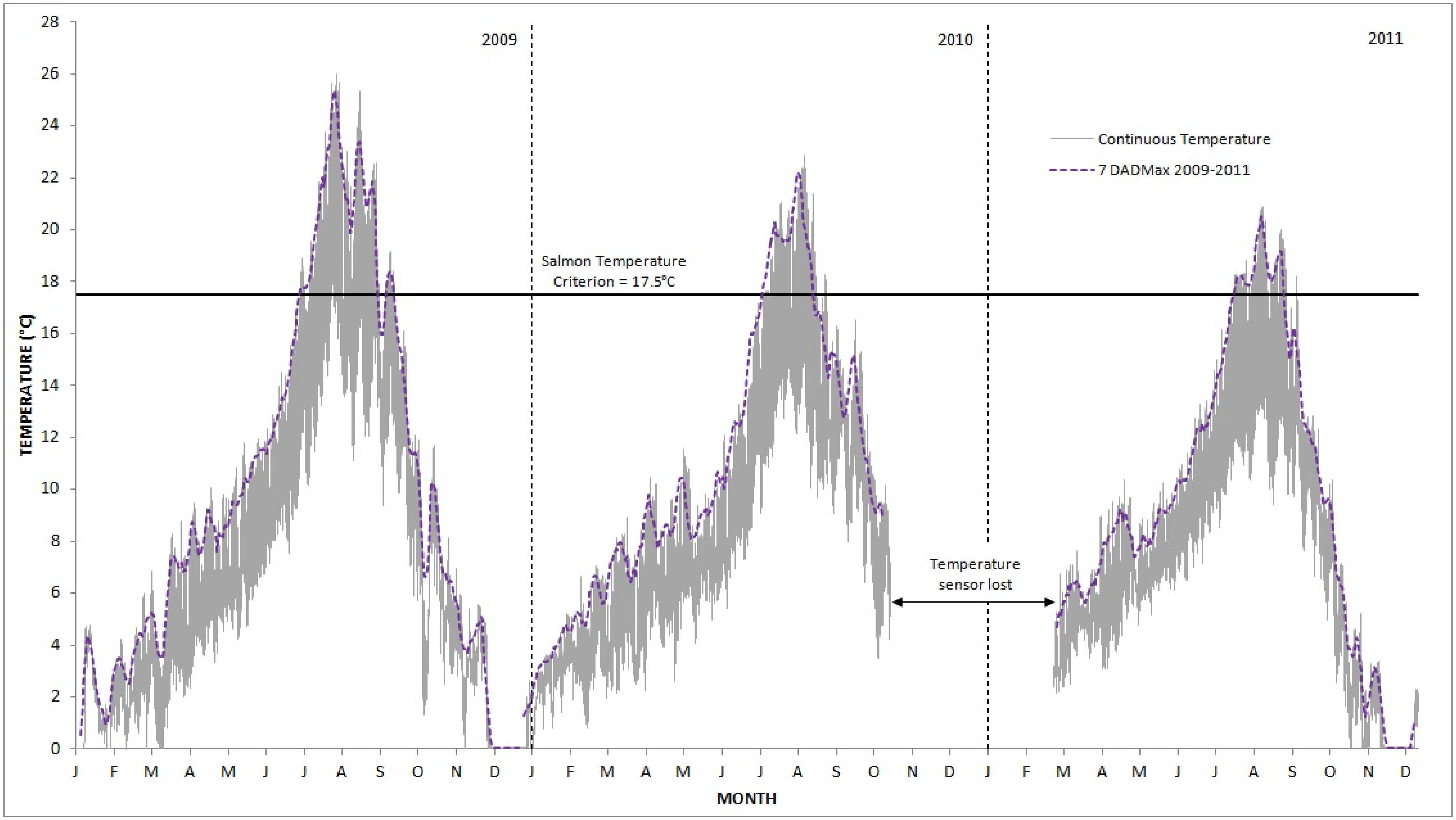


Figure K-12. Continuous temperature profile for Peshastin Creek, 2009-2011.

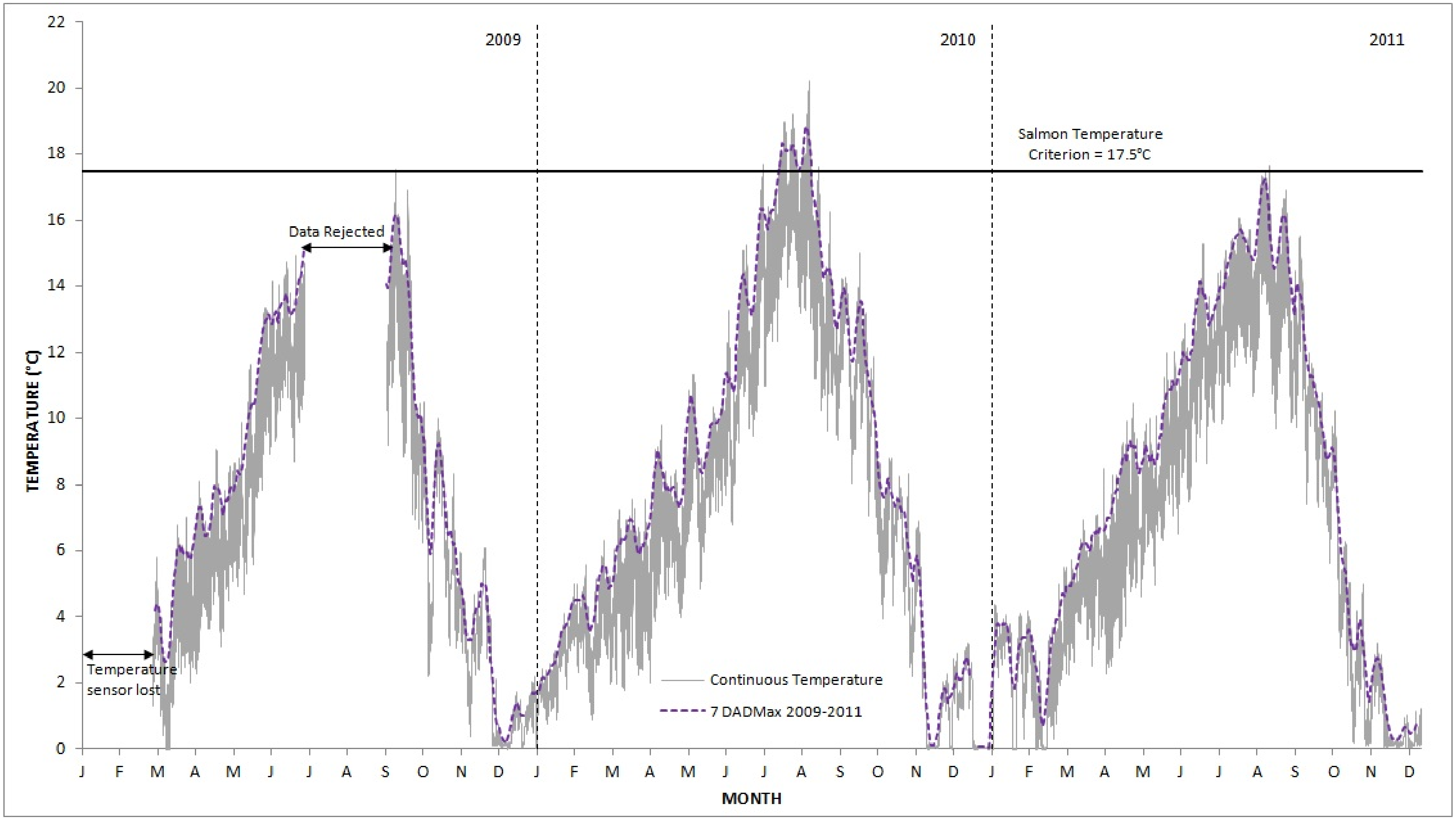


Figure K-13. Continuous temperature profile for Mission Creek, 2009-2011.

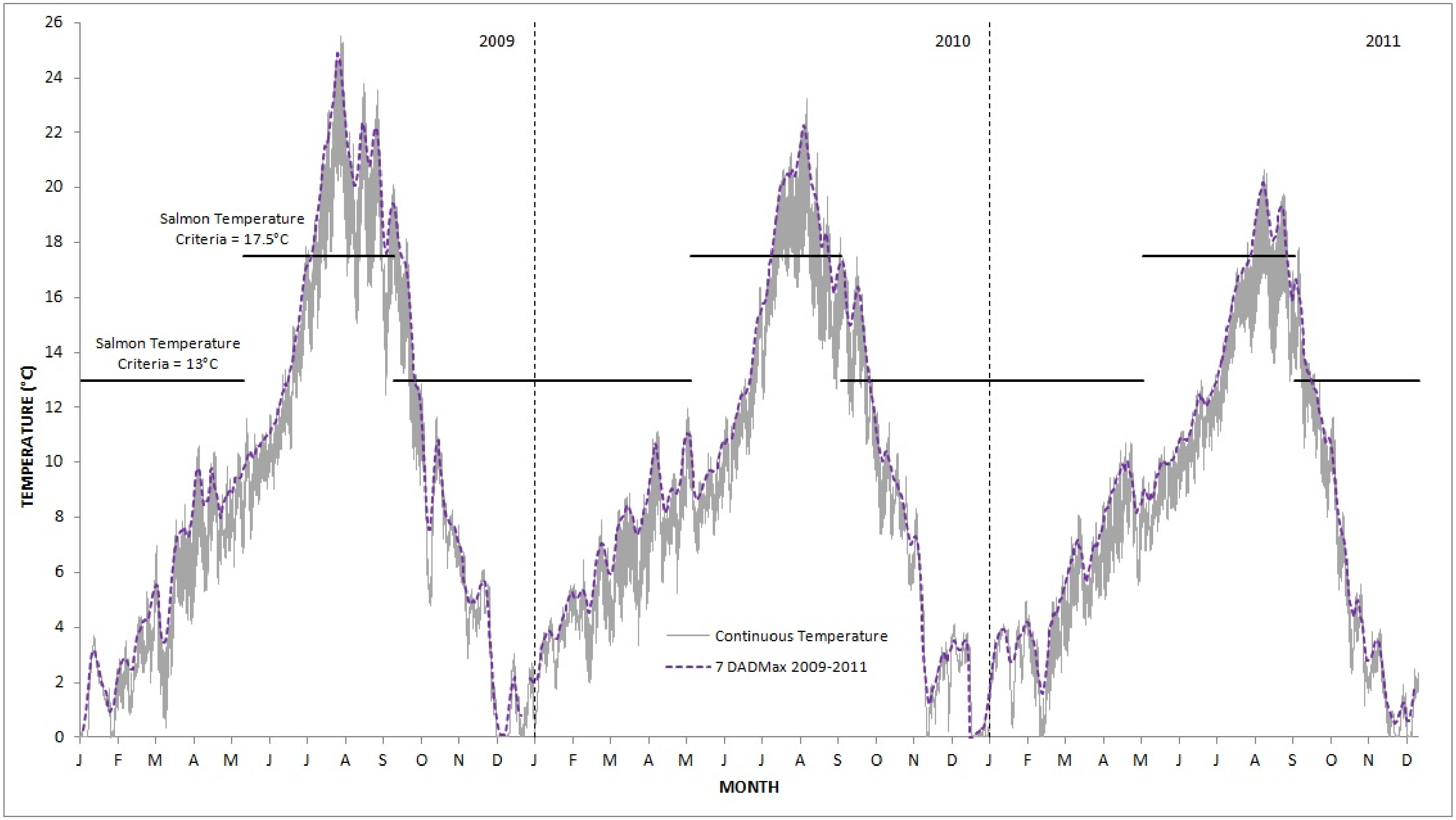


Figure K-14. Continuous temperature profile for the Wenatchee River, 2009-2011.

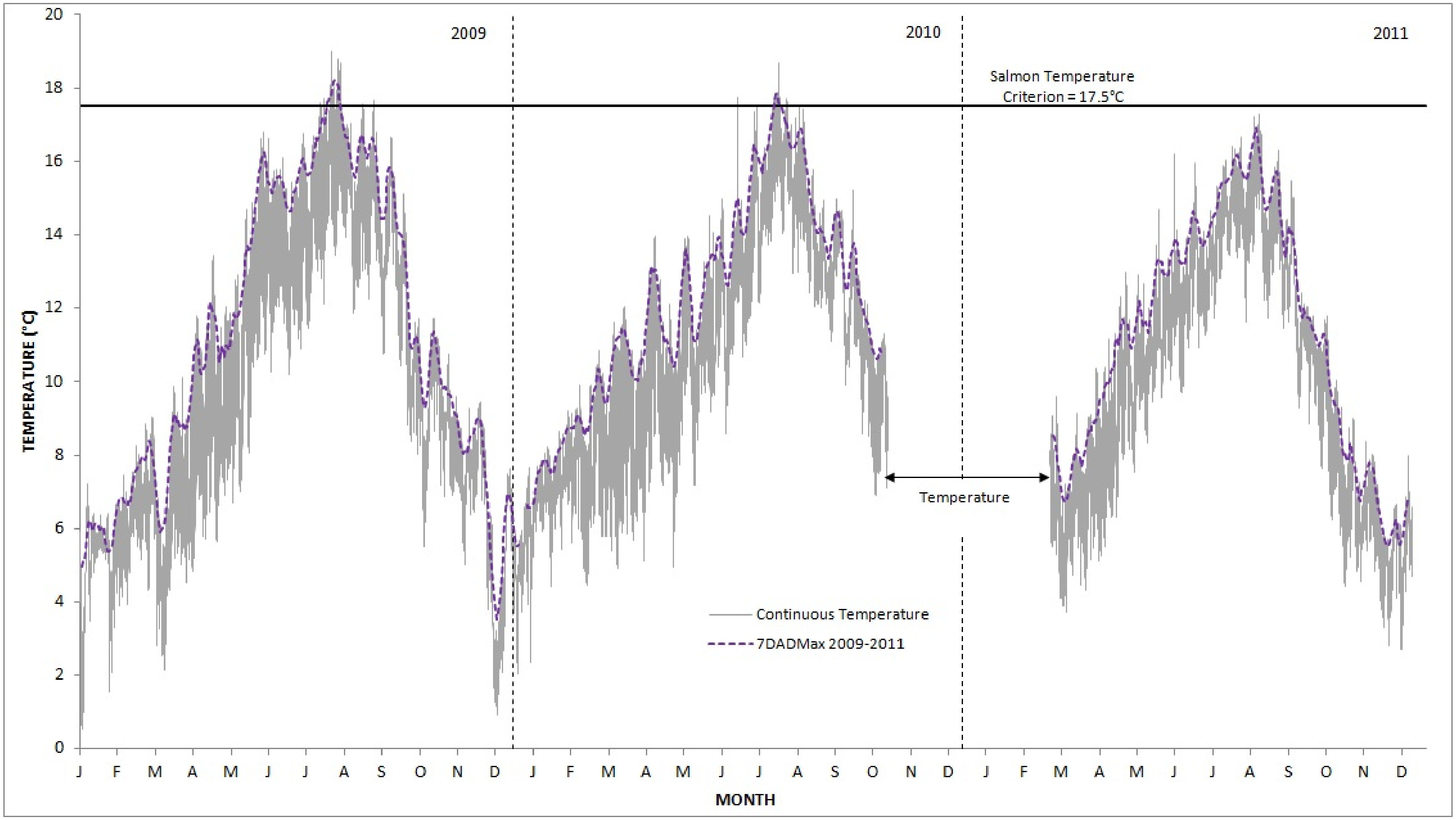


Figure K-15. Continuous temperature profile for Brender Creek, 2009-2011.

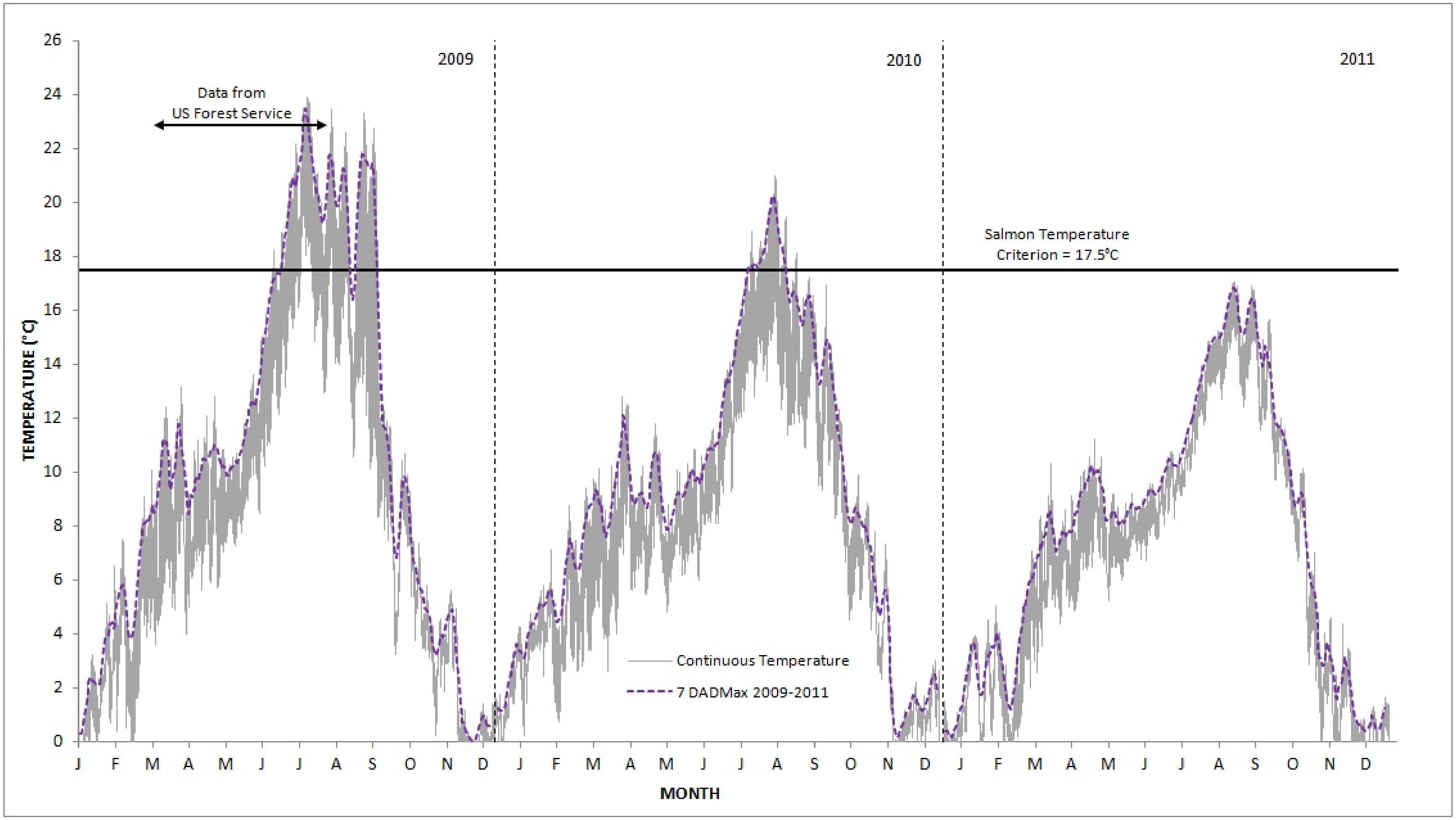


Figure K-16. Continuous temperature profile for the Entiat River, 2009-2011.