Idaho State Department of Agriculture
Division of Agricultural Resources

Ground Water Quality of Lower Boise Basin Regional Aquifer

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Introduction

The Idaho State Department of Agriculture (ISDA) developed the Agricultural Regional Ground Water Quality Monitoring Program to characterize degradation of ground water quality from contaminants leaching from agricultural sources. The ISDA has fifteen regional monitoring projects (Figure 1), thirteen of which are active. The objective of the program is to characterize nitrates and pesticides in the ground water, relate the data to agricultural land use practices, and provide data for Best Management Practices (BMPs) and/or regulatory implementation and evaluation.

The ISDA Lower Boise Basin regional monitoring project began in 2003 as a result of previous monitoring by the Idaho Department of Water Resources (IDWR). Several wells had nitrate concentrations that exceeded the Environmental Protection Agency (EPA) Maximum Contaminant Level (MCL)[1] of 10 milligrams per liter (mg/L). To establish this regional monitoring project, the ISDA randomly selected domestic wells in the area and coordinated with homeowners to conduct ground water sampling.

Nitrates, pesticides and common ions were evaluated during the four years (2003 through 2006) of ISDA's sampling efforts. Laboratory results have indicated that numerous domestic wells located within the project area have nitrate levels that suggest some type of land use influence on the ground water.

Description of Area

The Boise Valley Shallow regional monitoring project area is located in southwest Idaho, north of the Snake River (Figure 1). The 63 randomly selected wells are distributed through western Ada County, southern Payette County, the southwest corner of Gem County, and throughout most of Canyon County (Figures 1 and 2). The wells selected were believed to be representative of the upper ground water systems down to 350 feet below the ground surface (bgs) within the study area. The area encompasses approximately 1,100 square miles of irrigated agricultural land, urban areas and rural residences. Irrigation water is provided by diversions from both the Boise River and the Snake River. However, ground water is also used for irrigation in this area for production agriculture. Major crops in the area include onions, corn, corn silage, potatoes, sugarbeets, hay, wheat, barley, beans and mint (Idaho Agricultural Statistics, 2005). There are also livestock operations that range in size from a few individual animals to several thousand head (Bahr et al., 2000).

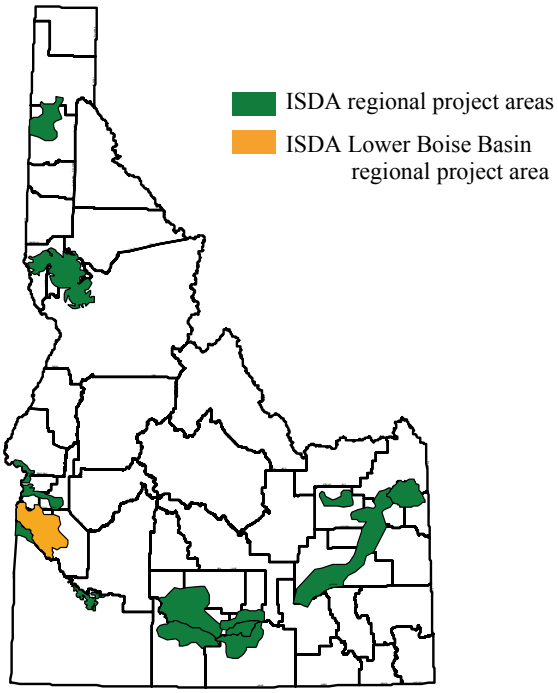

Figure 1. Location of Lower Boise Basin regional ground water monitoring project and other ISDA regional projects.

The hydrogeology throughout much of the project area can be characterized by two aquifers: a deep and shallow ground water zone, separated by a blue clay layer.

[1]MCLs represent the EPA health standard for drinking water.

The shallow ground water zone occurs in older terrace gravels, basalts of the Snake River Group, younger terrace gravels, and Quaternary alluvium. Recharge to the shallow zone is mainly from leakage of irrigation canals and laterals, downward percolation of applied irrigation water and precipitation, and downward percolation of domestic wastewater from septic tanks (Thomas and Dion, 1974). Other minor recharge sources include small streams, upward leakage of water from the deep aquifer, and natural leakage of ground water from outside the project area (Thomas and Dion, 1974). Most of the recharge occurs during April through October, which corresponds with the irrigation season (Dion, 1972). Water level highs occur in early fall (non-irrigated areas usually have high water levels in late spring) and lows occur during the spring (usual lows for non-irrigated areas occur in the fall). Petrich et al. (1999) calculated shallow zone transmissivities of less than 200,000 ft^2/day.

The deep aquifer is found in the blue or gray sand directly beneath the blue clay layer (Wood and Anderson, 1981). The blue clay is believed to be found throughout the project area between the depths of 300 to 700 feet below the ground surface and varies from a thickness of a few feet to a few hundred feet (Petrich et al., 1999). The clay acts as an aquitard separating the shallow aquifers from the deep aquifers (Petrich et al., 1999).

The direction of ground water movement is controlled largely by topography and surface drainage. Overall, regional ground water flow is towards the Boise River.

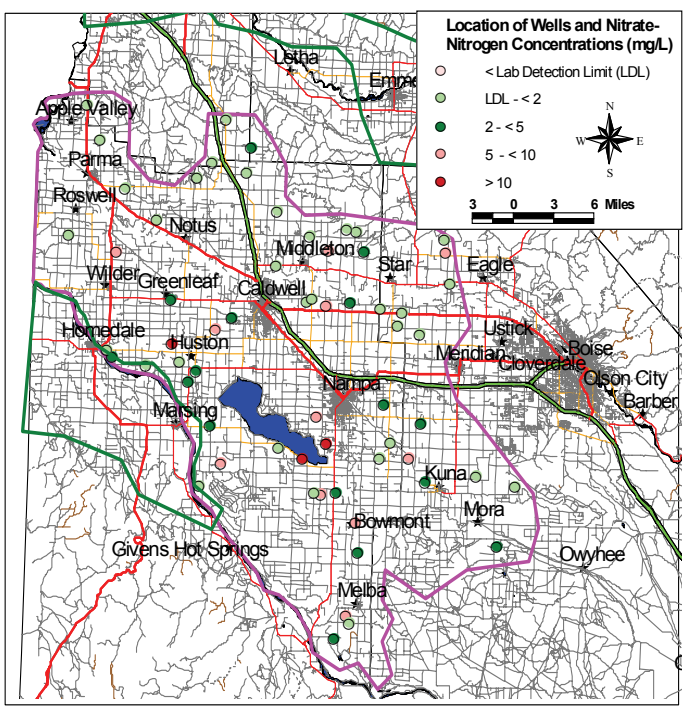

Figure 2. Location and nitrate concentrations of wells sampled in 2006.

Predominate soil type within northwest Ada County is the Feltham Series (Collett, 1980). This series is composed primarily of Feltham loamy fine sand with slopes ranging from 0 to 3% and 3 to 12%. This soil is very deep and rapidly drained. Permeability is rapid in the upper part of the profile and moderately rapid in the lower parts. The available water capacity is moderate. Runoff is slow and the hazard of erosion is slight. In most areas, the soil is used for irrigated crops and pasture. The rapid permeability is the major limitation to agriculture. Soils in western Ada County within the project area are described as poorly drained and well-drained including the following associations: Purdam-Abo-Power, Colthorp-Elijah-Purdam, Power-McCain-Purdam and Scism-Feltham-Garbutt according to the soil survey of Ada County Area Idaho.

The soil types within Canyon County range from well-drained silt loams to sandy loams to somewhat poorly drained and moderately well-drained fine sandy loams to silt loams.

Methods

ISDA statistically determined that sampling 63 domestic wells in the study area (Figure 2) would provide ground water quality results representative of the overall area. All sampling was conducted after a Quality Assurance Project Plan (QAPP) was established. Permission was gained from the home-owners prior to sampling.

Nutrients and common ions were evaluated each year during this project. Pesticides were evaluated during the first year (2003) of testing. Samples collected were sent to the University of Idaho Analytical Sciences Laboratory (UIASL) in Moscow, Idaho. The UIASL analyzed the ground water samples for nitrate, nitrite, ammonia, ortho-phosphorous, chloride, sulfate, bromide, fluoride using EPA Methods 300.0 and 350.1, and pesticides using EPA Methods 507, 508, 515.2, and 632.

Duplicates, splits, and matrix spikes/matrix spike duplicates were collected and submitted as part of the QAPP.

Results

Sampling results indicate moderate nitrate impacts to the broader aquifer. Results are summarized and presented in the following sections. The 63 wells selected for this project were sampled in 2003. In 2004, 2005 and 2006, some wells were not tested

and 62, 61 and 59 wells were sampled, respectively. Only the 58 wells that were sampled all four years were analyzed for the purpose of writing this report.

Nitrate

Results of ground water sampling in the project area suggested an average yearly mean and average yearly median nitrate value of 2.9 and 1.8 mg/L for the 2003 to 2006 time period, respectively, with an overall high value of 14 mg/L (Table 1) in 2006. The yearly average or mean had been increasing each year since 2003; however, in 2006 the yearly mean remained constant at 3.0 mg/L. The yearly median had also been increasing each year until it dropped from 2.0 to 1.7 mg/L (Table 1) in 2006.

In 2003, 47 (81%) wells tested below 5 mg/L for nitrate, 9 wells (approximately 15 %) had nitrate concentrations between 5 and 10 mg/L, and two wells (approximately 3%) tested greater than 10 mg/L.

In 2004, 10 (17%) tested below lab detection and were considered a non-detect (ND), 21 (37%) wells tested between ND and 2 mg/L, 16 wells (27%) tested between 2 and 5 mg/L, 9 wells (15%) tested between 5 and 10 mg/L and the same two wells that tested above the MCL of 10 mg/L in 2003 tested above the MCL in 2004.

In 2005, there were 9 wells (15%) with concentrations below the detection limit, 20 wells with concentrations above detection but less than 2 mg/L, 20 (34.5%) wells with concentrations between 2 and 5 mg/L and 6 wells (10%) with concentrations between 5 and 10 mg/L. The number of wells with concentrations above the MCL of 10 mg/L increased from two in 2004 to three in 2005. In 2006, 45 of the 58 wells sampled (approximately 78%) tested below 5 mg/L for nitrate, 11 wells (approximately 19%) had nitrate concentrations between 5 and 10 mg/L, and two wells (approximately 3%) tested greater than 10 mg/L (Table 1).

Nitrate concentrations are most elevated in the area northwest of Lake Lowell and south of Nampa (Figure 2). The detections over 10 mg/L are of concern because of potential health risks to the individuals drinking the water (Table 1).

Based on this monitoring, it is below the criteria (25% of wells are greater than 5 mg/L) for classification as a nitrate priority area. However, the number of wells with concentrations between 5 and 10 mg/L increased in 2006.

Table 1. ISDA nitrate results for the Lower Boise Basin regional project from 58 wells sampled each year.

General Statistics & Detections	2003	2004	2005	2006
Mean	2.7 mg/L	2.8 mg/L	3.0 mg/L	3.0 mg/L
Median	1.6 mg/L	1.8 mg/L	2.0 mg/L	1.7 mg/L
Max. Value	11 mg/L	11 mg/L	12 mg/L	14 mg/L
Non-Detects (ND)	10	10	9	9
ND - 2 mg/L	22	21	20	21
2 - 5mg/L	15	16	20	15
5 - 10mg/L	9	9	6	11
> 10mg/L	2	2	3	2

Pesticides

All 63 wells were tested for 119 pesticide compounds in 2003. Wells were tested for the following pesticide groups: chlorinated acid herbicides using EPA method 515.2, phenyl urea pesticides using EPA Method 632, OP and ON pesticides using EPA Method 507, and chlorinated pesticides using EPA Method 508.

Analysis of samples detected the presence of the pesticides atrazine, simazine, metolachlor, desethyl atrazine, bromacil and dacthal (DCPA) at relatively low levels (Table 2). All pesticides detected were at concentrations less than 20% of the health standards set by the EPA. The locations of the pesticide detections are shown in Figure 3.

Table 2. Pesticide detections in ground water from domestic wells within the project area for 2003.

Chemical Name	Trade Name	No. of Detections	Avg. Conc. (µg/L)	Max Conc. (µg/L)	Health Standard (µg/L)
Atrazine	Atrazine	5	0.07	0.11	3 µg/L(MCL)*
Bromacil	Hyvar, Krovar	1	0.05	0.05	70 µg/L (HAL)**
Dacthal	Dacthal	7	2.74	12	70 µg/L(HAL)**
Desethyl Atrazine	-----	13	0.07	0.23	3 µg/L***
Metolachlor	Dual Magnum, Pennant Magnum	1	0.13	0.13	100 µg/L (HAL)**
Simazine	Princep	1	0.02	0.02	4 µg/L(MCL)*

*MCL is the maximum contaminant level set by the EPA.
** HAL is the Health Advisory Level set by the EPA.
*** No health standard is available. Used parent compound Atrazine's health standard which is the MCL of 3 mg/L.

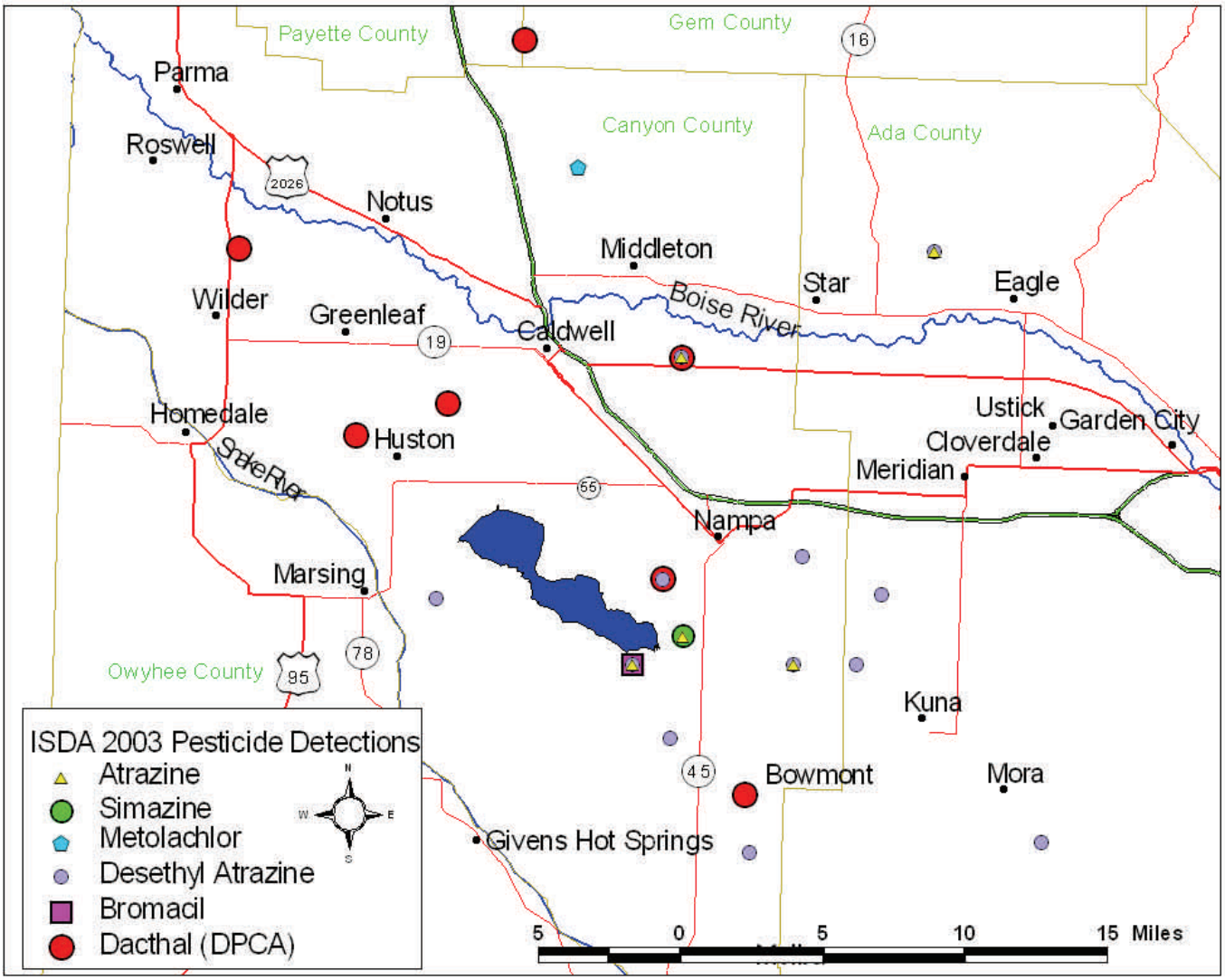

Figure 3. Locations of pesticide detections in 2003 within project area.

Nitrogen and Oxygen Isotopes

Overview

The ratio (denoted $\delta^{15}N$) of the common nitrogen isotope $_{14}N$ to its less abundant counterpart $_{15}N$ can be useful in determining sources of nitrate. Common sources of nitrate in ground water are from applied commercial fertilizers, animal or human waste, precipitation, residues from legume crops, and other organic nitrogen sources within the soil. Each of these nitrogen source categories may have a distinguishable nitrogen isotopic signature. Figure 4 illustrates ranges of $\delta_{15}N$ determined through numerous research studies. Typical $\delta_{15}N$ ranges for fertilizer and waste are –5 per mil ($^0/_{00}$) to +5$^0/_{00}$ and greater than 10, respectively. Numbers between 5$^0/_{00}$ and 10$^0/_{00}$ generally are believed to indicate an organic or mixed source. Use of nitrogen isotopes as the sole means to determine nitrate source should be done with great care. $\delta^{15}N$ values of fertilizer and animal waste in ground water can be complicated by several reactions (e.g., ammonia volatilization, nitrification, denitrification, ion exchange, and plant uptake) that can significantly modify the $\delta^{15}N$ values (Kendall and McDonnel, 1998). Furthermore, mixing of sources along shallow flowpaths makes determination of sources and extent of denitrification very difficult (Kendall and McDonnell, 1998).

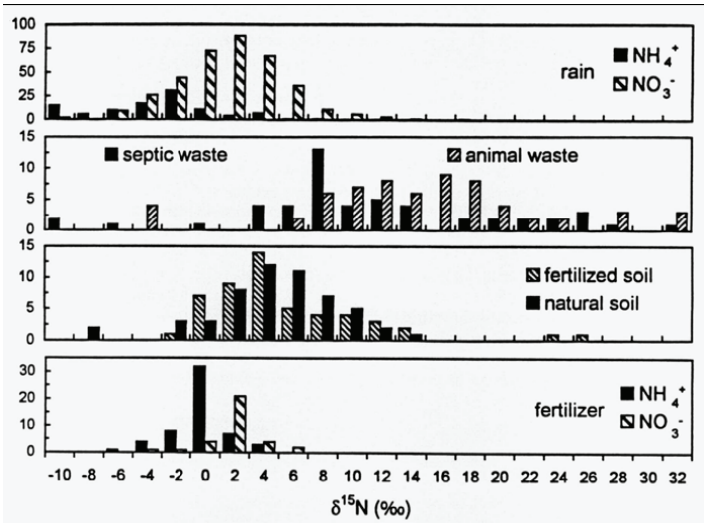

Figure 4. Ranges of $\delta^{15}N$ found in the hydrosphere based on a number of nitrogen isotope studies (after Kendall and McDonnell, 1998).

Findings

ISDA Water Program staff opted to implement $\delta^{15}N$ testing in order to use it as a possible indicator of source (s) of nitrate in the ground water. Because of the cost of testing and limited resources, only a portion of the wells in the area were selected for testing. This included all wells exceeding 10 mg/L for nitrate and a number of spatially distributed wells with nitrate detections above 5 mg/L (Table 3). Fourteen sites were initially selected in the study area to conduct isotope testing. Two additional wells were added in 2005, while four others were discontinued from the isotope testing. In 2003, three wells (2201901, 2203101, and 2206201) tested above 10$^0/_{00}$ for $\delta^{15}N$, which suggests a possible animal waste; however all three wells have shifted in nitrogen isotopic signature over time towards a possible organic or mixed source. The most recent data from 2005 indicates a potential fertilizer source for forty-two percent of the wells tested. The rest of the $\delta^{15}N$ results (58%) tested between 5$^0/_{00}$ and 10$^0/_{00}$, which suggests an organic or mixed source.

Table 3. Isotope results from 2003, 2004, and 2005.

Well ID	$\delta\ ^{15}N_{AIR}$ ($^0/_{00}$)		
	2003	**2004**	**2005**
2200101	7.489	5.408	5.507
2200201	5.981	5.078	2.338
2200301	7.843	3.978	3.576
2200701	9.820	6.067	------
2201301	9.891	------	5.715
2201501	8.111	5.700	5.296
2201901	10.861	5.819	------
2202901	-------	------	5.038
2203101	10.081	6.834	7.213
2203201	8.222	------	------
2203901	9.652	5.795	5.564
2204801	8.625	6.092	4.707
2205601	4.624	3.750	4.716
2205701	-----	-----	4.722
2205801	9.574	-----	-----
2206201	10.050	5.915	5.090

- - - - Sample was not taken.

Conclusions

Ground water monitoring results within the project area indicate that there are impacts occurring from nitrates. Mean ground water nitrate concentrations decreased in 2006, after two previous years of increasing. For each sampling year, less than 5% of the 63 wells sampled had nitrate concentrations exceeding the EPA MCL of 10 mg/L. The areas that had the highest nitrate concentrations were southwest of Nampa and around the town of Huston. The majority of wells sampled were less than 250 feet bgs.

Results indicate that nitrate impacts are greater in the area surrounding Lake Lowell. Potential sources of the

ground water nitrate contamination in the area include the application of nitrogen based fertilizers, crop residue, land application of manure, wastewater lagoons, livestock manure, and septic tanks.

Pesticide detections were generally low in concentration; however, there is concern about multiple pesticide detections per well. Pesticide detections mainly occur south of the Boise River and in the Lake Lowell area.

Recommendations

ISDA recommends continued monitoring and evaluation in the project area. ISDA also recommends the initiation of ground water quality education and the implementation of agricultural Best Management Practices (BMP). ISDA recommends that the local soil and water conservation districts lead a response process to create a plan of action to address these ground water contamination issues. ISDA will work with the Idaho Soil Conservation Commission and local Soil Conservation Districts to implement planning and BMP related projects after the plan of action and ground water plan has been created. ISDA will address pesticide issues for the area following ISDA response processes.

ISDA recommends a variety of actions to be taken by area landowners, producers, agencies and local governments to mitigate and prevent further contamination of the aquifer in the project area. Also, citizens living in the area and agencies should take measures associated with wells, well drilling, and drinking water management to prevent adverse health affects.

Agricultural, Agrichemical, and Animal Waste Management

ISDA recommends that measures to reduce nitrate and pesticide impacts on ground water be addressed and implemented. The ISDA recommends that:

- Producers and agrichemical professionals conduct nutrient, pesticide, and irrigation water management evaluations.
- Producers follow the Natural Resources Conservation Service (NRCS) Nutrient Management Standard (590) when using commercial fertilizers and/or animal waste.
- Producers and Confined Animal Feeding Operations (CAFOs) manage animal waste in a manner limiting impact to ground water. Ground water protection measures are necessary when storing, handling, hauling, and applying animal waste. For technical assistance, contact ISDA Engineers and certified nutrient management planners.
- Producers, noncrop applicators, and agrichemical dealers follow the NRCS 595 Pesticide Standard for pesticide storage, containment, mixing, loading, rinsing, disposal, and application practices in the project area.
- Pesticide products that are least likely to leach be chosen for the soil types in this project area.
- Producers consider utilizing Integrated Pest Management (IPM) techniques in this area.
- Applicators and homeowners assess lawn and garden practices, especially near wellheads.
- Applicators and homeowners apply pesticides according to the pesticide labels.
- Local residents assess animal and animal waste management situations near wellheads.
- Applicators assess current pesticide application practices to non-crop areas (examples: roadsides, canal banks, driveways, etc.).

Monitoring

To determine if current agricultural and pesticide application 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. Monitoring efforts could include, but not be limited to:

- The continuation of ground water monitoring from domestic wells to track changes over time related to nutrients, common ions, and pesticides.
- Conduct follow-up monitoring near areas of elevated nitrate concentrations.
- Conduct Best Management Practice effectiveness monitoring.
- Additional N^{15} isotope sampling and evaluation.

Private Well and Septic Tank Management

Domestic drinking water wells within the project area should be protected to provide the best possible drinking water. The ISDA suggests the following options:

- Residents sample their own wells for nitrate and bacteria on a regular basis, such as once per year.
- Activities near wellheads be done in a manner not to impact well water quality.
- Homeowners consider using the Home*A*Syst program to conduct self assessments related to wellhead protection.
- Construction of new wells or deepening of existing wells in the area be completed with the appropriate planning and design considerations to provide potable water.
- Homeowners manage private septic systems properly.

Ground Water Protection and BMP Response Effort

The ISDA recommends that the Ada and Canyon County Soil and Water Conservation Districts lead a coordinated local response process to create a plan of action to address these ground water contamination issues. The soil and water conservation districts should work with local land owners, agrichemical professionals, CAFO operators, county and city officials, and other agencies to implement this process and seek funding to support the implementation of these and other recommendations. The ISDA will support these local partners in seeking funding and implementing a comprehensive program.

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