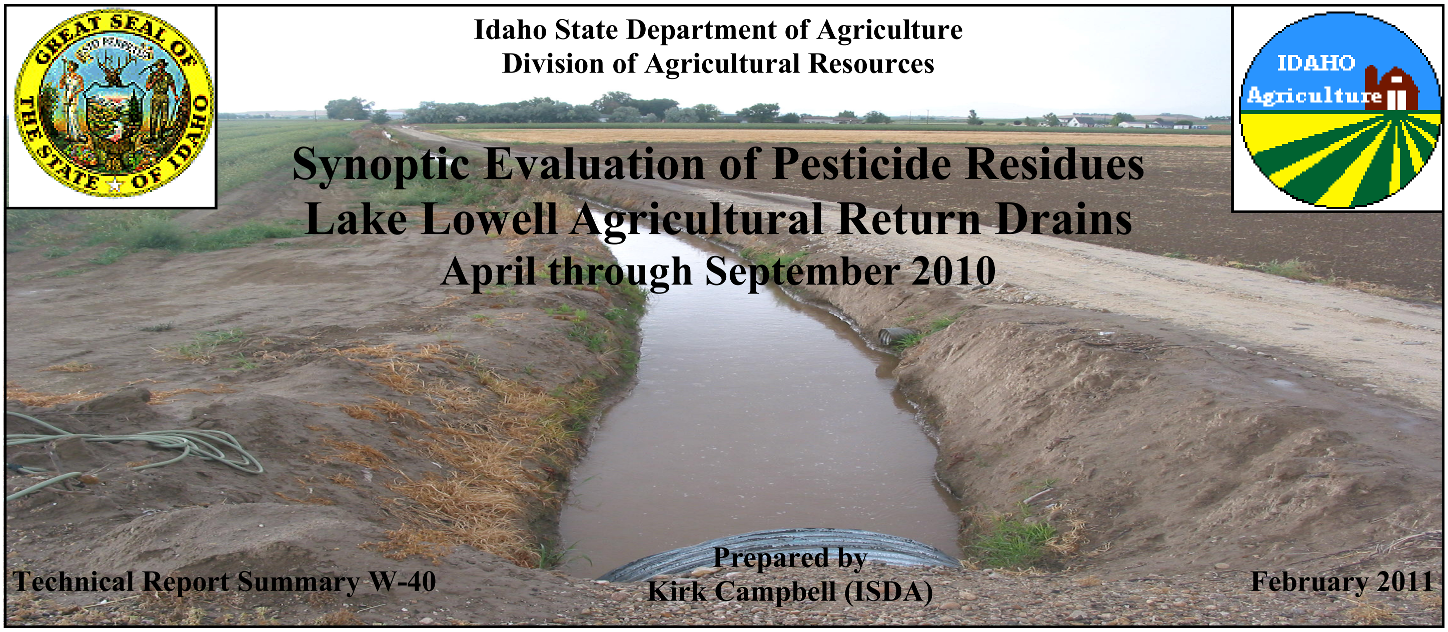
Idaho State Department of Agriculture
Division of Agricultural Resources



Synoptic Evaluation of Pesticide Residues Lake Lowell Agricultural Return Drains

April through September 2010

Technical Report Summary W-40

Prepared by
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Introduction

In 2010, the Idaho State Department of Agriculture (ISDA) conducted a water quality monitoring program for pesticides on four major agricultural return drains that discharge into Lake Lowell. Mr. Duane Casey, Water Master Division 4 of the Boise Project Board of Control helped identify the four drains that contribute the greatest load of sediment into Lake Lowell. These four drains transport irrigation return waste water along with canal spill water into Lake Lowell. The majority of acreage serviced by these drains consist of irrigated agriculture. The four drains studied were the Highland Wasteway-3 (HW-3), Bernard Drain (BD-1), Coulee Drain (CD-1), and Garland Drain (GD-1) (Figure 1). Lake Lowell is located in Canyon County, Idaho about 25 miles west of Boise and about five miles west of Nampa.

The Lake Lowell drainage area is approximately 62 square miles in Ada and Canyon Counties. Lake Lowell is part of U.S. Geological Survey (USGS) hydrologic Unit Code (HUC) 17050114; it is approximately 9,000 acres at full pool and is fed by water out of the Boise River through the New York Canal (IDEQ, 2010). Large to small agricultural return drains provide additional water inputs into Lake Lowell from the south and west shores.

Lake Lowell is included in the Deer Flat National Wildlife Refuge, which is managed by the U.S. Fish and Wildlife Service (USFWS). Lake Lowell is a warm water fishery which species include largemouth bass, smallmouth bass, yellow perch, bluegill, black crappies, bullheads, and channel catfish (DEQ, 2010).

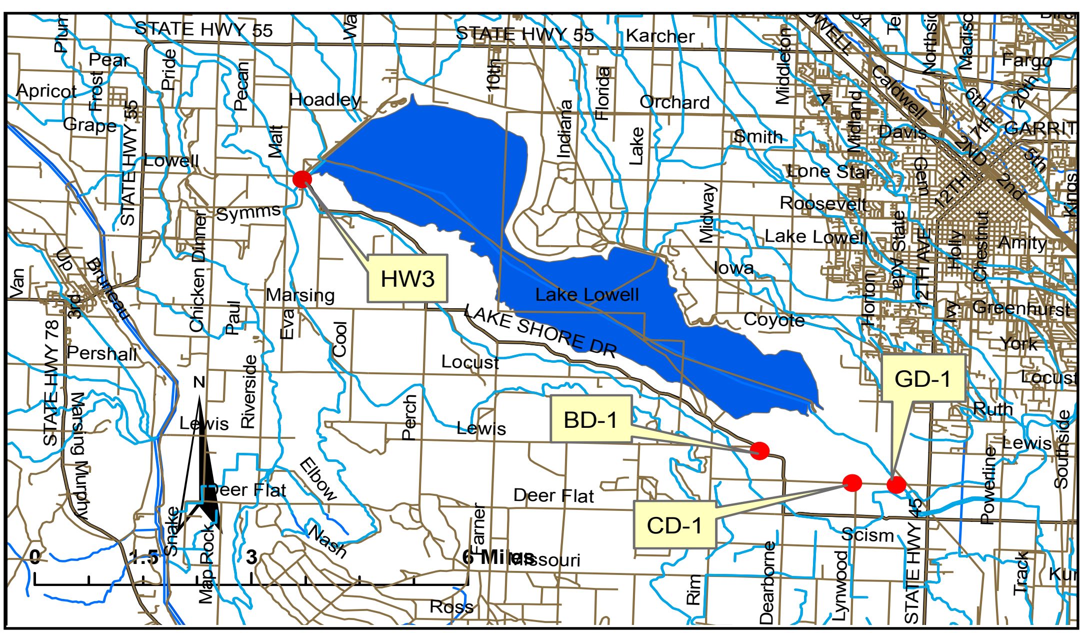

Figure 1. Lake Lowell drain monitoring locations.

Analytical Methods and Quality Assurance

Analytical methods and techniques used by the University of Idaho Analytical Science Laboratory (UIASL) in Moscow, Idaho are as follows: EPA Method 507 for nitrogen and phosphorus containing pesticides, EPA Method 509 for chlorinated pesticides, EPA Method 515.2 for chlorinated acids (herbicides), and EPA Method 632 for Carbamates and urea pesticides.

UIASL follows strict quality control guidelines that require the extraction and analysis of samples be accompanied by laboratory fortified blanks, laboratory reagent blanks, laboratory fortified sample matrix (matrix spikes), quality control samples, and performance check standards to evaluate and document data quality.

During this study, all analyte spikes and surrogate standard recoveries were within acceptable ranges (70-130%), indicating that pesticide residues were accurately recovered. All field blanks submitted during this study resulted in non-detectable results indicating both field and laboratory activities were free from contamination.

Sampling Methods and Quality Assurance

Samples for this project were collected using a USDH-81 depth integrated suspended sediment sampler. The sampler was equipped with a one-liter glass sample bottle and a Teflon cap and nozzle.

Multiple discrete samples from each site were composited into a clean 2.5 gallon glass carboy. The composite sample was then poured off into three laboratory cleaned, one-liter amber glass bottles. All sampling equipment was thoroughly cleaned between monitoring locations using the following procedure: thorough scrubbing with deionized water and Liqui-Nox detergent, deionized water rinse, acetone (high resolution chromatography grade) rinse, followed by a deionized water rinse. The equipment was then rinsed with source water just prior to collection.

For field quality assurance (QA) three types of QA samples were submitted during this project including: duplicates, field blanks, and equipment blanks. Duplicate samples were collected by compositing sample water into a clean 2.5 gallon glass carboy. The resultant composite was then mixed and poured off into six one-liter amber bottles. Field bottle blanks were collected by transferring deionized water directly from a Nalgene carboy into three clean one-liter amber bottles. Equipment blanks entail thorough cleaning of the sampling equipment, as previously mentioned, followed by filling the sampling equipment with deionized water and transferring that water into clean one-liter amber bottles. All QA samples were submitted to UIASL as blind samples.

All samples from each study were placed in a cooler on ice for shipment directly to the UIASL. All samples were shipped priority overnight and Chain-of-Custody protocols were followed throughout the project.

Overall Results

The four Lake Lowell return drains monitored for this study had a total of 260 pesticide detections of 26 pesticide compounds (Figure 2).

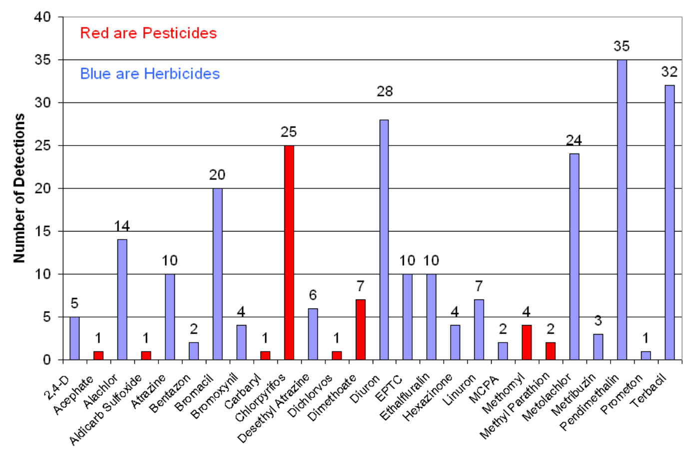

Figure 2. Total pesticides detected during this project.

Of the 260 detections 218 detections were herbicides and 42 were insecticides. The general use pesticides (GUP) with the greatest number of detections were the herbicides pendimethalin (35), terbacil (32), diuron (28), and metolachlor (24). Pendimethalin, diuron, and metolachlor all show moderate to high toxicities to fish and aquatic invertebrates at concentration much higher than those observed during this study. Terbacil is slightly to practically non-toxic to aquatic organisms. Pendimethalin, diuron, and metolachlor adsorb easily to soils and are primarily transported by sediment runoff. Terbacil is highly soluble in water which allows easy transport, during irrigation or rain events, from the application site (Extoxnet, 1996).

The greatest number of detections of an insecticide was the restricted use pesticide (RUP) and GUP (depending on the formulation) chlorpyrifos with 25 detections, followed by dimethoate (GUP) with seven detections, and methomyl (RUP) with four detections. Chlorpyrifos is an organophosphate insecticide which is highly toxic to fish and aquatic invertebrates. It adsorbs strongly to sediment and is primarily transported by eroded soils. Dimethoate and methomyl are highly soluble in water and are primarily transported by irrigation tail water. Methomyl is moderate to highly toxic to fish and highly toxic to aquatic invertebrates while dimethoate is moderately toxic to fish and somewhat more toxic to aquatic invertebrates (Extoxnet, 1996).

Table 1 lists the pesticides detected, type of pesticide, trade names and the Environmental Protection Agency (EPA) aquatic benchmark concentrations for acute and chronic effects on fish and aquatic invertebrates.

Table 1. Pesticides Detected, Type, Trade Names and Toxicity.

			EPA Aquatic Benchmarks (ug/L)			
			Fish	Fish	Invertebrate	Invertebrate
Pesticides Detected	Pesticide Type	[3]Trade Name	Acute ug/L	Chronic ug/L	Actue ug/L	Chronic ug/L
2,4-D	Herbicide	Curtail	50,000	14,200	12,500	16,400
Acephate	Insecticide	Orthene	416,000	5,760	550	150
Alachlor	Herbicide	Lasso	900	187	1,250	110
Aldicarb Sulfoxide	[1]Insecticide	Temik	3,570	—	21.5	—
Atrazine	Herbicide	Aatrex	2,650	65	360	60
Bentazon	Herbicide	Basagran	>50,000	—	>50,000	—
Bromacil	Herbicide	Krovar	18,000	3,000	60,500	8,200
Bromoxynil	Herbicide	Buctril	100	15	96	2.5
Carbaryl	Insecticide	Sevin	110	6.8	0.85	0.5
Chlorpyrifos	Insecticide	Dursban	0.9	0.57	0.05	0.04
Desethyl Atrazine	[2]Degredate	—	2,650	65	360	60
Dichlorvos	Insecticide	Prentox	79.5	5.2	0.035	0.0058
Dimethoate	Insecticide	Cygon	3,100	430	21.5	0.5
Diuron	Herbicide	Karmex	200	26	80	200
EPTC	Herbicide	Eptam	7,000	—	3,245	810
Ethalfluralin	Herbicide	Sonalan	16	0.4	30	24
Hexazinone	Herbicide	Velpar	137,000	17,000	75,800	20,000
Linuron	Herbicide	Lorox	1,500	5.58	60	0.09
MCPA	Herbicide	Banlene	48,000	12,000	41,000	11,000
Methomyl	Insecticide	Lannate	160	12	2.5	0.7
Methyl Parathion	Insecticide	Metacide	925	<10	0.49	0.25
Metolachlor	Herbicide	Dual	1,600	1,000	550	1
Metribuzin	Herbicide	Sencore	21,000	3,000	2,100	1,290
Pendimethalin	Herbicide	Prowl	69	6.3	140	14.5
Prometon	Herbicide	Pramitol	6,000	9,500	12,850	3,500
Terbacil	Herbicide	Sinbar	23,100	1,200	32,500	640
[1] Aldicarb Sulfoxide is a metabolite of Aldicarb			[3]Other tradenames may apply			
[2]Desethyl Atrazine is a degredate of Atrazine						

ISDA considers pesticides (herbicides, insecticides, and fungicides) as being a potential pesticide of concern (POC) if the concentration is at or greater than 50% of an acute or chronic concentration level for fish or aquatic invertebrates as established in the EPA Aquatic Benchmark Criteria (EPA, 2010). There were numerous POC detections during this study.

Garland Drain (GD-1)

The Garland Drain (GD-1) empties into the New York canal just upstream of Lake Shore Drive and just downstream of the New York Canal's final check gates (Photo 1).

Photo 1. Garland Drain outlet into New York Canal.

The drain collects wastewater from land south and east of Lake Lowell. The drainage area consists of approximately 10,418 acres with 82.4% in agricultural acreage (USGS StreamStats). Garland Drain's water went from containing heavy silts during May, June, July, to moderate to lighter silts in August and September (field observations).

There were a total of 17 pesticides identified at GD-1; 15 herbicides and two insecticides. Of these 17 pesticides there were 50 detections with 42 herbicide detections and eight insecticide detections (Table 2).

Table 2. Garland Drain pesticide detections.

GD-1			EPA Aquatic Benchmarks (ug/L)			
Pesticides Detected	# Detects	Highest Detects	Acute Fish	Chronic Fish	Inv. Acute	Inv. Chronic
2,4-D	3	0.27	50,000	14,200	12,500	16,400
Acephate	1	0.592	416,000	5,760	550	150
Alachlor	3	0.39	900	187	1,250	110
Atrazine	1	0.033	2,650	65	360	60
Bromacil	3	0.74	18,000	3,000	60,500	8,200
Bromoxynil	1	0.2	100	15	96	2.5
Chlorpyrifos	1	0.085	0.9	0.57	0.05	0.04
Chlorpyrifos	1	0.1	0.9	0.57	0.05	0.04
Chlorpyrifos	1	0.046	0.9	0.57	0.05	0.04
Chlorpyrifos	1	0.036	0.9	0.57	0.05	0.04
Chlorpyrifos	1	0.054	0.9	0.57	0.05	0.04
Dimethoate	2	0.11	3,100	430	21.5	0.5
Diuron	6	3.8	200	26	80	200
EPTC	2	0.22	7,000	—	3,245	810
Ethalfluralin	1	0.071	16	0.4	30	24
Hexazinone	2	0.26	137,000	17,000	75,800	20,000
MCPA	1	0.31	48,000	12,000	41,000	11,000
Metolachlor	3	0.098	1,600	1,000	550	1
Pendimethalin	7	0.43	69	6.3	140	14.5
Prometon	1	0.25	6,000	9,500	12,850	3,500
Terbacil	7	0.35	23,100	1,200	32,500	640

All of the herbicide detections were significantly lower than the concentrations listed in the EPA's aquatic benchmarks for chronic or acute effects (Table 2). The eight insecticides consisted of one acephate, two Dimethoate, and five chlorpyrifos detections. The five chlorpyrifos detections either exceeded or were ≥50% of the acute and chronic concentrations for aquatic invertebrates (Table 2).

Coulee Drain (CD-1)

Coulee Drain is located approximately 1.5 miles west of the New York Canal on Lake Shore Drive. This drain transported heavy loads of sediment from April through mid-September (visual observations) (Photo 2).

Photo 2. Coulee Drain looking southeast.

The drain collects irrigation water and wastewater from areas south and east of Lake Lowell. The estimated acreage contributing to Coulee Drain is approximately 13,650 acres with 93.3% of the drainage identified as agricultural lands (USGS StreamStats).

There were a total of 18 pesticides identified at CD-1; 14 herbicides and 4 insecticides. Of these 18 pesticides there were 76 detections with 59 herbicide detections and 17 insecticide detections (Table 3).

Table 3. Coulee Drain pesticide detections.

CD-1			EPA Aquatic Benchmarks (ug/L)			
Pesticides Detected	# Detects	Highest Detects	Acute Fish	Chronic Fish	Inv. Acute	Inv. Chronic
2,4-D	2	0.43	50,000	14,200	12,500	16,400
Alachlor	2	0.28	900	187	1,250	110
Aldicarb Sulfoxide	1	0.12	3,570	—	21.5	—
Atrazine	2	0.043	2,650	65	360	60
Bentazon	1	0.47	>50,000	—	>50,000	—
Bromacil	7	0.7	18,000	3,000	60,500	8,200
Bromoxynil	1	0.15	100	15	96	2.5
Chlorpyrifos	1	0.033	0.9	0.57	0.05	0.04
Chlorpyrifos	1	0.027	0.9	0.57	0.05	0.04
Chlorpyrifos	1	0.55	0.9	0.57	0.05	0.04
Chlorpyrifos	1	0.32	0.9	0.57	0.05	0.04
Chlorpyrifos	1	0.057	0.9	0.57	0.05	0.04
Chlorpyrifos	1	0.038	0.9	0.57	0.05	0.04
Chlorpyrifos	1	0.081	0.9	0.57	0.05	0.04
Chlorpyrifos	1	0.033	0.9	0.57	0.05	0.04
Chlorpyrifos	1	0.043	0.9	0.57	0.05	0.04
Chlorpyrifos	1	0.034	0.9	0.57	0.05	0.04
Chlorpyrifos	1	0.034	0.9	0.57	0.05	0.04
Dimethoate	2	0.78	3,100	430	21.5	0.5
Diuron	7	4.8	200	26	80	200
EPTC	3	0.17	7,000	—	3,245	810
Ethalfluralin	3	0.055	16	0.4	30	24
Linuron	3	0.16	1,500	5.58	60	0.09
Methomyl	2	0.2	160	12	2.5	0.7
Metolachlor	8	0.26	1,600	1,000	550	1
Metribuzin	1	0.09	21,000	3,000	2,100	1,290
Pendimenthalin	10	0.32	69	6.3	140	14.5
Terbacil	9	1.3	23,100	1,200	32,500	640

One detection of Linuron exceeded the chronic aquatic invertebrate benchmark (Table 3). Linuron is a GUP herbicide used to control annual and perennial broadleaf and grassy weeds on crop and non-crop sites. The remaining herbicide detections were well below any EPA aquatic benchmarks.

The four insecticide consisted of two Dimethoate detections with one (0.78 ug/L) exceeding the chronic invertebrate benchmark. Chlorpyrifos had 11 detections with nine detections ≥50% of both the chronic and acute aquatic invertebrate benchmark. One of the chlorpyrifos detection (0.32 ug/L) was ≥50% of the chronic fish benchmark and the other detection (0.55 ug/L) was ≥50% of the acute fish aquatic benchmark (Table 2). The other two insecticides, aldicarb sulfoxide (which is a metabolite of aldicarb) and methomyl did not exceed ISDA's POC criteria.

Bernard Drain (BD-1)

Bernard Drain (Photo 3) is located approximately three miles west of Coulee Drain and drains an estimated 1990 acres. Bernard Drain is comprised of approximately 87% agricultural lands (USGS StreamStat).

Bernard Drain historically transports heavy amounts of sediment and continued that trend in 2010. Total suspended solids data collected in 2003 by ISDA indicated that Bernard drain transported an average concentration of 816.4 mg/L of TSS per day. Using 2003 average discharge data the calculated sediment load to Lake Lowell is 23,757 pounds of TSS per day (ISDA, 2003).

Photo 3. Bernard Drain looking south.

There were a total of 21 pesticides identified at BD-1; 16 herbicides and 5 insecticides. There were 97 detections with 87 herbicides and 10 insecticides detected (Table 4).

Table 4. Bernard Drain pesticide detections.

BD-1			EPA Aquatic Benchmarks (ug/L)			
Pesticides Detected	# Detects	Highest Detects	Acute Fish	Chronic Fish	Inv. Acute	Inv. Chronic
Alachlor	8	0.79	900	187	1,250	110
Atrazine	6	0.22	2,650	65	360	60
Bentazon	1	2.7	>50,000	—	>50,000	—
Bromacil	8	1.7	18,000	3,000	60,500	8,200
Bromoxynil	2	0.14	100	15	96	2.5
Chlorpyrifos	1	0.029	0.9	0.57	0.05	0.04
Chlorpyrifos	1	0.26	0.9	0.57	0.05	0.04
Chlorpyrifos	1	0.043	0.9	0.57	0.05	0.04
Chlorpyrifos	1	0.038	0.9	0.57	0.05	0.04
Desethyl Atrazine	5	0.065	2,650	65	360	60
Dichlorvos	1	0.085	79.5	5.2	0.035	0.0058
Dimethoate	3	0.16	3,100	430	21.5	0.5
Diuron	9	4.3	200	26	80	200
EPTC	4	55	7,000	—	3,245	810
Ethalfluralin	6	0.16	16	0.4	30	24
Hexazinone	1	0.058	137,000	17,000	75,800	20,000
Linuron	3	0.27	1,500	5.58	60	0.09
MCPA	1	0.2	48,000	12,000	41,000	11,000
Methomyl	2	0.38	160	12	2.5	0.7
Methyl Parathion	1	0.12	925	<10	0.49	0.25
Metolachlor	11	1.6	1,600	1,000	550	1
Metolachlor		1.2	1,600	1,000	550	1
Metribuzin	2	0.61	21,000	3,000	2,100	1,290
Pendimethalin	11	2.0	69	6.3	140	14.5
Terbacil	9	1.5	23,100	1,200	32,500	640

The majority of the herbicides detected at BD-1 were well below any EPA aquatic benchmark concentrations. The herbicide metolachlor had a total of 11 detections with two detections that were greater than the chronic invertebrate level. There was also one detection of the herbicide Linuron that exceeded the chronic invertebrate benchmark (Table 4).

There were four detections of chlorpyrifos that were ≥50% of both the acute and chronic benchmark for aquatic invertebrates. One detection of the insecticide dichlorvos exceeded both the acute and chronic benchmarks for aquatic invertebrates and one detection of the insecticide methomyl was ≥50% of the chronic benchmark for aquatic invertebrates (Table 4).

Highland Wasteway 3 (HW-3)

The Highland Wasteway 3 transports irrigation water and irrigation waste water along the southern edge of Lake Lowell. At the HW-3 diversion, water is either sent to the Highline Canal and transported west or diverted into Lake Lowell (Photo 4). Data collected by ISDA in 2003 at this location indicated that HW-3 had a mean concentration of 111.5 mg/L of TSS and delivered, on average, 37,852 lbs/day of TSS into Lake Lowell (ISDA, 2003).

Photo 4. Highland Wasteway diversion to Lake Lowell.

There were a total of 14 pesticides identified at HW-3; 11 herbicides and 3 insecticides. There were 37 detections with 30 herbicides and 7 insecticides detected (Table 5).

Table 5. Highland Wasteway No. 3 pesticide detections.

HW-3			EPA Aquatic Benchmarks (ug/L)			
Pesticides Detected	# Detects	Highest Detects	Acute Fish	Chronic Fish	Inv. Acute	Inv. Chronic
Alachlor	1	0.099	900	187	1,250	110
Atrazine	1	0.026	2,650	65	360	60
Bromacil	2	0.057	18,000	3,000	60,500	8,200
Carbaryl	1	0.052	110	6.8	0.85	0.5
Chlorpyrifos	1	0.12	0.9	0.57	0.05	0.04
Chlorpyrifos	1	0.046	0.9	0.57	0.05	0.04
Chlorpyrifos	1	0.029	0.9	0.57	0.05	0.04
Chlorpyrifos	1	0.078	0.9	0.57	0.05	0.04
Chlorpyrifos	1	0.067	0.9	0.57	0.05	0.04
Desethyl Atrazine	1	0.031	2,650	65	360	60
Diuron	6	0.47	200	26	80	200
EPTC	1	0.22	7,000	—	3,245	810
Hexazinone	1	0.081	137,000	17,000	75,800	20,000
Linuron	1	0.17	1,500	5.58	60	0.09
Methhyl Parathion	1	0.081	925	<10	0.49	0.25
Metolachlor	2	0.075	1,600	1,000	550	1
Pendimethalin	7	0.24	69	6.3	140	14.5
Terbacil	7	0.26	23,100	1,200	32,500	640

Of the 30 herbicide detections only one linuron detection exceeded the EPA aquatic benchmark for chronic aquatic invertebrates. The remaining herbicide detections were well below any established benchmarks (Table 5).

Of the three insecticides detected, chlorpyrifos had five detections that all exceeded ISDA's POC criteria of ≥50% for acute and chronic aquatic invertebrates. The other two insecticides, carbaryl and methyl parathion were detected at levels below any EPA benchmark criteria (Table 5).

Conclusions

Of the 260 pesticide detections during this study 218 detections were herbicides and 42 were for insecticides. Of the herbicides, metolachlor had two detections at Bernard Drain that exceeded the EPA's chronic aquatic invertebrate concentration. Linuron had one detection at CD-1, BD-1, and HW-3 that all exceeded the chronic aquatic invertebrate benchmark.

The three insecticides with the highest detections during this study were chlorpyrifos (25) which is hydrophobic, dimethoate (7) and methomyl (4) which are highly soluble in water. Of these three insecticides, chlorpyrifos has the greatest potential to impact fish and aquatic invertebrates due to the compound's very low concentration thresholds for acute and chronic effects (Table 1). Very low concentrations of chlorpyrifos have proven to be highly toxic to both cold and warm water species of fish. Chlorpyrifos is highly toxic to a wide variety of aquatic organisms including: stoneflies, mayflies, damsel flies, caddis flies and numerous others (Day, 1990).

Chlorpyrifos bonds tightly to sediment and the drains in this study visually contained heavy amounts of sediment. The numerous chlorpyrifos detections and concentrations found in the drains could potentially cause chronic or acute conditions in Lake Lowell's littoral zone. Research on the overall activity of chlorpyrifos in lake bed sediments are limited. A study of chlorpyrifos binding to colloidal materials, found that chlorpyrifos bound strongly to a calcium-humate and did not desorb, but moderately sorbed to, and desorbed from, a river sediment. Both the organic and inorganic material in suspended sediment affect the adsorption and desorption of chlorpyrifos (Wu and Laird, 2004). DowElanco, manufacturer of chlorpyrifos states that chlorpyrifos "dissipates very rapidly from the water column" while dissipation from sediments in streams, rivers, lakes, or ponds is "similar to that observed for soil" (Racke, 1993). Chlorpyrifos is moderately persistent in soils. The half-life of chlorpyrifos in soil is between 60 and 120 days, but can range from 2 weeks to over 1 year, depending on the soil type, climate and other conditions (Howard, 1991). The longer half-lives means chlorpyrifos is available in soil longer for possible transport off site.

Chlorpyrifos was detected 25 times during this study. The site with the most detections was CD-1 (11) followed by GD-1 and HW-3 (both 5) and BD-1 (4). All of the 25 detections were ≥50% of the chronic and acute concentrations for aquatic invertebrates. Two of the detections at CD-1 were ≥50% of the chronic fish concentation (Figure 2).

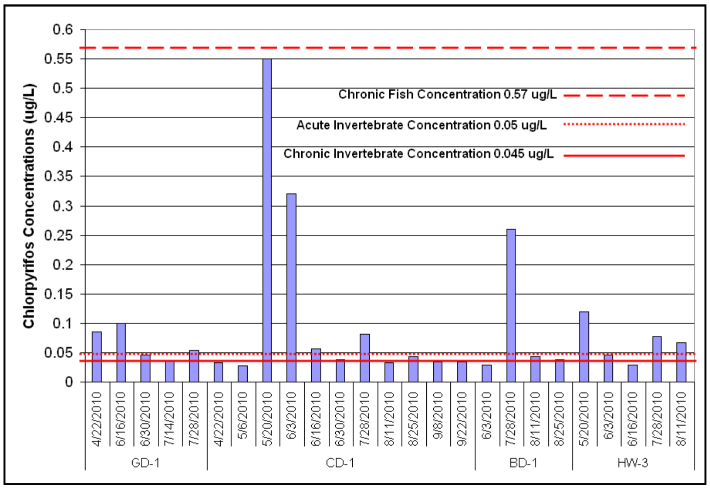

Figure 2. Chlorpyrifos detections at all sites.

The numerous detections of chlorpyrifos could indicate a chronic condition primarily for aquatic invertebrates in areas of Lake Lowell where these drains deposit their sediment loads. ISDA considers chlorpyrifos to be a potential pesticide of concern (POC) for the littoral area of Lake Lowell.

The large number of detections for both herbicides and pesticides could pose a chronic or acute effect on aquatic organisms within Lake Lowell's water column and sediment. On going research is attempting to determine the overall toxicity of pesticide mixtures and which mixtures tend to show an additive or synergistic effect on aquatic organisms. Some research has indicated that the toxicity of some pesticides is increased by several magnitudes when mixed with other pesticides.

Recommendations

Future monitoring along the south shore of Lake Lowell (in the proximity of these drains) may help to determine what, if any, impact these pesticide may be having on aquatic invertebrates. ISDA along with the USFWS could explore a joint effort, on Lake Lowell, to design and complete a specific sampling plan to evaluate water quality, sediment, and macroinvertebrates for pesticide impacts.

ISDA will work to educate landowners and applicators of the potential impacts related to pesticides that effect water quality and the environment. The following management recommendations should be considered:

- Read and follow label directions.
- Conduct maintenance on application equipment.
- Implementation of management strategies including: Integrated Pesticide Management (IPM), field scouting, selection of proper pesticides, irrigation water management, and irrigation scheduling.
- Implement structural controls including: conservation buffers, vegetative filter strips, sediment basins, and pump back systems.
- Avoid overspray and drift.
- Do not mix and load near water.

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