Idaho State Department of Agriculture
Division of Agricultural Resources

Ground Water Quality of Minidoka County Alluvial Aquifer, 1997—2007

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Introduction

The Idaho State Department of Agriculture (ISDA) developed the Regional Agricultural Ground Water Quality Monitoring Program to characterize degradation of ground water quality by contaminants leaching from agricultural sources. The ISDA currently is conducting monitoring at thirteen regions in Idaho, including the alluvial aquifer in southern Minidoka County (Figure 1). The objectives of the program are to: (1) characterize ground water quality, primarily related to nitrate-nitrogen (NO_3-N) and pesticides, (2) determine if legal pesticide use contributes to aquifer degradation, (3) relate data to agricultural land use practices, and (4) provide data to support Best Management Practices (BMP) and/or regulatory decision making and evaluation processes.

The ISDA Minidoka County alluvial aquifer regional monitoring project began in 1997 as a result of previous monitoring by the United States Department of Agriculture (USDA) and the United States Geological Survey (USGS). One hundred and ninety-five samples were taken from 54 wells located in the Minidoka County alluvial aquifer for the USDA Demonstration Project during May through October 1991 (Bidondo et al., 2008). The average NO_3-N concentration from the USDA Demonstration Project was 6.5 mg/L, the maximum NO_3-N concentration was 28 mg/L, and 16% of the wells had NO_3-N concentrations that exceeded the Environmental Protection Agency (EPA) Maximum Contaminant Level (MCL) of 10 mg/L during at least one sampling event (Bidondo et al., 2008). Twenty-nine wells in the Minidoka County alluvial aquifer were tested for NO_3-N by the USGS from 1991 to 1995. The NO_3-N concentrations ranged from less than 0.05 mg/L to 58 mg/L; the 50th percentile concentration was 7.1 mg/L (Rupert, 1997).

To establish this regional monitoring project, the ISDA randomly selected domestic wells in the area and coordinated with homeowners to conduct ground water sampling. Nutrients, pesticides, and common ions were evaluated during the eleven years (1997 through 2007) of ISDA's testing. Laboratory results indicate several domestic wells located west of Heyburn and the area surrounding Paul and Rupert have NO_3-N values that suggest some type of land use influences on the ground water. In addition, low level concentrations of various pesticides were detected in numerous wells.

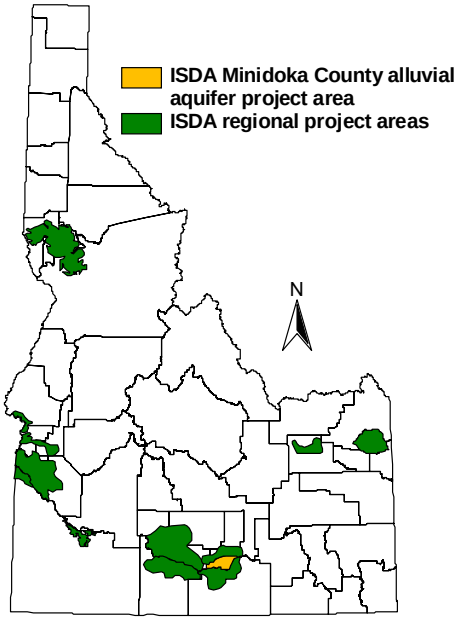

Figure 1. Location of Minidoka County alluvial aquifer project and other regional project areas.

The ISDA is currently working to advise residents and officials of the area on how to minimize further ground water contamination and possible health risks. Ground water monitoring will continue at least through the year 2008 to assist with these efforts.

Methods

To establish this project, ISDA statistically assessed nitrate, chloride, and atrazine ground water data. ISDA statistically determined that sampling 45 randomly selected domestic wells would provide adequate data to evaluate overall ground water quality. All sampling was conducted after a quality assurance project plan (QAPP) was established. Permission was gained from the land owners prior to sampling.

Nutrients and other common ions were evaluated every year since 1997. All sample collections followed established ISDA protocols for handling, storage, and shipping. Samples were sent to the University of Idaho Analytical Sciences Laboratory (UIASL) in Moscow, Idaho. UIASL conducted tests for nitrate, nitrite, ammonia, orthophosphorous, chloride, sulfate, bromide, and fluoride using EPA Methods 300.0 and 350.1. Duplicates, splits, and field blanks were collected and submitted as a part of the QAPP.

In 1997, samples were sent to the Washington Department of Ecology (WDOE) Laboratory in Manchester, Washington for pesticide analysis. The methods used for pesticide analysis were EPA Methods 1618 and SW8150, which have very low detection limits. In 1999, 2001, and 2004 samples were sent to the UIASL in Moscow, Idaho for pesticide analysis. Samples were tested for various pesticides utilizing modified EPA Methods 507, 508, 515.1, 515.2, 531.1, and 632. Duplicates, splits, field blanks, and matrix spikes/matrix spike duplicates were collected and submitted as a part of the QAPP.

In 2000, samples were collected from selected wells following ISDA protocols for nitrogen isotope analysis. The wells selected for nitrogen isotope analysis had elevated NO_3-N concentrations during the previous sampling event. Samples were sent to the ^{15}N Analysis Service, Department of Natural Resources and Earth Sciences, University of Illinois Champaign-Urbana. In 2001 and 2002, samples were collected from selected wells for nitrogen and oxygen isotope analysis, following ISDA protocols and sent to the North Carolina State University Stable Isotope Laboratory for analysis. In 2003 through 2005, samples were collected from selected wells for nitrogen isotope analysis, following ISDA protocols and sent to the University of Idaho Stable Isotope Laboratory for analysis.

Description of Project Area

The Minidoka County alluvial aquifer regional monitoring project encompasses an approximately 16 mile wide and 10 mile long area of irrigated agricultural land adjacent to the Snake River. The main source of irrigation is provided by surface water diverted from the Snake River (Rupert, 1997). Local irrigation systems vary from the typical and historic practice of flood irrigation to more efficient techniques, such as sprinkler irrigation. Major crops in the area include potatoes, sugar beets, wheat, barley, corn and beans (Mitchell, 1998).

Potential sources for NO_3-N leaching to ground water in the project area include applied nitrogen-based fertilizers, septic systems, cattle manure, legume crops, and nitrogen mineralization. A study of the upper Snake River Basin conducted by Rupert (1996) calculated that 93% of the total NO_3-N input into the regional system is supplied by the following land use sources: fertilizer (45%), cattle manure (29%), and legume crops (19%). He also concluded that domestic septic systems had minimal NO_3-N input (less than 1%) and precipitation provided 7% of the NO_3-N input. The percentages were calculated for the entire upper Snake River Basin, based on data from the early to mid 1990s. Due to changes in agricultural practices and land use in Idaho since the 1990s, the percentages calculated in the study are probably not reflective of current conditions. In addition, the percentages were calculated for the regional area, not specifically for Minidoka County. However, the study still provides insight into the potential NO_3-N sources in Minidoka County.

Hydrogeology

The top soil in the project area can be classified into two basic types. The soil north of the Snake River and south of Paul and Rupert is somewhat poorly drained loamy sands to clay loams on low alluvial terraces (Hansen, 1975). These soils are very deep and are underlain by mainly sand and gravel. The soil north of Paul and Rupert is well drained sands to silty clay loams on low alluvial terraces (Hansen, 1975). Nearly all of the acreage of both soil types is used for irrigated crops and pasture (Hansen, 1975).

Figure 2 suggests the alluvial aquifer, in part, may be perched on top of clay layers, that separate the shallow alluvial aquifer from the deeper regional basalt aquifer. Water elevation contouring of the deep system suggests

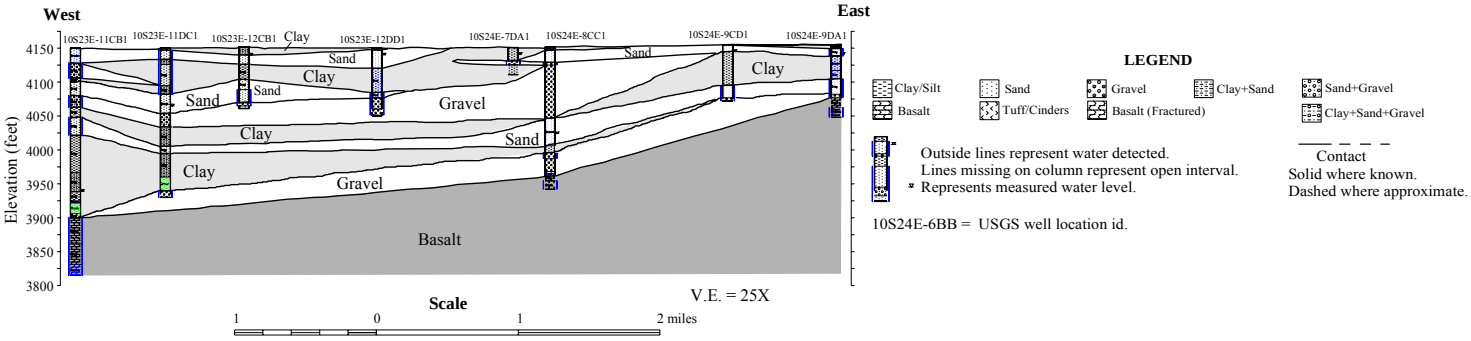

Figure 2. Geologic cross section based on well drillers' reports from Minidoka Alluvial Aquifer project area. Cross section line is displayed on Figure 5 (after Carlson, 1999).

an area of mixing at the northern most extent of the shallow system. The majority of the alluvial aquifer is composed of sands and gravels deposited by streams and the Snake River (Rupert, 1997). The aquifer is recharged mainly from infiltration of irrigation water, with some shallow wells going dry after the end of the irrigation season (Rupert, 1997). Based on well driller's reports from domestic wells in the project area, typical depth to ground water is less than 100 feet and is as little as 4 feet below land surface in some areas.

The geological cross section of Figure 2 indicates that unconsolidated deposits of sand and gravel extend to a depth of 200 to 250 feet below land surface and are underlain by basalt. In addition, the geologic cross section suggests that the unconsolidated deposits and basalt are fairly continuous laterally with a very slight dip to the west.

Data collected from the area suggests a relatively low gradient for the shallow system with direction of ground water flow to the north (Carlson, 1999) (Figure 3). However, in a study done by the USGS, water flow direction of the shallow system was determined to be south towards the Snake River (Mitchell, 1998).

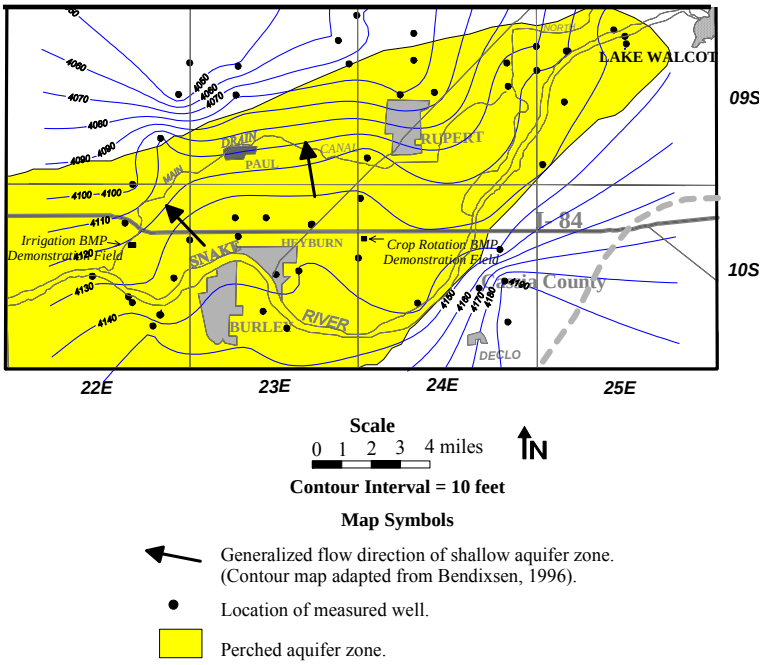

Figure 3. Contour map of the shallow alluvial ground water system in southern Minidoka County. Map shows generalized direction of ground water flow and extent of perched aquifer zone (after Carlson, 1999).

Results

Sampling results of the first eleven years indicate NO_3-N and pesticide impacts have occurred to the shallow alluvial aquifer. Results are summarized and presented in the following sections.

Nitrate

Table 1 presents statistics for 34 wells that have been sampled every year (1997 to 2007). Approximately 45 wells have been sampled per year; however, only wells that have been sampled consistently every year are used for the statistics.

In 2007, the maximum NO_3-N concentration for the 34 wells consistently sampled was 16 mg/L, which was the highest value since the beginning of the project. The median NO_3-N concentration has fluctuated between 3.15 mg/L in 2004 to 4.8 mg/L in 2000. In 2007, the median NO_3-N concentration was 3.95 mg/L for the 34 wells used for the statistics. In general, the mean and median NO_3-N concentrations have been fairly consistent during the period of this study (Figure 4). The maximum NO_3-N concentration has generally decreased from 1997 to 2005; however in 2006 and 2007 the maximum NO_3-N concentration has increased (Figure 4). The maximum NO_3-N detections from 2006 and 2007 in Figure 4 occurred in a well located approximately 2 miles southeast of Rupert.

Table 1. Nitrate results for Minidoka County Alluvial Aquifer regional project, 1997-2007.[1]

Concentration Range (mg/L)	1997 34 Wells	1998 34 Wells	1999 34 Wells	2000 34 Wells	2001 34 Wells	2002 34 Wells	2003 34 Wells	2004 34 Wells	2005 34 Wells	2006 34 Wells	2007 34 Wells
<Laboratory Detection Limit	0	0	0	0	0	0	0	1	1	1	3
Laboratory Detection Limit - <2.0	7	7	8	7	9	11	10	9	7	8	7
2.0 to <5.0	12	14	15	10	12	12	14	13	15	10	12
5.0 to 10.0	13	11	11	15	13	10	10	11	11	14	10
>10.0	2	2	0	2	0	1	0	0	0	1	2
Mean Value	4.78	4.82	4.26	5.1	4.29	3.98	3.74	3.87	3.87	4.27	4.35
Median Value	4.25	4.64	3.8	4.88	3.72	3.25	3.4	3.15	3.59	3.94	3.95
Maximum Value	11.4	12.9	10	10.1	9.76	11	8.8	8.9	7.98	11	16

[1]The 34 wells used in Table 1 were sampled consistently for all eleven sampling years. Approximately 45 wells were sampled per year; however, only wells that have been sampled every year were used in this table.

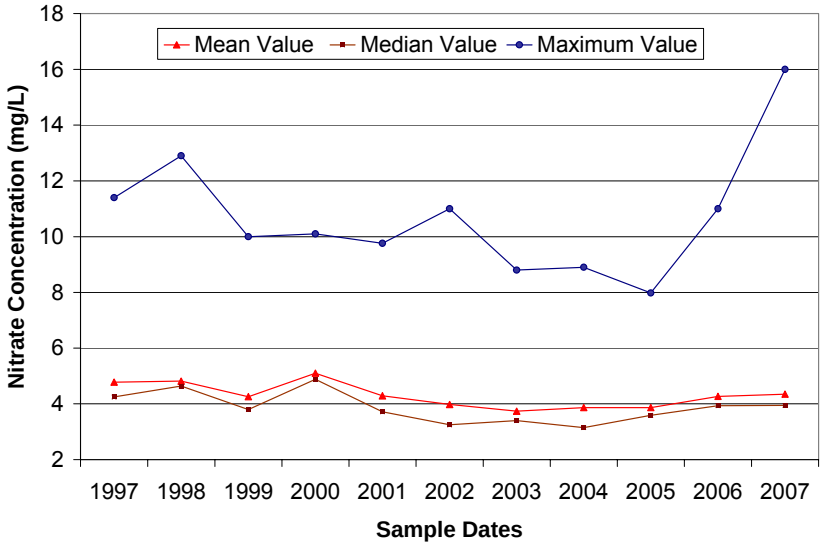

Figure 4. Time series plot of mean, median, and maximum nitrate values for the 34 consistently sampled wells from 1997 through 2007.

A total of 41 wells were sampled in 2007. Four of these wells had NO_3-N concentrations above 10 mg/L (Figure 5). Out of the 41 wells sampled in 2007, the largest detection of NO_3-N was 25 mg/L in a well located approximately five miles west of Heyburn. The detections over the EPA MCL of 10 mg/L for NO_3-N are of concern because of potential health risks.

Pesticides

Samples were collected in 1997 and sent to the WDOE Laboratory in Manchester, Washington. Testing for pesticides was accomplished utilizing EPA Methods 1618 and SW8150 with very low laboratory detection limits. In 1999, 2001, and 2004 samples were sent to the University of Idaho Analytical Sciences Laboratory (UIASL) in Moscow, Idaho for pesticide analysis. Samples were tested for various pesticides utilizing modified EPA Methods 507, 508, 515.1, 515.2, 531.1, and 632.

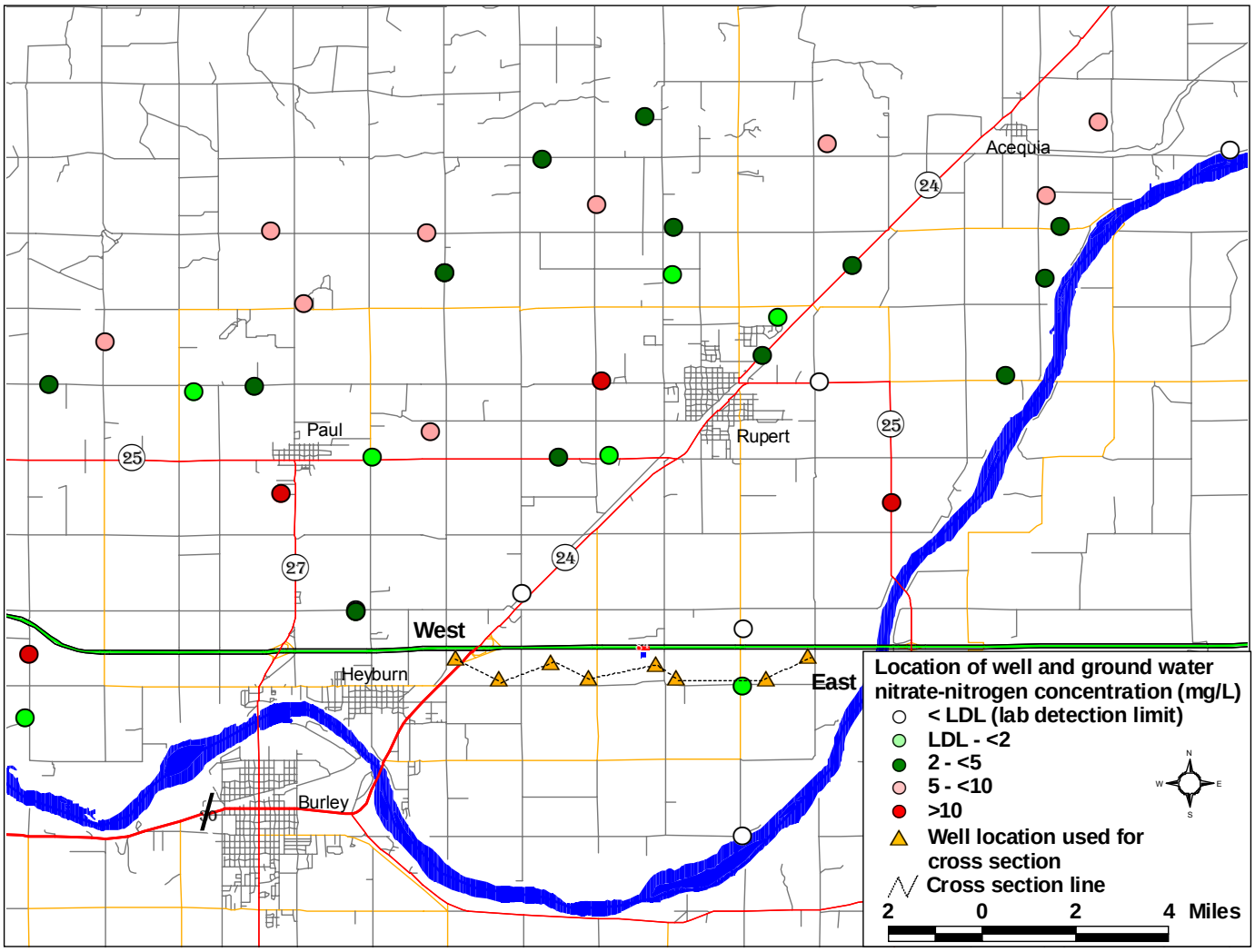

Figure 5. Location of wells sampled by ISDA in Minidoka County and geologic cross section line. Colors represent NO_3-N concentration measured in ground water from each well during ISDA 2007 sampling.

In 1997, 43 wells were sampled for pesticides (Table 2). Analysis of samples detected the presence of the following, in order from most to least frequently detected: atrazine, desethyl atrazine, simazine, bromacil, prometon, metribuzin, propazine, desisopropyl prometon, diuron, desisopropyl atrazine, alachlor, benzene, EPTC, hexazinone, and triallate. There were a total of 121 pesticide detections in 36 wells during 1997. All of the detections were below any EPA health standards. Two wells had a pesticide that was detected between 20% to 50% of the health standard, which are Level 2 detections in accordance with IDAPA 02.03.01 Idaho Pesticide Management Plan for Ground Water Protection Rule (PMP Rule). One well, located south of Paul, had a Level 2 atrazine detection; the other well, located west of Heyburn, had a Level 2 diuron detection. The Idaho PMP Rule outlines processes to protect ground water from pesticides based on the concentration of the detection in the ground water compared to a health standard. When a pesticide is detected in the ground water at a Level 2, ISDA will follow the processes outlined in the PMP Rule, including follow up monitoring of the well. Both wells that had a pesticide detected at a Level 2 concentration were resampled, and all follow up samples dropped to a Level 1 concentration, or less than 20% of the health standard. Level 1 is the lowest detection concentration of the PMP Rule. In addition to Level 1 and Level 2 concentrations, the PMP Rule establishes Level 3 detections (50% to 100% of the health standard) and Level 4 detections (the concentration exceeds the health standard and is not safe to drink). There were no Level 3 or 4 detections during 1997.

In 1999, 43 wells were tested for pesticides (Table 3). The pesticides detected included the following, in order

Table 2. Pesticide results for Minidoka County alluvial aquifer regional project, 1997.

Pesticide Detects	Number of Detects	Range (µg/L)	Mean Value of Detects (µg/L)	Median Value of Detects (µg/L)	Health Standard (µg/L)
Alachlor	1	0.042	-----	-----	2 (MCL)[1]
Atrazine	31	0.001 - 0.680	0.048	0.013	3 (MCL)
Benzene	1	0.32	-----	-----	5 (MCL)
Bromacil	10	0.004 - 3.10	0.44	0.08	70 (HAL)[2]
Desethyl Atrazine	28	0.002 - 0.27	0.02	0.007	-----[3]
Desisopropyl Atrazine	2	0.006 - 0.086	0.046	0.046	-----[3]
Desisopropyl Prometon	3	0.011 - 0.050	0.029	0.027	-----[4]
Diuron	3	0.020 - 9.20	3.157	0.25	21 (RfD)[5]
EPTC	1	0.038	-----	-----	175 (RfD)
Hexazinone	1	0.003	-----	-----	400 (HAL)
Metribuzin	5	0.001 - 0.007	0.004	0.004	70 (HAL)
Prometon	9	0.001 - 0.490	0.086	0.016	100 (HAL)
Propazine	4	0.003 - 0.100	0.029	0.006	100 (HAL)
Simazine	21	0.001 - 0.430	0.037	0.012	4 (MCL)
Triallate	1	0.027	-----	-----	0.45 (DWLOC)[6]

[1]MCL - EPA Maximum Contaminant Level

[2]HAL - EPA Lifetime Health Advisory

[3]Breakdown product of atrazine, MCL for atrazine (3 mg/L) is used as health standard.

[4]Breakdown product of prometon, HAL for prometon (100 mg/L) is used as health standard.

[5]RfD - EPA Reference Dose

[6]DWLOC - EPA Drinking Water Level of Comparision

Table 3. Pesticide results for Minidoka County alluvial aquifer regional project, 1999.

Pesticide Detects	Number of Detects	Range (µg/L)	Mean Value of Detects (µg/L)	Median Value of Detects (µg/L)	Health Standard (µg/L)
Atrazine	22	0.029 - 0.23	0.053	0.044	3 (MCL)[1]
Bentazon	2	1.10 - 2.90	2.0	2.0	200 (HAL)[2]
Bromacil	1	4.90	4.90	4.90	70 (HAL)
Cycloate	1	0.36	0.36	0.36	47.2 (DWLOC)[3]
Dacthal (DCPA)	1	0.25	0.25	0.25	70 (HAL)
Diuron	1	1.40	1.40	1.40	21 (RfD)[4]
Prometon	4	0.060 - 0.130	0.081	0.066	100 (HAL)
Propazine	1	0.027	0.027	0.027	100 (HAL)
Simazine	17	0.021 - 0.810	0.115	0.05	4 (MCL)

[1]MCL - EPA Maximum Contaminant Level

[2]HAL - EPA Lifetime Health Advisory

[3]DWLOC - EPA Drinking Water Level of Comparision for most sensitive subgroup (Children 3 - 5 years old).
Cycloate DWLOC for U.S. General Population is 171 µg/L.

[4]RfD - EPA Reference Dose

from most to least frequently detected: atrazine, simazine, prometon, bentazon, bromacil, cycloate, dacthal (DCPA), diuron, and propazine. There were a total of 50 pesticide detections in 29 wells during 1999. All of the detections were below any EPA health standards. One well, located southwest of Rupert, had a Level 2 simazine detection. The well was resampled, and all follow up samples dropped to a Level 1 concentration. A potential reason for fewer pesticide detections in 1999 versus 1997 is the higher laboratory detection limits utilized by the UIASL as compared to WDOE Laboratory. For example, the WDOE detected atrazine, simazine and desethyl atrazine at concentrations of 0.005 μg/L, 0.001 μg/L, and 0.002 μg/L, respectively. In comparison, at UIASL the minimum detection level for atrazine, simazine, and desethyl atrazine is 0.025 μg/L.

In 2001, 44 wells were tested for pesticides (Table 4). The pesticides detected included the following, in order from most to least frequently detected: desethyl atrazine, atrazine, bromacil, simazine, dacthal (DCPA), desisopropyl atrazine, diuron, hexazinone, metolachlor, and prometon. There were a total of 41 pesticide detections in 23 wells during 2001. All detections were below any EPA health standards and were at Level 1 concentrations.

In 2004, 44 wells were sampled for pesticides (Table 5). The pesticides detected included the following, in order from most to least frequently detected: desethyl atrazine, atrazine, diuron, simazine, hexazinone, prometon, and desisopropyl atrazine. There were a total of 32 pesticide detections in 20 wells during 2004. Most of the detections occurred north of Paul and Rupert (Figure 6). All detections were below any EPA health standards and were at Level 1 concentrations.

Table 4. Pesticide results for Minidoka County alluvial aquifer regional project, 2001.

Pesticide Detects	Number of Detects	Range (μg/L)	Mean Value of Detects (μg/L)	Median Value of Detects (μg/L)	Health Standard (μg/L)
Atrazine	10	0.028 - 0.33	0.08	0.041	3 (MCL)[1]
Bromacil	5	0.11 - 0.44	0.22	0.18	70 (HAL)[2]
Dacthal (DCPA)	4	0.39 - 4.20	1.90	1.5	70 (HAL)
Desethyl Atrazine	12	0.026 - 0.55	0.080	0.35	-----[3]
Desisopropyl Atrazine	1	0.28	0.28	0.28	-----[3]
Diuron	1	0.50	0.50	0.50	21 (RfD)[4]
Hexazinone	1	0.17	0.17	0.17	400 (HAL)
Metolachlor	1	0.099	0.099	0.099	700 (HAL)
Prometon	1	0.65	0.65	0.65	100 (HAL)
Simazine	5	0.027 - 0.40	0.13	0.081	4 (MCL)

[1]MCL - EPA Maximum Contaminant Level

[2]HAL - EPA Lifetime Health Advisory

[3]Breakdown product of atrazine, MCL for atrazine (3 mg/L) is used as health standard.

[4]RfD - EPA Reference Dose

Table 5. Pesticide results for Minidoka County alluvial aquifer regional project, 2004.

Pesticide Detects	Number of Detects	Range (μg/L)	Mean Value of Detects (μg/L)	Median Value of Detects (μg/L)	Health Standard (μg/L)
Atrazine	8	0.025 - 0.15	0.055	0.0385	3 (MCL)[1]
Desethyl Atrazine	10	0.027 - 0.35	0.0638	0.033	-----[2]
Desisopropyl Atrazine	1	0.16	-----	-----	-----[2]
Diuron	4	0.026 - 0.41	0.167	0.116	21 (RfD)[3]
Hexazinone	3	0.087 - 0.18	0.126	0.11	400 (HAL)[4]
Prometon	2	0.059 - 0.29	0.175	0.175	100 (HAL)
Simazine	4	0.021 - 0.21	0.081	0.046	4 (MCL)

[1]MCL - EPA Maximum Contaminant Level

[2]Breakdown product of atrazine, MCL for atrazine (3 μg/L) is used as health standard.

[3]RfD - EPA Reference Dose

[4]HAL - EPA Lifetime Health Advisory

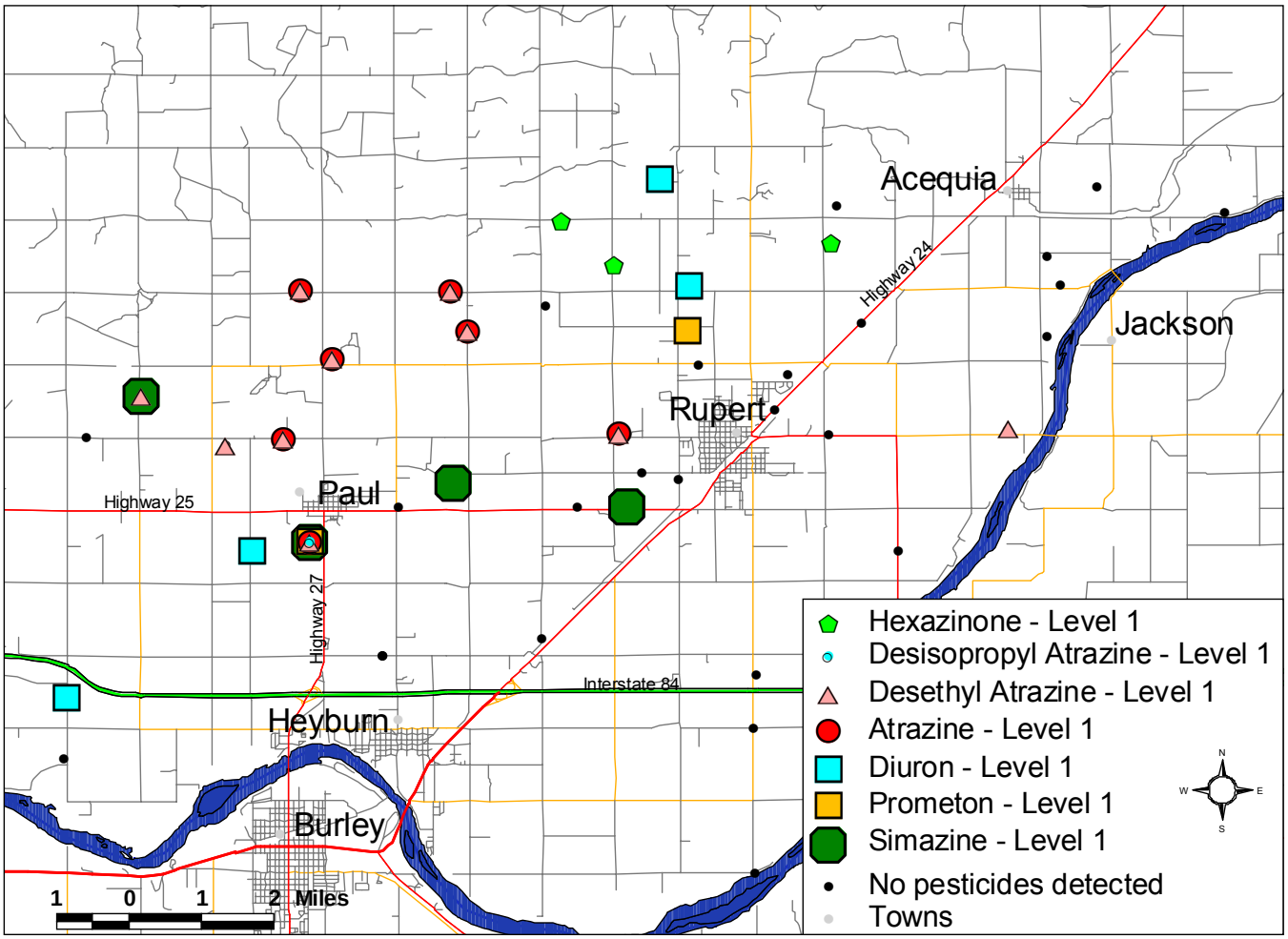

Figure 6. Pesticide detections for Minidoka County alluvial aquifer regional project, 2004.

Nitrogen and Oxygen Isotopes

Overview

The ratio of the common nitrogen isotope ^{14}N to its less abundant counterpart ^{15}N relative to a known standard (denoted $\delta^{15}N$) can be useful in determining sources of NO_3-N. Common sources of NO_3-N in ground water are from applied commercial fertilizers, animal or human waste, precipitation, legume crops, and organic nitrogen within the soil. Each of these NO_3-N source categories has a potentially distinguishable nitrogen isotopic signature. Typical $\delta^{15}N$ ranges for fertilizer is –5 per mil ($^0/_{00}$) to +5 $^0/_{00}$, while typical waste sources have ranges greater than $10^0/_{00}$ (Kendall and McDonnell, 1998). Nitrogen isotope values between $5^0/_{00}$ and $10^0/_{00}$ are generally believed to indicate an organic or mixed source (Kendall and McDonnell, 1998).

Use of nitrogen isotopes as the sole means to determine NO_3-N sources should be done with great care. Nitrogen isotope values in ground water can be complicated by several reactions (e.g., ammonia volatilization, nitrification, denitrification, plant uptake, etc.) that can modify the $\delta^{15}N$ values (Kendall and McDonnell, 1998). Furthermore, mixing of sources along shallow flowpaths makes determination of sources and extent of denitrification very difficult (Kendall and McDonnell, 1998).

^{18}Oxygen (^{18}O) fractionization of the nitrate molecule together with $\delta^{15}N$ can be used to trace the effects of denitrification (Clark and Fritz, 1997). Denitrification results in enrichment of both $\delta^{15}N$ and $\delta^{18}O_{NO_3}$. By analyzing both $\delta^{15}N$ and $\delta^{18}O_{NO_3}$, denitrification effects can be distinguished from mixing sources since the ratio of enrichment in $\delta^{15}N$ to $\delta^{18}O_{NO_3}$ is about 2:1 (Kendall et. al, 1995).

Findings

In 2000 through 2005, ISDA conducted $\delta^{15}N$ testing as a possible indicator of source(s) of NO_3-N in the ground water. Wells chosen for $\delta^{15}N$ testing had elevated NO_3-N concentrations in previous monitoring rounds. Six wells were tested in 2000, four wells were tested in 2001, 15 wells were tested in 2002, 14 wells were tested in 2003 and 2005, and 12 wells were tested in 2004. Table 6 presents the $\delta^{15}N$ results along with NO_3-N concentrations. The data for $\delta^{15}N$ testing from 2000

Table 6. $\delta^{15}N$ and $\delta^{18}O_{NO_3}$ results for selected wells, 2000 through 2005. $\delta^{15}N$ values highlighted in green suggest a possible fertilizer source of NO_3-N, $\delta^{15}N$ values highlighted in orange suggest a possible waste source of NO_3-N. $\delta^{15}N$ values not highlighted suggest a mixed or organic source of NO_3-N.

	2000 Data		2001 Data			2002 Data			2003 Data		2004 Data		2005 Data	
Well ID	NO_3-N (mg/L)	$\delta^{15}N$ ($^0/_{00}$)	NO_3-N (mg/L)	$\delta^{15}N$ ($^0/_{00}$)	$\delta^{18}O_{NO_3}$ ($^0/_{00}$)	NO_3-N (mg/L)	$\delta^{15}N$ ($^0/_{00}$)	$\delta^{18}O_{NO_3}$ ($^0/_{00}$)	NO_3-N (mg/L)	$\delta^{15}N$ ($^0/_{00}$)	NO_3-N (mg/L)	$\delta^{15}N$ ($^0/_{00}$)	NO_3-N (mg/L)	$\delta^{15}N$ ($^0/_{00}$)
7300201	9.32	NT[1]	8.64	NT[1]	NT[1]	8.3	5.491	6.485	8.6	NT[1]	8.5	5.79	7.98	7.71
7300601	5.62	NT[1]	5.06	NT[1]	NT[1]	4.3	8.552	1.483	4.4	6.410	4.5	NT[1]	4.1	NT[1]
7300701	10.1	NT[1]	9.6	6.118	5.160	8.1	6.304	3.429	7.9	5.45	8.5	5.72	7.9	7.12
7300901	7.97	NT[1]	7.25	11.872	3.443	7.4	15.586	5.684	4.2	9.13	2.9	NT[1]	3.58	12.93
7301101	7.06	NT[1]	6.68	NT[1]	NT[1]	6.5	4.614	1.960	6.5	8.3	6.9	5.94	5.65	6.49
7301601	9.39	4.81	8.51	NT[1]	NT[1]	8.1	6.870	1.232	7.4	7.13	7.2	7.23	6.0	7.17
7301801	5.78	NT[1]	5.35	NT[1]	NT[1]	4.7	6.284	1.918	4.6	NT[1]	5.3	NT[1]	4.0	6.59
7301901	5.51	NT[1]	1.64	NT[1]	NT[1]	2.2	NT[1]	NT[1]	5.6	NT[1]	5.2	11.42	7.2	10.92
7302601	NT[1]	NT[1]	18.9	NT[1]	NT[1]	12	5.179	3.303	8.8	8.53	NT[1]	NT[1]	NT[1]	NT[1]
7302701	9.8	8.68	9.15	10.397	2.197	9.8	5.665	0.215	8.8	8.45	8.9	5.33	7.9	6.5
7302801	10.1	8.42	9.76	NT[1]	NT[1]	7.9	3.209	0.695	7.2	13.82	8.4	NT[1]	7.9	15.99
7303101	3.02	NT[1]	3.08	10.797	10.711	3	NT[1]	NT[1]	3.3	NT[1]	3.5	NT[1]	3.6	NT[1]
7303201	24.1	12.28	23.7	NT[1]	NT[1]	33	9.511	3.731	14	17.64	28	8.88	9.7	10.19
7303901	8.32	NT[1]	7.16	NT[1]	NT[1]	5.4	4.032	2.721	7.5	7.86	6.8	3.49	5.9	5.09
7304101	9.53	8.12	7.85	NT[1]	NT[1]	8	6.331	3.588	7.1	9.2	11	5.22	12	NT[1]
7304201	4.67	NT[1]	3.72	NT[1]	NT[1]	3.4	NT[1]	NT[1]	3.4	7.24	3.8	NT[1]	3.9	NT[1]
7304301	7.2	4.45	5.67	NT[1]	NT[1]	11	4.799	3.051	5.0	7.33	7.2	3.84	7.5	3.45
7304401	3.56	NT[1]	2.74	NT[1]	NT[1]	3	NT[1]	NT[1]	5.6	NT[1]	6.3	18.43	4.5	19.32
7304501	7.32	NT[1]	5.86	NT[1]	NT[1]	5.5	12.512	3.141	6.2	7.83	7.7	5.33	7.8	6.98

[1]NT - Not tested

through 2002 are summarized in the ISDA Technical Results Summary #18 (Fox and Carlson, 2003).

The 14 water samples collected in 2003 were sent to the University of Idaho Stable Isotope Laboratory for $\delta^{15}N$ analysis. Results of the $\delta^{15}N$ testing returned values that ranged from $5.45^0/_{00}$ to $17.64^0/_{00}$ (Table 6). Two wells had values that suggested an animal or human waste source; one was located west of Heyburn while the other was located south of Paul. The remaining 12 wells had $\delta^{15}N$ values that indicated an organic or mixed source of NO_3-N.

The 12 water samples collected in 2004 were sent to the University of Idaho Stable Isotope Laboratory for $\delta^{15}N$ analysis. Results of the $\delta^{15}N$ testing returned values that ranged from $3.49^0/_{00}$ to $18.43^0/_{00}$ (Table 6). Two wells had values that suggested an animal or human waste source; one was located between Paul and Rupert while the other was located southeast of Rupert. Two wells had $\delta^{15}N$ values that suggested a fertilizer source for the NO_3-N; both were located approximately 2 miles north of Rupert. The remaining 8 wells had $\delta^{15}N$ values that indicated an organic or mixed source of NO_3-N.

The 14 water samples collected in 2005 were sent to the University of Idaho Stable Isotope Laboratory for $\delta^{15}N$ analysis. Results of the $\delta^{15}N$ testing returned values that ranged from $3.45^0/_{00}$ to $19.32^0/_{00}$ (Table 6). Figure 7 shows the location of the wells sampled and the corresponding $\delta^{15}N$ value. One well had a $\delta^{15}N$ value that suggested a fertilizer source for NO_3-N, and was located approximately 2 miles north of Rupert (Figure 7). Five wells had values that suggested an animal or human waste source; two were located between Paul and Rupert, one was located southeast of Rupert, one was located south of Paul, and one was located west of Heyburn (Figure 7). The remaining seven wells had $\delta^{15}N$ values that indicated an organic or mixed source of NO_3-N.

Four water samples were collected in 2001 and 15 water samples were collected in 2002 at sites in which $\delta^{15}N$ was also sampled and sent to the NCSU Stable Isotope Laboratory for $\delta^{18}O_{NO_3}$ analysis (Table 6). Results of the $\delta^{18}O_{NO_3}$ analysis are summarized in the ISDA Technical Results Summary #18 (Fox and Carlson, 2003). The linear regression analysis of $\delta^{15}N$ and $\delta^{18}O_{NO_3}$ data completed by Fox and Carlson (2003) indicate that denitrification was not a significant source of isotope enrichment. The process of denitrification is thought to

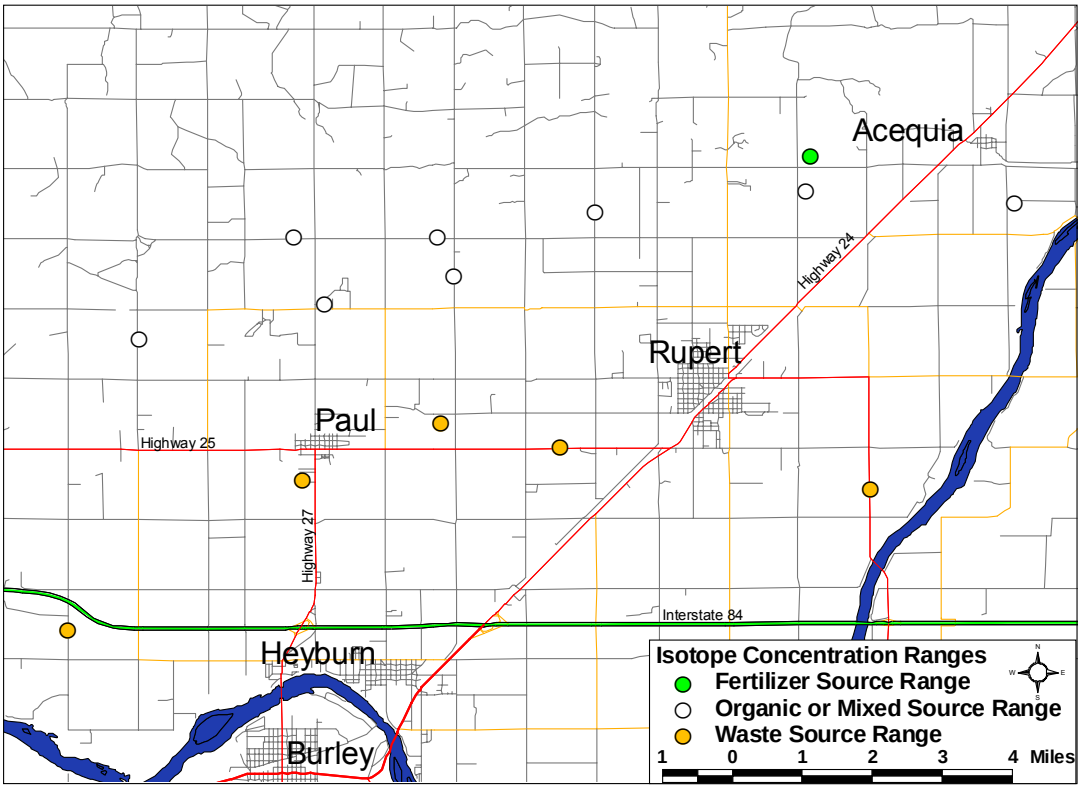

Figure 7. Location of wells sampled by ISDA in Minidoka County, 2005 for nitrogen isotope analysis. Colors represent possible sources of nitrate-nitrogen in ground water from each well based on $\delta^{15}N$ testing.

enrich $\delta^{15}N$ and $\delta^{18}O_{NO_3}$ by 2:1 (Kendall et. al, 1995). Waste from animal operations and septic tanks in the project area could be a source of $\delta^{15}N$ values greater than $10^{0}/_{00}$ detected within the wells.

Conclusions

Ground water within the Minidoka County alluvial aquifer is being impacted from NO_3-N and pesticides. The median NO_3-N concentration for the statistically assessed wells for 2007 was 3.95 mg/L. Four wells tested in 2007 had a NO_3-N concentration over the EPA MCL of 10 mg/L. Areas of elevated NO_3-N concentrations are located west of Heyburn, and the area surrounding Paul and Rupert. Median nitrate concentrations in ground water from 1997 to 2007 indicate stable NO_3-N levels in the 34 wells that have been sampled every year. The most recent $\delta^{15}N$ data from 2005 suggests that there are a variety of NO_3-N sources, including fertilizer (1 well), human or animal waste (5 wells), and organic or mixed (7 wells).

The number and variety of pesticide detections has declined since the beginning of the project. Although concentrations of pesticide detections were generally low, there is concern about multiple pesticide detections per well. Health risks associated with consuming low level concentrations of multiple pesticide compounds is poorly understood.

Agricultural practices likely contribute to the NO_3-N and pesticide concentrations in the ground water of this project area. Testing results indicate NO_3-N and pesticide impacts to the Minidoka County alluvial aquifer are widespread. This is common in irrigated agricultural areas with agrichemical input overlying a shallow alluvial aquifer. Leaching of applied commercial fertilizers, legume crops, and waste are potentially major causes of NO_3-N entering the ground water.

Recommendations

To determine if current farming practices are contributing to ground water degradation and to locate other potential contaminant sources, the ISDA recommends continued and more intensive monitoring in the project area.

Testing should include, but not be limited to:

- Continued ground water monitoring for nutrients, common ions, and pesticides.
- Soil sampling and soil pore water sampling.
- Analysis of farm practices in the project area, including nutrient and pesticide applications, irrigation practices, and agricultural best management practices (BMP).

- Further evaluation of wells that have had $\delta^{15}N$ trends.
- Further determination of NO_3-N sources.

Currently, the Minidoka County Ground Water Quality Management Plan Advisory Committee is meeting to address nitrate contamination of the Minidoka County alluvial aquifer. The committee is comprised of agency personnel, local municipalities, businesses and residents with the goal of developing a ground water management plan to address the different sources of nitrate entering the ground water. After the Minidoka County Ground Water Quality Management Plan Advisory Committee finalizes its report and recommendations, ISDA encourages all residents to read the report to determine what actions they can take to decrease their potential nitrate impact to the alluvial aquifer.

The ISDA further recommends that measures to reduce NO_3-N and pesticide impacts on ground water be addressed and implemented. The ISDA recommends that:

- Growers and agrichemical professionals conduct nutrient, pesticide, and irrigation water management evaluations.
- Producers follow the Idaho Agricultural Pollution Abatement Plan and Natural Resources Conservation Service Nutrient Management Standard.
- Producers and agrichemical dealers evaluate their storage, mixing, loading, rinsing, containment, and disposal practices.
- Homeowners assess lawn and garden practices, especially near wellheads.
- Local residents assess animal waste management practices.
- State and local agencies assess impacts from private septic systems.
- Home and garden retail stores establish outreach programs to illustrate proper application and management of nutrients and pesticides.
- Responsible parties assess current pesticide application practices to non-crop areas (such as roadsides, railroad areas, etc.).

The ISDA recommends that the Minidoka Soil and Water Conservation District lead a response process to create a plan of action to address these ground water contamination issues. Some actions that could be beneficial to ground water protection would be irrigation water management and soil sampling. The soil and water conservation district should work with local agrichemical professionals, landowners, and agencies to implement this process and seek funding to support these efforts. The ISDA will support these local partners in seeking funding and implementing a comprehensive program.

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