Surface Water Pesticide Monitoring and Assessment Project

North Dakota Department of Agriculture
Pesticide Water Quality Program

2008

ND Dept of Agriculture
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Acknowledgements

The Department thanks Mike Ell from the North Dakota Department of Health for his assistance in coordinating the sampling events. Sampling was performed by Fred Ryckman from the North Dakota Game and Fish Department, and Heather Duchscherer and Mike Hargiss from the North Dakota Department of Health.

The Department also thanks the Water Quality Advisory Committee for its input and advice. The Committee consists of the following state and federal agencies:

ND Department of Health
ND Department of Parks and Recreation
ND Game and Fish Department
ND Geological Survey
ND State University Extension Service
ND State Water Commission
US Department of Agriculture-NRCS
US Fish and Wildlife Service
US Geological Survey

Summary

The North Dakota Department of Agriculture, working in cooperation with the North Dakota Department of Health's Division of Water Quality, coordinated a surface water monitoring survey in 2008 for pesticides and pesticide degradates. Nine sample sites in three different watersheds (Sheyenne, Souris, and Yellowstone Rivers) in North Dakota were sampled and tested for over 184 different pesticides every three weeks from April through October. A total of nine pesticides and one pesticide degradate were detected. The most commonly detected pesticides were the herbicides 2,4-D and diuron. For all but one pesticide, concentrations were below levels deemed harmful by the U.S. Environmental Protection Agency (EPA). Diuron was found in the Souris River at concentrations that could be harmful to aquatic life. The study supports the need for regular, comprehensive monitoring of surface water for pesticides to verify 2008 results, assess risks to human health and the environment, and identify trends.

Introduction

Through the authority provided in Chapters 4-35, 4-35.1, and 19-18 of the North Dakota Century Code, the North Dakota Department of Agriculture (hereafter "Department") is the lead pesticide regulatory agency in the state. Under a cooperative agreement with the U.S. Environmental Protection Agency (EPA), the Department is charged with regulating pesticides in the public's interest to ensure that they do not pose a risk of unreasonable adverse effects to human health or the environment.

In the past, the Department's Pesticide Water Quality Program (hereafter "Program") was concerned only with those pesticides that posed a risk of contaminating groundwater. The Department has had a committee in place for over a decade to advise them on groundwater issues. Agencies represented on the committee include the ND Department of Health (NDDoH), US Department of Agriculture – Natural Resource Conservation Service, ND State University Extension Service, US Geological Survey, ND Geological Survey and the ND State Water Commission.

The EPA has recently identified surface water resources as a priority area of focus. Therefore, the Program's focus has expanded to protect both groundwater and surface water from pesticide contamination. To reflect this expansion, the Groundwater Working Committee has been renamed the Water Quality Advisory Committee (WQAC) and now includes representatives from the US Fish and Wildlife Service (US FWS), ND Game and Fish Department (NDGF), and ND Parks and Recreation.

Identifying pesticide and surface water issues is a priority for the Department and WQAC. Before the 2008 monitoring project, no agency routinely monitored for pesticides in North Dakota's surface waters. Therefore, we do not know what pesticides are present in surface water or at what concentrations. A comprehensive surface water monitoring program was necessary to assess the risk of pesticides to surface water, including risk to drinking water, recreational uses and aquatic ecosystems.

The WQAC identified three priority watersheds for monitoring in 2008. These are the Yellowstone River in the northwest, the Souris River (often referred to as the Mouse River) in the north-central region, and the Sheyenne River in the eastern part of the state (Figure 1). The committee chose watersheds in three regions because the state is generally divided into three main geographic regions.

In the western part of the state, the Yellowstone River was selected for sampling by the USFWS because of its importance as habitat for the endangered pallid sturgeon (*Scaphirhynchus albus)*. The Yellowstone River was also selected because it is an area with significant levels of in-furrow irrigation, and the effects of irrigation return flows on the water quality were uncertain. Two of the sampling sites on the Yellowstone River were chosen because of their proximity to suspected pallid sturgeon spawning habitat and return flows from an irrigation drain. The third sampling site was on the Montana/North Dakota to assess the quality of incoming water from Montana (Figure 2). The Souris River was chosen for the central part of the state because the other major watershed, the James was tested during a 2005 surface water monitoring pilot project and had no pesticide detections. The Souris River was chosen to not only represent surface water in the central part of North Dakota, but since it is largely downstream from the city of Minot, to assess the potential for pesticides in surface water downstream from urban areas. The Sheyenne was chosen to represent the eastern third of the state because it is situated in a high intensity agricultural area and does not receive flow from Minnesota.

Table 1. Sampling locations with latitude and longitude information

Site ID	Sampling Site	Location	Latitude	Longitute
SHR-1	Sheyenne River at Horace	within the city of Horace	46.76059	-96.9092
SHR-2	Sheyenne River near Cooperstown	4.5 Mi E Of Cooperstown	47.43292	-98.02784
SHR-3	Sheyenne River at Lisbon	1.5 Mi S, 0.5 Mi E Of Lisbon	46.40567	-97.67297
SR-1	Souris River E of Bantry	8 Mi E Of Bantry	48.50602	-100.4346
SR-2	Souris River near Sawyer	1 Mi N Of Hwy 52 On Co Line	48.08934	-101.0149
SR-3	Souris River at Verendrye	1 Mi W Of Verendrye	48.12481	-100.74933
YR-1	Yellowstone River at ND/MT line	at river mile 15 on ND/MT border	47.80801	-104.0431
YR-2	Yellowstone River at river mile 7.3	at river mile 7.3 return flow outlet	47.88258	-103.9621
YR-3	Yellowstone River at river mile 5.5	at river mile 5.5 mid river	47.90332	-103.9547

Figure 1. Sampling locations for the 2008 pesticide monitoring study

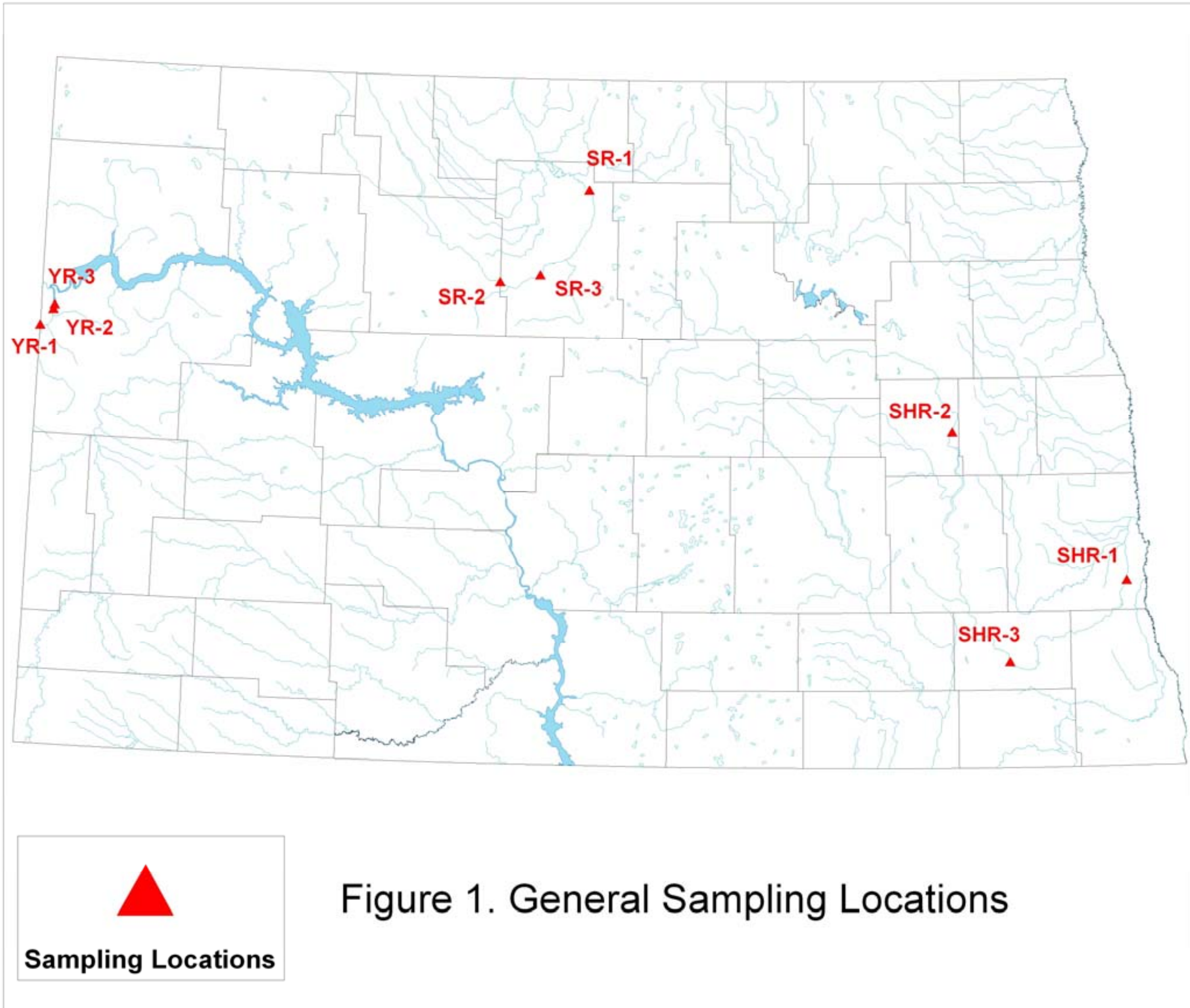


Figure 2. Sampling locations on the Yellowstone River

Previous surface water monitoring efforts have shown pesticide detections at low concentrations. A pilot monitoring project between the Department and the NDDoH was conducted in 2006. Eleven sites were sampled twice from late June through August and tested for 63 different pesticides. Results showed one detection of picloram at a concentration of 0.23 parts per billion (ppb), which is below any level of concern.

Project goals

The goals of the 2008 monitoring study were to:

- determine the occurrence and concentration of pesticides in rivers;
- determine whether any pesticides may be present at concentrations that could adversely affect human health, aquatic life, or fish-eating wildlife; and
- determine the frequency of sampling needed to assess contamination, thereby helping to refine future pesticide monitoring design .

The Department will also use the monitoring data as part of its cooperative agreement with the EPA. Under that agreement, the Department has committed to evaluate national and local pesticides of interest that may pose a risk to water quality. Furthermore, the Department is required to demonstrate that any risks are appropriately managed.

In addition, the Department administers an Endangered Species Protection Program that is focused on ensuring that pesticides do not negatively impact threatened and endangered species in North Dakota. Since most of the seven listed species in the state are found in or near surface water, the Department will also use the results of the monitoring study to identify pesticides that may pose a risk to threatened and endangered species.

Project Organization and Responsibilities

The surface water monitoring project was a cooperative effort among the Department, the NDDoH, and the NDGF. Overall project coordination was the responsibility of Jessica Orr, Environmental Scientist for the Department. Mike Ell, Program Manager for the NDDoH's Surface Water Quality Management Program, was responsible for sampling procedures and training. All field sampling activities and tasks, including water quality sampling, were the responsibility of the NDGF on the Yellowstone River and the NDDoH on the Sheyenne River and Souris River.

Materials and Methods

Pesticide samples and associated field measurements were collected at three sites in each of the three watersheds, Sheyenne River, Souris River, and Yellowstone River, every three weeks during the 2008 growing season. Samples were collected during the weeks of April 21st, May 12th , June 2nd, June 23rd, July 14th, August 4th, August 25th, Sept 15th, Oct 6th and Oct 27th . Locations of the sampling sites can be found in Table 1 and Figures 1 and 2.

Dissolved oxygen, temperature, pH, and specific conductivity were measured at the time of sampling with a YSI Model 650 MDS (Multiparameter Display System) / Data Logger combined with a YSI Model 600XL 6 sensor sonde. Results were recorded in the field on a field log form.

Grab samples were collected for pesticide analysis. Samples from the Souris and Sheyenne Rivers were collected in the main current at a depth of approximately 60 percent of the total water depth below the surface. This depth was chose for sample collection as it is assumed to be representative of the entire stream.

At the start of the season when there was greater water depth, a 1.2-L Teflon Kemmerer sampling device was used to collect samples. This was done by lowering the Kemmerer sampling device from a bridge or crossing. The device was lowered into the stream and the sampler tripped at 60 percent of the total stream depth.

Later in the season when water depths were lower, grab samples were collected by wading into the stream. Samples from the Yellowstone River were all near surface samples, collected either via shore access to a rock jetty for the ND/MT border site or by boat for the other two sites.

All of the near surface samples were collected by inserting a sample upside down into the water flow approximately a foot below the surface. The container was then placed upright and faced into the current, allowing it to fill naturally. Care was taken so that the sample was not contaminated by disturbing the stream bed upstream from the collection point. When the sample was collected by wading, the stream was entered slightly down current from the sampling site then the sampler waded to the area with the greatest current. The lid was placed on the sample bottle then submerged to approximately 60 percent of the stream depth, the lid was removed and the bottle was allowed to fill facing towards the current. The lid was replaced prior to removing bottle from stream.

Samples were dispensed into two 500-mL amber glass jars with Teflon-coated lids. Sample bottles were provided by the lab and did not need to be rinsed.

Appropriate labels were placed on the sample bottles. Custody reports and sample logs were immediately completed after sample collection (Appendix A). The samples were carefully packed with bubble wrap and rubber mesh and put into a cooler with ice and more packing materials shortly after collection. There were no problems with sample bottles breaking or leaking during shipping or handling. Coolers with the samples and ice inside were shipped to the laboratory using a next-day shipping service. The samples were usually shipped within a few hours of collection, a small number of times samples were kept in a fridge overnight and shipped the next day.

Selected field samples were collected in replicate to provide estimates of sample variability. The replicates consisted of two separate sets of samples collected one after another. Replicate samples were submitted blind to the laboratory.

Samples were analyzed for 184 different pesticides and degradates (Appendix B) by Pacific Agricultural Laboratory (Portland, OR) using the EPA standard methods. Methods employed for analysis can be found in Table 2.

Table 2. Description of analytical methods used by Pacific Agricultural Labs.

Pesticide Class	Method Description
Organochlorine pesticides	Modified EPA method 608 (GC-ECD)
Organophosphorous pesticides	Modified EPA method 614 (GC-FPD)
Organonitrogen pesticides	Modified EPA method 625 (GC-MS)
Chlorinated pesticides	Modified EPA method 8321A (HPLC-MS)
Imidazolinone herbicides	Am. Cyanamid method (HPLC-MS)
Miscellaneous pesticides	Modified EPA method 8321A (HPLC-MS)

Results and Discussion

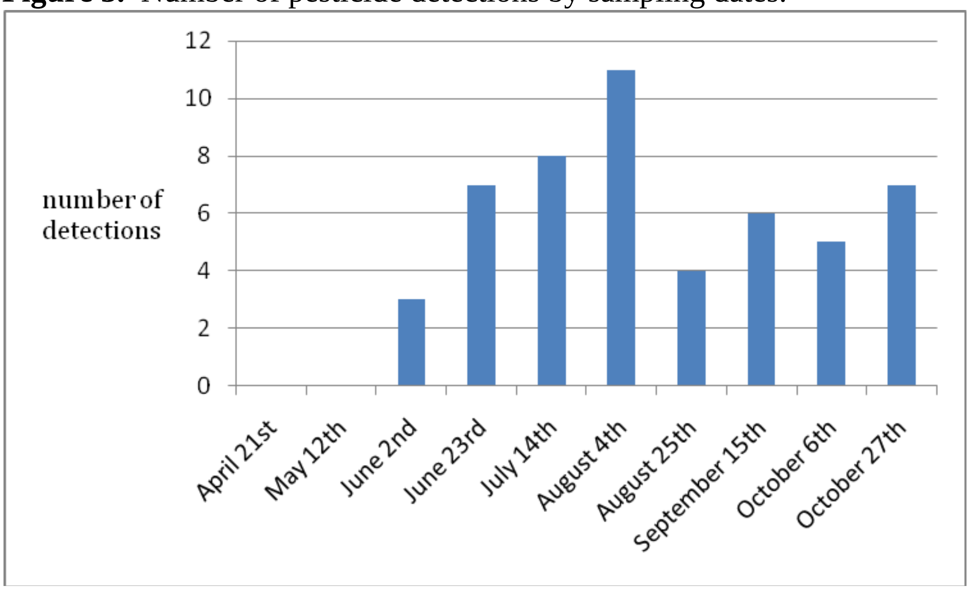
Over 74% of the surface water samples had no detectable pesticide concentrations. There were 51 detections of ten different pesticides (Table 4). However, most concentrations were less than 1 ppb.

Table 4. Pesticides detected in the 2008 surface water monitoring project.

Pesticide	Trade name	# of detects	Maximum concentration	EPA benchmark
2,4-D	2,4-D	13	0.35	299.2
Atrazine	Aatrex	1	0.48	17.5
Bentazon	Basagran	1	0.014	4500
Clopyralid	Stinger, Curtail	5	0.17	N/A
DCPMU	Diuron degradate	9	0.92	N/A
Dicamba	Banvel	4	0.49	61
Dichlorprop	Weedone, Strike	1	0.14	N/A
Diuron	Direx, Karmex	14	4.2	2.4
Imazapyr	Stalker	2	0.056	N/A
Triclopyr	Garlon	1	0.11	100

No pesticides were detected in any of the nine sampling sites on the first two dates, April 21st and May 12th (Figure 3). Detections began in June and peaked at the beginning of August. Pesticides were still being detected when sampling ended at the end of October.

Figure 3. Number of pesticide detections by sampling dates.



The Yellowstone River was the least contaminated watershed, with 93% of the samples having no pesticide detections. Ninety percent of the samples taken from the Sheyenne River had no pesticide detections. The Souris River had the most pesticide detections with 60% of the samples having some level of pesticides detected.

Risk of pesticides to human health or the environment is a function of both toxicity and exposure. The EPA has established Maximum Contaminant Levels (MCLs) for pesticides in drinking water based on risk to human health. The EPA has also established aquatic life benchmarks based on risk of pesticides to aquatic ecosystems (Appendix C). To assess risk and establish aquatic life benchmarks, the EPA relies on studies required under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), as well as a wide range of environmental laboratory and field studies available in the public scientific literature. Aquatic life benchmarks, which are based on the most sensitive toxicity endpoint for a given taxa (e.g., freshwater fish), are estimates of the concentrations below which pesticides are not expected to harm aquatic life. In most cases we were able to compare the concentration detected in surface water to the aquatic life benchmark, but not an MCL, because the EPA has not established MCLs for many pesticides.

The majority of 184 pesticides and degradates assayed in the study were not detected in any samples from any of the nine sampling sites. A total of nine pesticides were detected, all of which were herbicides. The pesticides found were: 2,4-D; atrazine; bentazon; clopyralid; dicamba; dichlorprop; diuron, imazapyr; and triclopyr. DCPMU, a degradate of diuron, was also detected. (Table 4 and Appendix B).

2,4-D was detected in 13 samples, with concentrations ranging from 0.086 to 0.35 ppb. The chemical was found in all three watersheds and was most commonly found in the Souris River. 2,4-D is a systemic herbicide used on wheat, barley, oats, flax, alfalfa, hay, CRP and pastures in North Dakota. 2,4-D is used on approximately 3 million acres in agriculture each year, either in stand-alone products or in mixtures (Zollinger, 2004). Many more acres are sprayed for lawns and other urban uses, however this amount is not known. The relatively large number of detections of 2,4-D is most likely a reflection of the fact that 2,4-D is used on such a large number of acres throughout the state.

The concentrations of 2,4-D found in North Dakota surface water are 200 times lower than the MCL of 70 ppb established for 2,4-D. The EPA's lowest aquatic benchmark for 2,4-D is 299.2 ppb, a level that may be harmful to aquatic plants. The highest 2,4-D concentration of 0.35 ppb was 854 times lower than this benchmark, indicating that while the chemical was found in a number of locations, the concentrations are well below the levels of concern.

Atrazine, a broadleaf herbicide used primarily on corn, is applied to approximately 185,500 acres in North Dakota each year (Zollinger, 2004). Atrazine was detected only once in 2008 on the Sheyenne River at Horace (SHR-1) in late June. The southeastern section of the state is the primary area for corn production, so it is not surprising that atrazine was only found in the Sheyenne River and not the other two watersheds.

Atrazine was detected in the sample at a concentration of 0.48 ppb. The EPA's lowest aquatic benchmark for atrazine is 17.5 ppb and is based on the risk of chronic toxicity to aquatic communities. The detected atrazine concentration of 0.48 ppb is 36 times lower than the lowest aquatic benchmark, suggesting minimal risk of the detected atrazine levels to aquatic species.

Atrazine has an MCL of 3 ppb, The concentration found on the Sheyenne is 6.25 times lower than the MCL, suggesting that the detected concentration posed minimal risk to drinking water.

Bentazon is used in North Dakota for wheat, barley, corn flax, sugarbeet, CRP and pastures. It is used on 569,000 acres alone in North Dakota. In addition, it is applied in a mixture with other pesticides on 628,000 acres (Zollinger, 2004).

Bentazon was detected in one sample collected on the Sheyenne River near Lisbon (SHR-3) at a concentration of 0.014 ppb. The EPA aquatic life benchmark concentration is 4,500 ppb for the most sensitive species, which is acute toxicity to non-vascular plants. The concentrations found during sampling were over 320,000 times less than the established benchmark, suggesting very minimal risk. There are no MCLs established for bentazon.

Clopyralid was detected in five samples, with the highest concentration of 0.17 ppb found in the Souris River at Sawyer (SR-2) in late October. Clopyralid was detected once in the Sheyenne River and four times in the Souris River. There is currently no established EPA aquatic life benchmark for clopyralid. However, another common measure of toxicity is the LC_{50} value, a measure of the concentration of a pollutant or effluent at which 50% of the test organisms die. LC_{50} values have been established for clopyralid on many different organisms. Water fleas, *Daphnia magna*, are one of the most sensitive species to clopyralid with an LC_{50} value over 100,000 ppb. The highest concentration found in surface water, 0.17 ppb, is 588,000 times less than the $LC_{50,}$ suggesting that the detected concentrations pose minimal risk to aquatic ecosystems.

Dicamba is most commonly used to manage broadleaf weeds in wheat, barley, oats, corn, dry beans, CRP, pasture and fallow lands in North Dakota. It is used on over 1.1 million acres as a stand-alone product and on 332,000 acres in mixtures in the state (Zollinger 2004).

There were four detections of dicamba with the highest concentration of 0.49 ppb. All dicamba detections were on the Souris River. The EPA aquatic life benchmark for the most sensitive species, acute non-vascular plants is 61 ppb. The concentration detected was 1,201 times less than the established benchmark for the most sensitive species, suggesting that detected levels of dicamba pose minimal risk. There are no MCLs for dicamba.

Dichlorprop was found once on the Souris River at a concentration of 0.14 ppb. There are no benchmarks for dichlorprop. The $LC_{50}$for the most sensitive species, blue-gill sunfish is 1.1 ppb. The concentrations found in the Souris were 7.85 times lower than the LC_{50}

Imazapyr was found twice in 2008, once on the Yellowstone River at river mile 7.3 (YR-2) and once on the Souris River near Sawyer (SR-2). The highest concentration of imazapyr was 0.056 ppb. There is no established EPA aquatic life benchmark for imazapyr. LC_{50} values for the most sensitive species, water flies (*Daphnia magna*), is 100,000 ppb. The concentrations found were 1.7 million times lower than the LC_{50} for water fleas, suggesting minimal risk to aquatic life.

There was one detection of triclopyr, in the Yellowstone River at a concentration of 0.11 ppb. The lowest EPA benchmark for triclopyr is 100 ppb established for acute non-vascular plants. The concentration of triclopyr found was 909 times less than the benchmark, suggesting a low risk to aquatic life.

Diuron was detected 14 times, with all detections from the Souris River. The highest diuron concentration found was 4.2 ppb in mid-July. DCPMU, a degradate of diuron, was detected in nine samples from the Souris River. The EPA aquatic life benchmark for diuron is 2.4 ppb for acute non-vascular plants, specifically green algae, *Selenastrum capricornutum*. The highest detected concentration of diuron was almost twice as high as this benchmark. Diuron concentrations did not exceed EPA benchmarks for other aquatic species. The second highest concentration of diuron was 1.7 ppb, which is 70% of the EPA benchmark.

Diuron concentrations were high enough to be of concern for the aquatic community. Therefore, additional investigation and mitigation are necessary. Investigation should include trying to determine if the high levels of diuron found are from regular use, misuse or an accident such as a spill. Department compliance personnel will work to determine if any unusual activity has occurred that relates to diuron usage. Diuron is used on rights of way and as a soil sterilant, so there is a defined list of users. Department staff will also work to try to quantify the amount of diuron used in the Souris River watershed and the predominate use patterns in the area.

If the high levels of diuron in the Souris River are a result of normal use patterns, possible mitigations measures need to be considered by the Department and the WQAC. Mitigation measures could include increased use inspections focused on diuron, increased user education and compliance assistance, and voluntary or non-voluntary use restrictions. Use restrictions could include mandatory use buffer distances from water, designating diuron products as restricted use pesticides to limit their use to certified applicators, reducing use rates or number of allowed applications, or product cancellations.

The results of the 2008 monitoring study show more detections compared to one of the few studies in the area, a 2006 pilot study conducted by the Department and NDDoH. The pilot study looked at some of the same areas of the state as the 2008 study including the Sheyenne River in two spots, the Souris River West of Verendrye as well as areas of the state not monitored in 2008 including the James, Little Missouri, Cannonball, Heart, Goose and Red rivers. The pilot study showed only one pesticide detection of picloram at 0.23 ppb. This concentration was far below levels of concern. Picloram was included in the 2008 monitoring study, but none was found. More pesticides and degradates were found in the 2008 monitoring most likely because the study was for a longer duration, tested for more pesticides, and at lower detection limits.

Several years of sampling would help us to characterize pesticide concentrations in surface water during the typical pesticide use season. Right now, low or no detections of certain pesticides cannot be deemed as normal levels. One year of sampling would not be enough to show regulatory agencies that a pesticide is or is not of concern, nor do they indicate that we are not concerned about these chemicals.

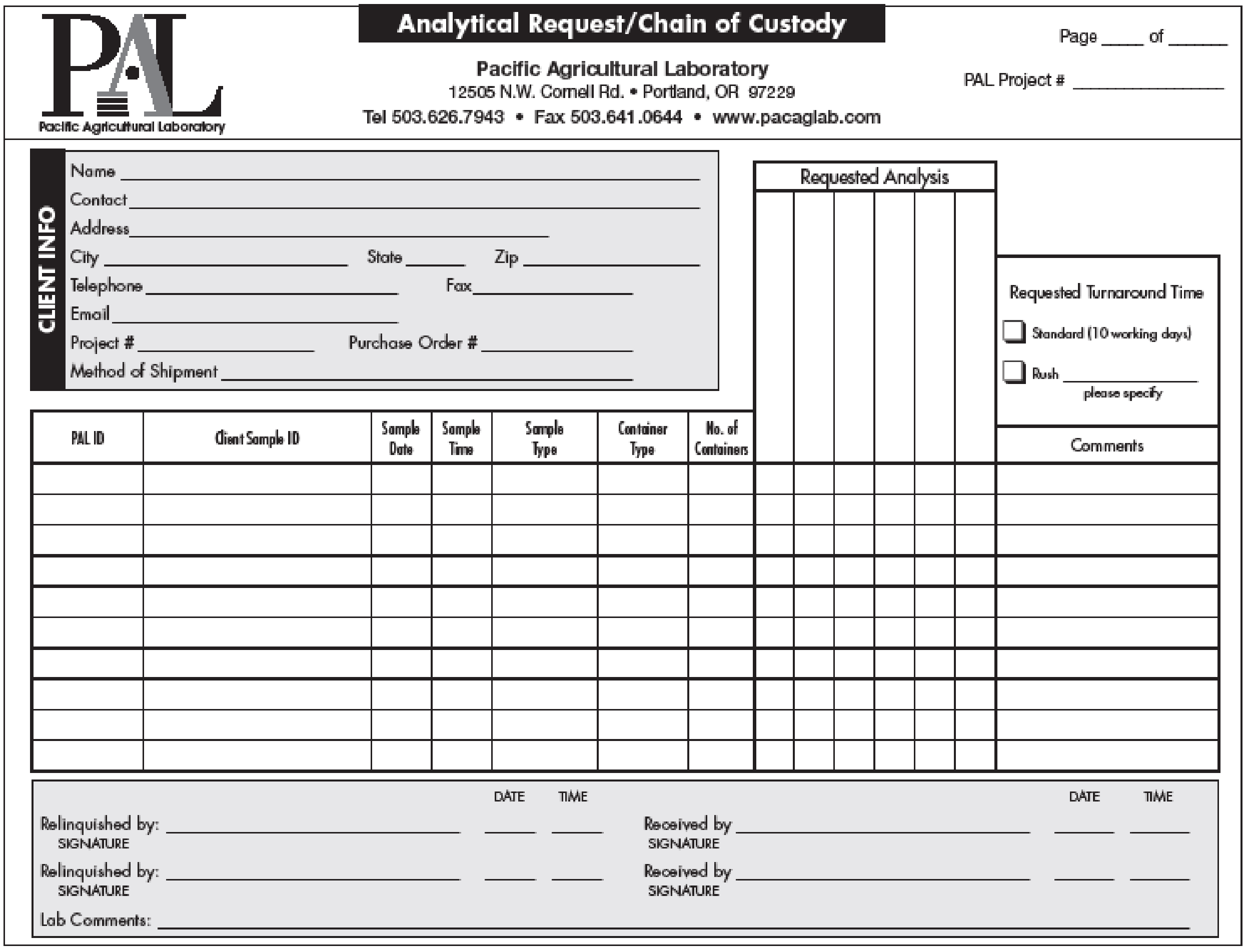
Because this study reflects only one year of data, the results should be viewed as preliminary. However, the repeated detections of several pesticides in the Souris River do raise concerns.

A comprehensive, state-wide pesticide monitoring program would be invaluable to the Department as we evaluate the potential risks of pesticide use to impair the state's surface water resources and on human health. At the present time, we have limited data on the levels of pesticides in surface water or on the frequency of occurrence. This lack of data and information has severely limited our ability to evaluate pesticide risks for many of our programs. Without water quality monitoring for pesticides, the Department has been forced to use models developed by the EPA to assess risk. These models are derived from data from other states, and the accuracy of the models is questionable. Quality data on pesticide concentrations and their occurrence in surface water would allow the Department to better protect surface water resources from pesticides, while not imposing unnecessary burdens to our agricultural producers and other pesticide users.

References

Zollinger, R.K., P. Glogoza, M.P. McMullen, C.A. Bradley, A.G. Dexter, D. Knopf, E. Wilson, T. DeJong, and W. Meyer. 2004. Pesticide use and pest management practices in North Dakota. North Dakota State University Ext. Publication W-1308.

Appendix A. Chain of Custody Form



PAL
Pacific Agricultural Laboratory

Analytical Request/Chain of Custody

Pacific Agricultural Laboratory
12505 N.W. Cornell Rd. • Portland, OR 97229
Tel 503.626.7943 • Fax 503.641.0644 • www.pacaglab.com

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PAL Project # _______________

CLIENT INFO

Name ______________________________
Contact ______________________________
Address ______________________________
City ____________ State ______ Zip ____________
Telephone ____________ Fax ____________
Email ______________________________
Project # ____________ Purchase Order # ____________
Method of Shipment ______________________________

Requested Analysis

Requested Turnaround Time
☐ Standard (10 working days)
☐ Rush ____________ please specify

PAL ID	Client Sample ID	Sample Date	Sample Time	Sample Type	Container Type	No. of Containers							Comments

Relinquished by: ____________ DATE ______ TIME ______
SIGNATURE
Received by ____________ DATE ______ TIME ______
SIGNATURE
Relinquished by: ____________ ______ ______
SIGNATURE
Received by ____________ ______ ______
SIGNATURE
Lab Comments: ______________________________

Appendix B. List of pesticides analyzed in the 2008 North Dakota surface monitoring study

Analyte	Trade name	Type	Reporting Limit
2,4,5-T	N/A	H	0.080 ug/liter (ppb)
2,4,5-TP (fenoprop)	Silvex	H	0.080 ug/liter (ppb)

Appendix B. List of pesticides analyzed in the 2008 North Dakota surface monitoring study

Analyte	Trade name	Type	Reporting Limit
2,4-D	2,4-D, Weed-B-Gon	H	0.20 ug/liter (ppb)
2,4-DB	Butryac, Butoxone	H	0.20 ug/liter (ppb)
3-Hydroxycarbofuran	degradate	D	0.12 ug/liter (ppb)
Acetochlor	Surpass, Harnass	H	0.30 ug/liter (ppb)
Alachlor	Intrro, Lariat, Lasso	H	0.12 ug/liter (ppb)
Aldicarb	Temik	I	0.12 ug/liter (ppb)
Aldicarb sulfone	degradate	D	0.12 ug/liter (ppb)
Aldicarb sulfoxide	degradate	D	0.12 ug/liter (ppb)
Aldrin	Aldrex	I	0.12 ug/liter (ppb)
Ametryn	Evik, Gesapax	H	0.30 ug/liter (ppb)
Amitraz	Avartan, Triatox, Mitac	I	0.60 ug/liter (ppb)
Aspon	N/A	I	0.30 ug/liter (ppb)
Atrazine	Aatrex,	H	0.30 ug/liter (ppb)
Azinphos-methyl	Guthion, Bay	I	0.30 ug/liter (ppb)
Azoxystrobin	Quadris	F	0.30 ug/liter (ppb)
Bendiocarb	Dycarb, Niomil	I	0.12 ug/liter (ppb)
Benfluralin	Balan	H	0.12 ug/liter (ppb)
Bifenthrin	Talstar, Capture, Brigade	I	0.12 ug/liter (ppb)
Bolstar	Sulprofos	I	0.30 ug/liter (ppb)
Bromacil	Hyvar, Bromax	H	0.30 ug/liter (ppb)
Bromopropylate	Acarol, Folbex	I	0.60 ug/liter (ppb)
Captafol	Captafol, Sanspor	F	0.12 ug/liter (ppb)
Captan	Captanex, Orthocide	F	0.30 ug/liter (ppb)
Carbaryl	Sevin, Savit	I	0.12 ug/liter (ppb)
Carbophenothion	Trithion, Garrathion	I	0.30 ug/liter (ppb)
Carbofuran	Furadan, Carbodan	I	0.12 ug/liter (ppb)
Carfentrazone-ethyl	Aim	H	0.30 ug/liter (ppb)
Chlordane	Belt, Chlortox	I	1.2 ug/liter (ppb)
Chlorfenvinphos	N/A	I	0.30 ug/liter (ppb)
Chlorobenzilate	Akar, Acaraben	I	0.30 ug/liter (ppb)
Chloroneb	Terraneb	F	0.30 ug/liter (ppb)
Chlorothalonil	Bravo, Ole, Farben	F	0.12 ug/liter (ppb)
Chlorpropham	Furloe, Beet-kleen	H	0.30 ug/liter (ppb)
Chlorpyrifos	Lorsban, Dursban	I	0.30 ug/liter (ppb)
Chlorpyrifos-methyl	Reldan, Storcide	I	0.30 ug/liter (ppb)
Clopyralid	Stinger, Curtail	H	0.080 ug/liter (ppb)
Coumaphos	Resistox, Asuntol	I	0.30 ug/liter (ppb)
Cyanazine	Bladex	H	0.60 ug/liter (ppb)
Cyfluthrin	Tempo, Baythroid	I	1.2 ug/liter (ppb)
Cyhalothrin	Grenade, Karate	I	1.2 ug/liter (ppb)
Cypermethrin	Ammo	I	1.2 ug/liter (ppb)
Dacthal	Dacthal	H	0.12 ug/liter (ppb)
	Dacthal	H	0.20 ug/liter (ppb)
DCPMU	degradate	D	0.12 ug/liter (ppb)
Deltamethrin	Butox, K-Othrin	I	1.2 ug/liter (ppb)

Appendix B. List of pesticides analyzed in the 2008 North Dakota surface monitoring study

Analyte	Trade name	Type	Reporting Limit
Demeton-O	N/A	I	0.30 ug/liter (ppb)
Demeton-S (Metasystox)	N/A	I	0.30 ug/liter (ppb)
Diazinon	Knox Out, Diazol	I	0.30 ug/liter (ppb)
Dicamba	Banvel	H	0.080 ug/liter (ppb)
Dichlorfenthion	Mobilawn, Gro13	I	0.30 ug/liter (ppb)
Dichlorprop	Weedone, Strike, Envert	H	0.20 ug/liter (ppb)
Dichlorvos	Vapona, DDVP	I	0.30 ug/liter (ppb)
Diclofop-methyl	Hoelon	H	0.60 ug/liter (ppb)
Dicloran	Botran	F	0.12 ug/liter (ppb)
Dicrotophos	Bidrin	I	0.30 ug/liter (ppb)
Dieldrin	Dieldrex	I	0.12 ug/liter (ppb)
Dimethenamid	Outlook	H	0.30 ug/liter (ppb)
Dimethoate	Cygon, Roxion	I	0.30 ug/liter (ppb)
Dinoseb	Aretit, Dinitro	H	0.20 ug/liter (ppb)
Disulfoton	Disyston, Dithiosystox	I	0.30 ug/liter (ppb)
Diuron	Direx, Karmex	H	0.12 ug/liter (ppb)
Endosulfan I	Thionex, Thiodan	I	0.12 ug/liter (ppb)
Endosulfan II	Thionex	I	0.12 ug/liter (ppb)
Endosulfan sulfate	degradate	D	0.12 ug/liter (ppb)
Endrin	Endrex	I	0.12 ug/liter (ppb)
Endrin aldehyde	degradate	D	0.12 ug/liter (ppb)
EPN	N/A	I	0.30 ug/liter (ppb)
Esfenvalerate	Asana, Pydrin	I	0.12 ug/liter (ppb)
Ethalfluralin	Sonalan	H	0.12 ug/liter (ppb)
Ethion	Ethiol, Cethion	I	0.30 ug/liter (ppb)
Ethofumesate	Progress, Tramat	H	0.30 ug/liter (ppb)
Ethoprop	Mocap	I	0.30 ug/liter (ppb)
Famphur	N/A	I	0.30 ug/liter (ppb)
Fenarimol	Rubigan	F	0.12 ug/liter (ppb)
Fenbuconazole	Indar	F	0.60 ug/liter (ppb)
Fenhexamid	Elevate	F	0.12 ug/liter (ppb)
Fenitrothion	Cyfen, Folithion	I	0.30 ug/liter (ppb)
Fenobucarb	Folistar, Prostar, Moncut	F	0.12 ug/liter (ppb)
Fenoxaprop-ethyl	Puma, Option, Whip	H	0.60 ug/liter (ppb)
Fensulfothion	Terracur, Dasanit	I	0.30 ug/liter (ppb)
Fenthion	Baytex	I	0.30 ug/liter (ppb)
Fenuron	Dybar, PDU	H	0.30 ug/liter (ppb)
Fenvalerate	Pydrin	I	0.12 ug/liter (ppb)
Fipronil	Regent	I	0.60 ug/liter (ppb)
Fluazifop-P-butyl	Fusilade	H	0.60 ug/liter (ppb)
Fludioxanil	Maxim, Celest	F	0.30 ug/liter (ppb)
Flumioxazin	Sumisoya, Valor	H	0.30 ug/liter (ppb)
Fluometuron	Cortoran, Lanex	H	0.30 ug/liter (ppb)
Fluroxypyr-meptyl	Starane	H	0.30 ug/liter (ppb)
Flutolanil	Moncoat	F	1.2 ug/liter (ppb)

Appendix B. List of pesticides analyzed in the 2008 North Dakota surface monitoring study

Analyte	Trade name	Type	Reporting Limit
Folpet	Cosan, Fungitrol	F	0.30 ug/liter (ppb)
Heptachlor	Heptamule	I	0.12 ug/liter (ppb)
Heptachlor epoxide	degradate	D	0.12 ug/liter (ppb)
Hexachlorobenzene	HCB	F	0.12 ug/liter (ppb)
Hexazinone	Velpar	H	0.30 ug/liter (ppb)
Imazamethabenz	Assert	H	0.02 ug/liter (ppb)
Imazamox	Raptor	H	0.02 ug/liter (ppb)
Imazapic	Plateau	H	0.02 ug/liter (ppb)
Imazapyr	stalker	H	0.02 ug/liter (ppb)
Imazethapyr	Pursuit	H	0.02 ug/liter (ppb)
Imidacloprid	Touchstone PF	I	0.30 ug/liter (ppb)
Iprodione	Rovral	F	0.12 ug/liter (ppb)
Isoxaben	Cent 7, Gallery	H	0.30 ug/liter (ppb)
Kelthane	Dicofol	I	0.30 ug/liter (ppb)
Linuron	Linex, Lorox	H	0.30 ug/liter (ppb)
Malathion	Malathion, Cythion	I	0.30 ug/liter (ppb)
MCPA	MCP	H	20 ug/liter (ppb)
MCPP	Encore, Trimec	H	20 ug/liter (ppb)
Mefenoxam	Apron, Dividend,Dynasty	F	0.30 ug/liter (ppb)
Metalaxyl	Hi-Yield, Ridomil	F	0.30 ug/liter (ppb)
Methidathion	Somonic, suprathion	I	0.30 ug/liter (ppb)
Methiocarb	Mesurol	I	0.12 ug/liter (ppb)
Methomyl	Lannate	I	0.12 ug/liter (ppb)
Methoxychlor	Methoxychlor	I	0.12 ug/liter (ppb)
Metolachlor	Dual, Magnum	H	0.30 ug/liter (ppb)
Metribuzin	Sencor, Lexone	H	0.60 ug/liter (ppb)
Mevinphos	Phosdrin	I	0.30 ug/liter (ppb)
Mirex	Ferriamicide, Dechlorane	I	0.12 ug/liter (ppb)
Monocrotophos	N/A	I	0.30 ug/liter (ppb)
Monuron	CMU, Telvar	I	0.12 ug/liter (ppb)
Myclobutanil	Rally	F	0.60 ug/liter (ppb)
Neburon	Kloben	H	0.12 ug/liter (ppb)
Norflurazon	Solicam	H	0.12 ug/liter (ppb)
Oryzalin	Surflan	H	0.30 ug/liter (ppb)
Ovex	Ovochlor, Ovotran	I	0.12 ug/liter (ppb)
Oxamyl	Vydate	I	0.12 ug/liter (ppb)
Oxyflorfen	Goal	H	0.12 ug/liter (ppb)
p,p'-DDD	N/A	I	0.12 ug/liter (ppb)
p,p'-DDE	degradate	D	0.12 ug/liter (ppb)
p,p'-DDT	N/A	I	0.12 ug/liter (ppb)
Parathion	Parathion, Thiophos	I	0.30 ug/liter (ppb)
Parathion-methyl	Penncap-M, Folidol-M	I	0.30 ug/liter (ppb)
PCA	degradate	D	0.12 ug/liter (ppb)
PCNB (quintozene)	Terraclor, Tritisan	F	0.12 ug/liter (ppb)
Pendimethalin	Prowl	H	0.30 ug/liter (ppb)

Appendix B. List of pesticides analyzed in the 2008 North Dakota surface monitoring study

Analyte	Trade name	Type	Reporting Limit
Pentachlorophenol	PCP	H	0.080 ug/liter (ppb)
Permethrin	Ambush, Pounce	I	1.2 ug/liter (ppb)
Phorate	Thimet	I	0.30 ug/liter (ppb)
Phosmet	Imidan	I	0.30 ug/liter (ppb)
Phosphamidon	Phosphamidon	I	0.30 ug/liter (ppb)
Picloram	Tordon	H	0.20 ug/liter (ppb)
Pirimicarb	Pirimor	I	0.30 ug/liter (ppb)
Pirimiphos-methyl	Tomahawk,Silosan	I	0.30 ug/liter (ppb)
Prodiamine	Barricade	H	0.12 ug/liter (ppb)
Prometon	Pramitol	H	0.60 ug/liter (ppb)
Prometryn	Caparol	H	0.30 ug/liter (ppb)
Pronamide	Kerb	H	0.12 ug/liter (ppb)
Propachlor	Ramrod	H	0.30 ug/liter (ppb)
Propanil	Stampede, Prop-Job	H	0.12 ug/liter (ppb)
Propargite	Comite, Omite	I	0.60 ug/liter (ppb)
Propazine	Milogard	F	0.30 ug/liter (ppb)
Propham	IPC	H	0.30 ug/liter (ppb)
Propiconazole	Banner, Tilt, Radar	F	0.30 ug/liter (ppb)
Propoxur	Baygon	I	0.12 ug/liter (ppb)
Pyraclostrobin	Cabrio, Headline	F	0.30 ug/liter (ppb)
Pyrethrins	Wilson, Mushroom House	I	1.2 ug/liter (ppb)
Pyridaben	Pyromite, Dynomite	I	0.60 ug/liter (ppb)
Quinclorac	Paramount	H	0.20 ug/liter (ppb)
Sethoxydim	Poast	H	6.0 ug/liter (ppb)
Siduron	Tupersan	H	0.12 ug/liter (ppb)
Simazine	Princep	H	0.60 ug/liter (ppb)
Simetryn	Gybon	H	0.30 ug/liter (ppb)
Sulfentrazone	Spartan	H	0.30 ug/liter (ppb)
Tebuconazole	Folicur	F	0.60 ug/liter (ppb)
Tebuthiuron	Spike	H	0.60 ug/liter (ppb)
Terbacil	Sinbar	H	0.12 ug/liter (ppb)
Terbufos	Counter	I	0.30 ug/liter (ppb)
Tetrachlorvinphos	Disvap	I	0.30 ug/liter (ppb)
Thiabendazole	Arbotect	F	0.30 ug/liter (ppb)
Thiobencarb	Bolero, Saturn, Abolish	H	0.30 ug/liter (ppb)
Toxaphene	Phenatox,Toxakil	I	6.0 ug/liter (ppb)
Triadimefon	Bayleton	F	0.60 ug/liter (ppb)
Trichlorfon	Dylox, Neguvon	I	0.60 ug/liter (ppb)
Triclopyr	Garlon	H	0.080 ug/liter (ppb)
Trifloxystrobin	Ronilan	F	0.12 ug/liter (ppb)
Triflumazole	Terraguard, Procure	F	0.12 ug/liter (ppb)
Trifluralin	Treflan, Trilin	H	0.12 ug/liter (ppb)
Vinclozalin	Ronilan	F	0.12 ug/liter (ppb)
α-BHC	degradate	D	0.12 ug/liter (ppb)
β-BHC	degradate	D	0.12 ug/liter (ppb)
γ-BHC (Lindane)	Gamma BHC	I	0.12 ug/liter (ppb)

Appendix B. List of pesticides analyzed in the 2008 North Dakota surface monitoring study

Analyte	Trade name	Type	Reporting Limit
δ-BHC	degradate	D	0.12 ug/liter (ppb)

* H=Herbicide, F=Fungicide, I=Insecticide, D=Degradate

Appendix C. Complete list of detections					
Chemical	**Concentration in ppb**	**Lowest EPA Aquatic Life Benchmark**	**Benchmark Organism**	**Sample Location**	**Date Collected**
2,4-D	0.086	299.2	acute vascular plants	Souris River at Verendry	6/2/2008
2,4-D	0.21	299.2	acute vascular plants	Sheyenne near Lisbon	6/3/2008
2,4-D	0.21	299.2	acute vascular plants	Sheyenne near Cooperstown	6/4/2008
2,4-D	0.11	299.2	acute vascular plants	Souris River near Sawyer	6/24/2008
2,4-D	0.18	299.2	acute vascular plants	Sheyenne at Horace	6/23/2008
2,4-D	0.15	299.2	acute vascular plants	Souris River near Bantry	7/15/2008
2,4-D	0.24	299.2	acute vascular plants	Souris River near Sawyer	7/15/2008
2,4-D	0.24	299.2	acute vascular plants	Souris River near Bantry	8/4/2008
2,4-D	0.35	299.2	acute vascular plants	Souris River at Verendry	8/4/2008
2,4-D	0.12	299.2	acute vascular plants	Souris River near Sawyer	8/4/2008
2,4-D	0.14	299.2	acute vascular plants	Souris River at Verendry	9/15/2008
2,4-D	0.25	299.2	acute vascular plants	Sheyenne at Horace	10/7/2008
2,4-D	0.088	299.2	acute vascular plants	Yellowstone at rm 5.5	11/3/2008
Atrazine	0.48	17.5	chronic aquatic community	Sheyenne at Horace	6/23/2008
Bentazon	0.014	4,500	acute non-vascular plants	Sheyenne near Lisbon	9/15/2008
Clopyralid	0.089	none	N/A	Sheyenne at Horace	6/23/2008
Clopyralid	0.14	none	N/A	Souris River near Sawyer	7/15/2008
Clopyralid	0.097	none	N/A	Souris River at Verendry	8/4/2008
Clopyralid	0.13	none	N/A	Souris River at Verendry	10/29/2008
Clopyralid	0.17	none	N/A	Souris River near Sawyer	10/29/2008
DCPMU	0.92	none	N/A	Souris River near Sawyer	7/15/2008
DCPMU	0.35	none	N/A	Souris River at Verendry	8/4/2008
DCPMU	0.58	none	N/A	Souris River near Sawyer	8/4/2008
DCPMU	0.26	none	N/A	Souris River at Verendry	8/26/2008
DCPMU	0.52	none	N/A	Souris River near Sawyer	8/26/2008
DCPMU	0.48	none	N/A	Souris River at Verendry	9/15/2008
DCPMU	0.31	none	N/A	Souris River near Sawyer	9/15/2008
DCPMU	0.35	none	N/A	Souris River at Verendry	10/7/2008
DCPMU	0.45	none	N/A	Souris River near Sawyer	10/7/2008
Dicamba	0.49	61	acute non-vascular plants	Souris River near Sawyer	6/24/2008
Dicamba	0.35	61	acute non-vascular plants	Souris River at Verendry	7/15/2008
Dicamba	0.081	61	acute non-vascular plants	Souris River at Verendry	8/4/2008
Dicamba	0.12	61	acute non-vascular plants	Souris River near Sawyer	8/4/2008
Dichlorprop	0.14	none		Souris River near Sawyer	7/15/2008
Diuron	0.2	2.4	acute non-vascular plants	Souris River near Sawyer	6/24/2008
Diuron	0.14	2.4	acute non-vascular plants	Souris River at Verendry	7/15/2008
Diuron	4.2	2.4	acute non-vascular	Souris River near Sawyer	7/15/2008

Appendix C. Complete list of detections					
Chemical	**Concentration in ppb**	**Lowest EPA Aquatic Life Benchmark**	**Benchmark Organism**	**Sample Location**	**Date Collected**
			plants		
Diuron	1	2.4	acute non-vascular plants	Souris River at Verendry	8/4/2008
Diuron	1.7	2.4	acute non-vascular plants	Souris River near Sawyer	8/4/2008
Diuron	0.62	2.4	acute non-vascular plants	Souris River at Verendry	8/26/2008
Diuron	1.2	2.4	acute non-vascular plants	Souris River near Sawyer	8/26/2008
Diuron	1.5	2.4	acute non-vascular plants	Souris River at Verendry	9/15/2008
Diuron	0.62	2.4	acute non-vascular plants	Souris River near Sawyer	9/15/2008
Diuron	0.8	2.4	acute non-vascular plants	Souris River at Verendry	10/7/2008
Diuron	1.3	2.4	acute non-vascular plants	Souris River near Sawyer	10/7/2008
Diuron	0.17	2.4	acute non-vascular plants	Souris River near Bantry	10/29/2008
Diuron	0.27	2.4	acute non-vascular plants	Souris River at Verendry	10/29/2008
Diuron	0.17	2.4	acute non-vascular plants	Souris River near Sawyer	10/29/2008
Imazapyr	0.026	none	N/A	Souris River near Sawyer	6/24/2008
Imazapyr	0.056	none	N/A	Yellowstone at rm 7.3	8/4/2008
Triclopyr	0.11	100	acute non-vascular plants	Yellowstone at rm 5.5	11/3/2008