Idaho Department of Agriculture - Idaho Department of Environmental Quality

Assessment of Water Quality in the Sunnyside Area Washington County, Idaho: 2006 Update

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Technical Results Summary #26 June 2006

Introduction

The Sunnyside monitoring project was implemented in 2002 by the Idaho State Department of Agriculture (ISDA) as a result of citizen concerns of possible ground water contamination in the area surrounding a confined animal feeding operation (CAFO) and onion disposal site (Figure 1). The Idaho Department of Environmental Quality (IDEQ) and ISDA have worked jointly on the project since 2004. The site is approximately 2 miles south of Weiser, Idaho, with local ground water flowing west towards the Snake River.

Ground water sampling events occur bi-annually in the spring and fall in domestic and monitoring wells. Twenty-four domestic wells have been sampled since 2002 and twelve monitoring wells have been sampled since 2004. Nutrients, common ions, dissolved metals, isotopes, bacteria, antibiotics, hormones, and pesticide ground water concentrations have been monitored over time.

In November 2005, laboratory results indicated a majority of wells (58%) in the project area had nitrate concentrations that exceeded the Environmental Protection Agency (EPA) Maximum Contaminant Level (MCL)[1] of 10 milligrams per liter (mg/L). In addition, a majority of wells had $\delta^{15}N$ isotope values that suggested an animal or human waste source of nitrate. Antibiotics and steroids are also present in the ground water in monitoring and domestic wells directly downgradient of the feedlot.

Soil samples were collected from five fields in December 2005 to evaluate potential nitrate impacts from land application of manure and fertilizers. The phosphorus threshold was exceeded at three fields upgradient of the feedlot and one field downgradient.

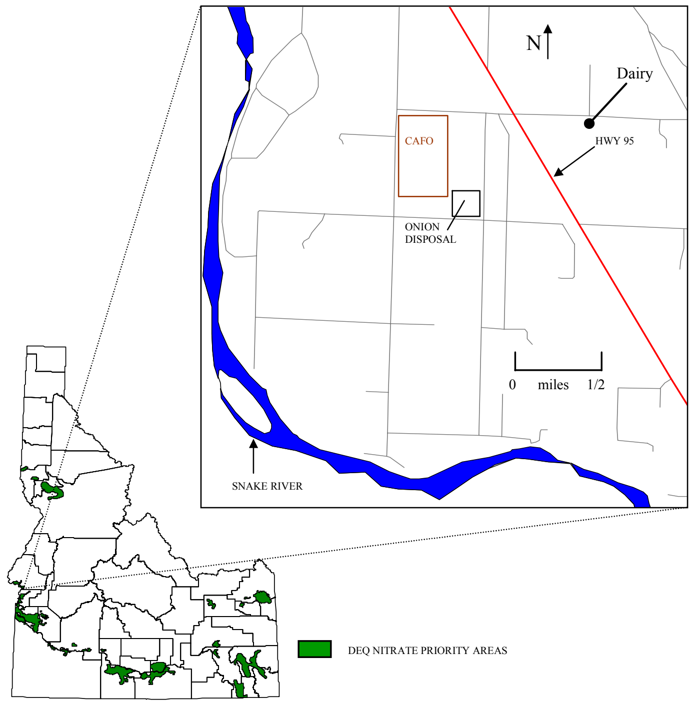

Figure 1. Sunnyside project area and location of DEQ nitrate priority areas

Description of Project Area

The Sunnyside project encompasses an approximately one mile wide and three mile long area of agricultural, commercial, and residential land adjacent to the Snake River (Figures 1 and 2). Land use in the area consists of irrigated agricultural fields, a confined animal feeding operation, a dairy operation, an onion disposal site, commercial businesses, and rural housing. Crops in the area include alfalfa, wheat, corn, and onions. Feedlot and dairy manure is applied to some agricultural fields within the project area.

Shallow ground water conditions exist across this area. Typically, depths to ground water are less than 20 feet. Potential sources of recharge to this shallow system include applied irrigation waters, canal leakage, and

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

precipitation. Shallow subsurface alluvial deposits (primarily sands and gravels) conducive to leaching underlie the Sunnyside area. Potential sources for nitrate leaching to ground water in the area include cattle manure, land applications of manure, wastewater lagoons, applied nitrogen-based fertilizers, rotations of legume crops, and septic systems.

Hydrogeology

The Sunnyside area lies within the western Snake River Plain, a basin filled with sedimentary deposits and volcanic rocks. The sedimentary deposits make up the major portion of the shallow aquifer in the project area (Figure 3). The majority of these sediments accumulated during prehistoric and historic Snake River deposition (Newton, 1991). Coarse-grained channel-type deposits may exist across the project area constituting preferential pathways for ground water flow and contaminant migration. The new monitoring wells were drilled through the upper aquifer, which is defined by the sand and gravel unit that lies above the extensive clay deposits of the Glenns Ferry Formation. The upper aquifer varies in thickness from 15 to 35 feet with ground water encountered at depths ranging from 11 to 31 feet below ground surface (Figure 3). Ground water in the upper

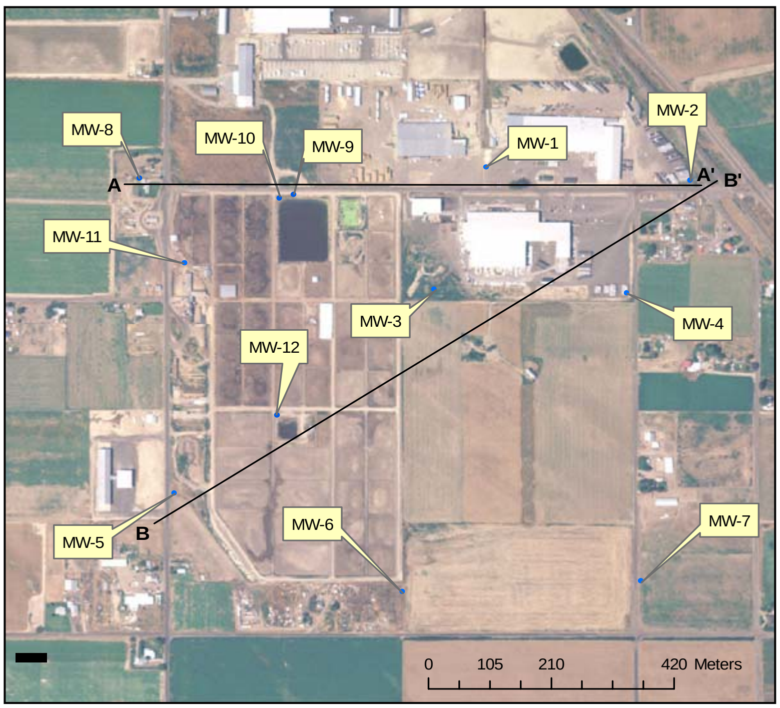

Figure 2. Monitoring Well Location Map

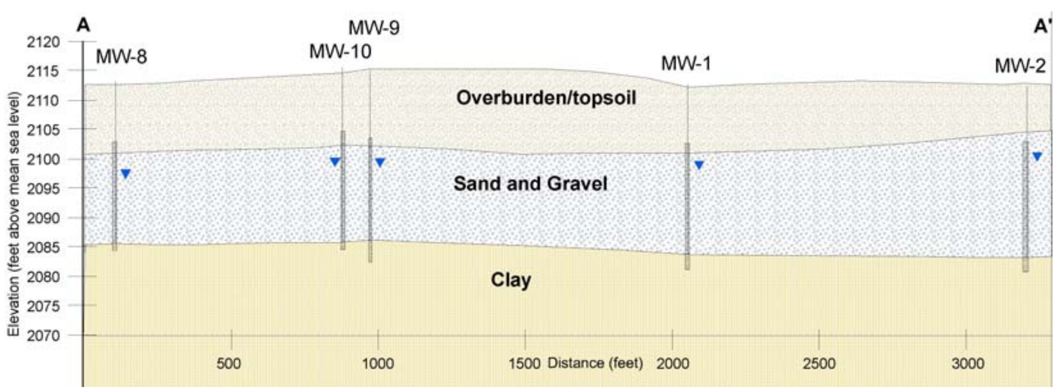

Figure 3. Geologic Cross-Section from A to A' (See location above)

aquifer of the study area is highly susceptible to contamination due to (1) high transmissivity materials (sand and gravel), (2) shallow depth to ground water, and (3) lack of a clay layer, or aquitard, overlying the aquifer.

A geologic cross-section has been constructed from the monitoring well logs (Figure 3). A majority of domestic wells are screened in the sand and gravel zone. A thick layer of blue clay underlies the shallow sand and gravel aquifer. The blue clay separates the shallow alluvial aquifer from the deeper sedimentary aquifer (Newton, 1991).

The elevations of the ground water monitoring wells installed at the site were surveyed to the nearest 0.01 feet by ISDA Engineering Services. Using the surveyed elevations and the ground water measurements collected during each sampling event, ground water flow direction and gradient was determined. The ground water in the vicinity of the feedlot flows from the east to west, towards the Snake River (Figure 4) with a relatively flat water table of approximately 0.0015 feet/foot.

Two ground water mounds that exist in the project area suggest additional recharge to the aquifer (Figure 4). The first mound exists directly downgradient of the large soil adsorption system used to treat the effluent septic waste from a home building facility. The second mound exists near a large run-off collection pond located on the feedlot property. The exact location and quantity of potential recharge to the system is unknown, based on the data collected.

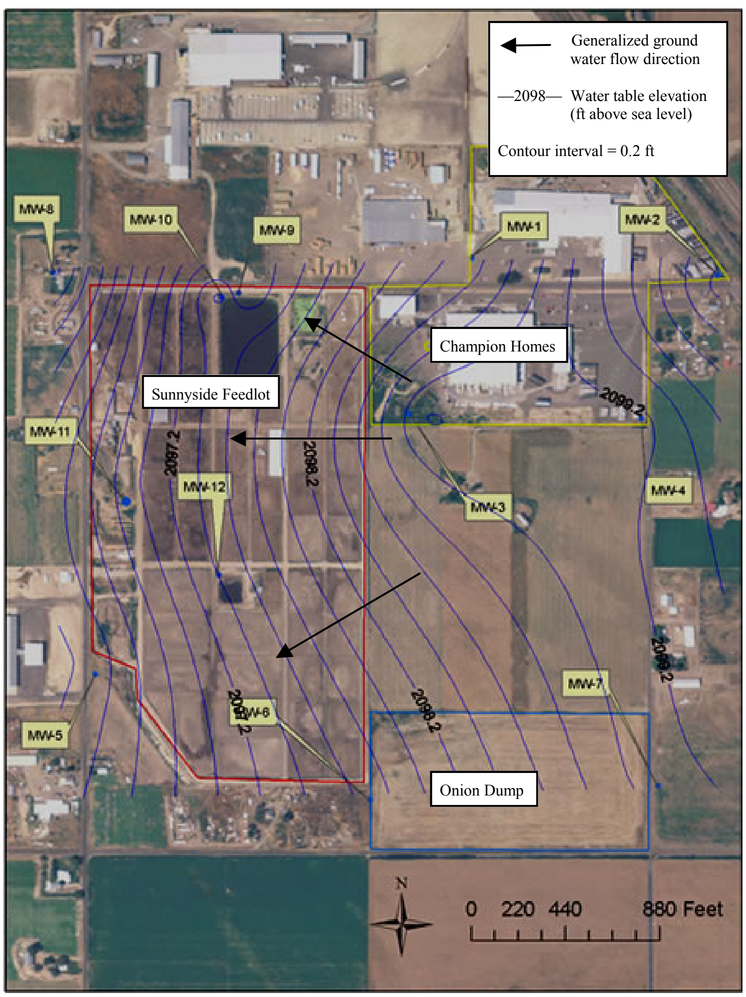

Figure 4. Ground water flow map, upper alluvial aquifer, Sunnyside area

Methods

To establish this local monitoring project, 22 domestic wells up, down, and side gradient of the CAFO and onion disposal site were selected in November 2002. Twelve monitoring wells were drilled in 2004 to add sampling sites. All sampling was conducted after a quality assurance project plan (QAPP) was established. Permission was granted by the land owners prior to sampling.

Nutrients, isotopes, antibiotics, and steroids are the focus of ground water testing. All sample collection followed the established QAPP for preservation, handling, storage, and shipping. Field quality assurance/quality control protocols consisted of duplicate samples (at 10% of the sample load) along with blank samples (one set per sampling event). Field blanks consisted of laboratory grade deionized water. The blank samples were used to determine the integrity of the field team's sample handling, the cleanliness of the sample containers, and the accuracy of the laboratory methods. Samples were sent to the EPA certified University of Idaho Analytical Sciences Laboratory (UIASL) in Moscow, Idaho.

UIASL conducted tests for nitrate, nitrite, ammonia, orthophosphorus, chloride, sulfate, bromide, and fluoride using EPA Methods 300.0 and 350.1. UIASL also conducted tests for antibiotics, hormones, and pesticides. Internal laboratory spikes and duplicates were also completed as part of UIASL's quality assurance program.

In 2005, isotope samples were collected, frozen, and shipped to the Stable Isotope Laboratory, University of Idaho, Forest Resources for analysis.

Results

Sampling results indicate nitrate, antibiotic, and steroid impacts have occurred to the shallow alluvial aquifer. Results are summarized and presented in the following sections.

Nitrate

ISDA and IDEQ conducted nitrate testing of 24 domestic wells and 12 monitoring wells in November 2005 (Figure 5). Results of ground water sampling indicated a

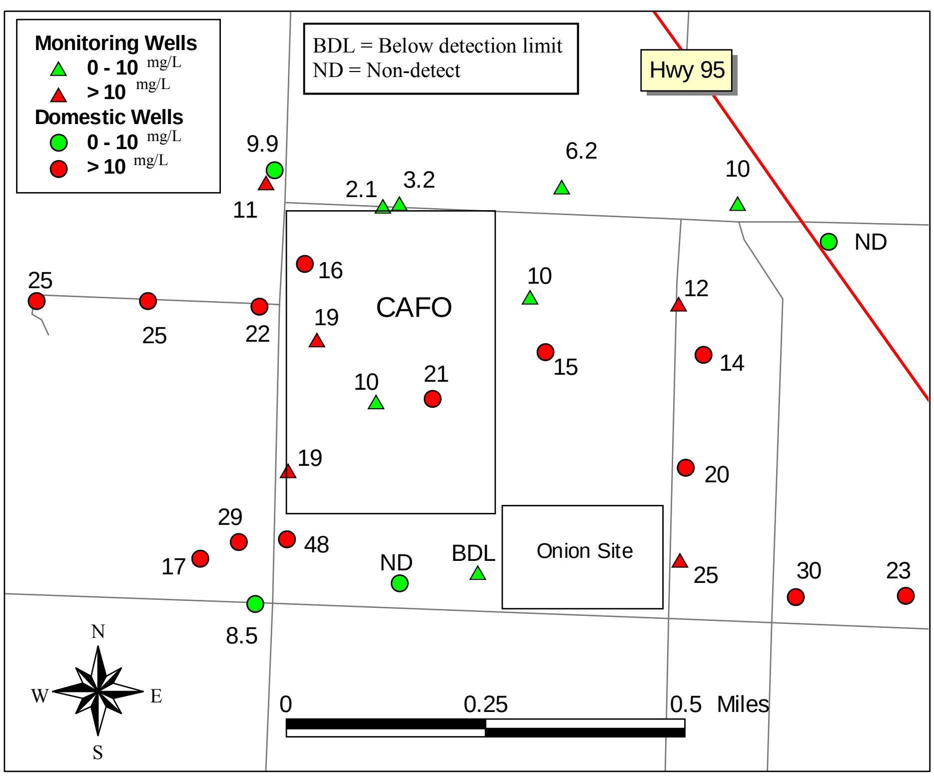

Figure 5. Nitrate Concentrations in 17 domestic and 12 monitoring wells, Fall 2005. Six sampled wells reside outside the boundaries of this figure

Table 1. Nitrate concentration distribution and statistics in 36 wells, Fall 2005.

Concentration Statistics (mg/L)	Fall 2005
	# wells (% wells)
0.0 to 10.0	15 (42%)
> 10.0	21 (58%)
Total	36 (100%)
Mean	15 mg/L
Median	14 mg/L
Maximum	48 mg/L

Table 2. Nitrate distribution and statistics for a group of the same 20 wells sampled in both Fall 2002 and Fall 2005.

Concentration Statistics (mg/L)	Fall 2002	Fall 2005
	# wells (% wells)	# wells (% wells)
0.0 to 10.0	4 (20%)	5 (25%)
> 10.0	16 (80%)	15 (75%)
Total	20 (100%)	20 (100%)
Mean	17 mg/L	19 mg/L
Median	16 mg/L	19 mg/L
Maximum	37 mg/L	48 mg/L

maximum concentration of 48 mg/L in November 2005 with a median concentration of 14 mg/L (Table 1). The EPA MCL health standard of 10 mg/L was exceeded in 58% of the wells, with many exceeding 20 mg/L nitrate upgradient and downgradient of the CAFO (Figure 5).

The November 2005 sampling event occurred two years after the construction of new wastewater ponds and represented the third year of sampling domestic wells around the feedlot. Figures 6 and 7 exhibit the change in nitrate in domestic wells from the fall of 2002 to the fall of 2005. Two major nitrate concentration changes occurred (1) directly west of the feedlot (-12 mg/L) and (2) directly southwest of the facility (+14 mg/L). Nitrate concentration distribution, however, has stayed fairly consistent since 2002 (Table 2).

Nitrogen Isotopes

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 nitrate in ground water are applied commercial fertilizers, animal or human waste, and organic nitrogen within the soil. Each of these nitrate source categories has a potentially distinguishable nitrogen isotopic signature. The typical $\delta^{15}N$ range for fertilizer is –5 per mil ($^0/_{00}$) to +5 $^0/_{00}$, while typical

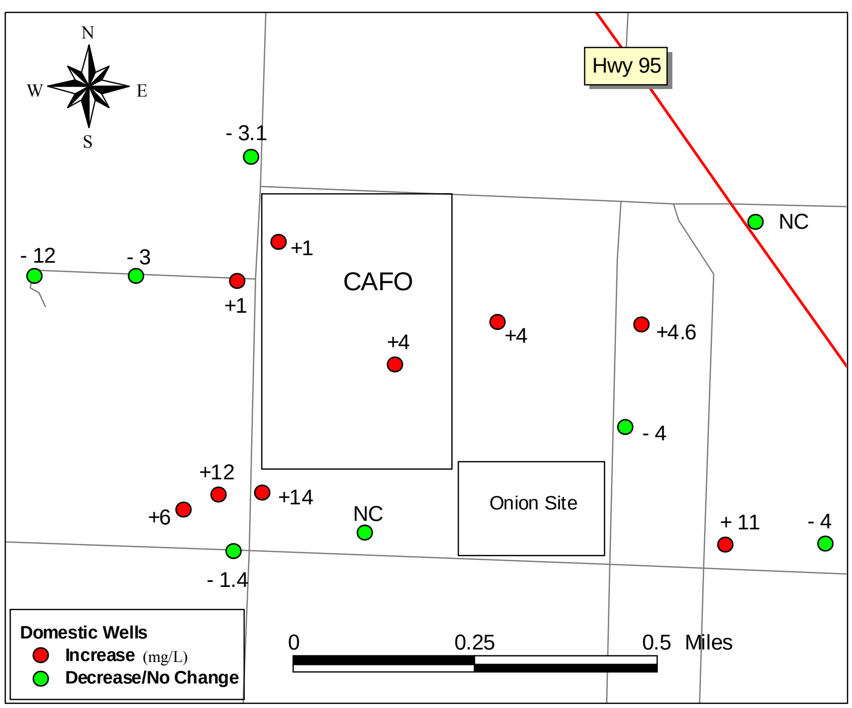

Figure 6. Nitrate Concentration Change (in mg/L) from Fall 2002 to Fall 2005 in 17 Domestic Wells

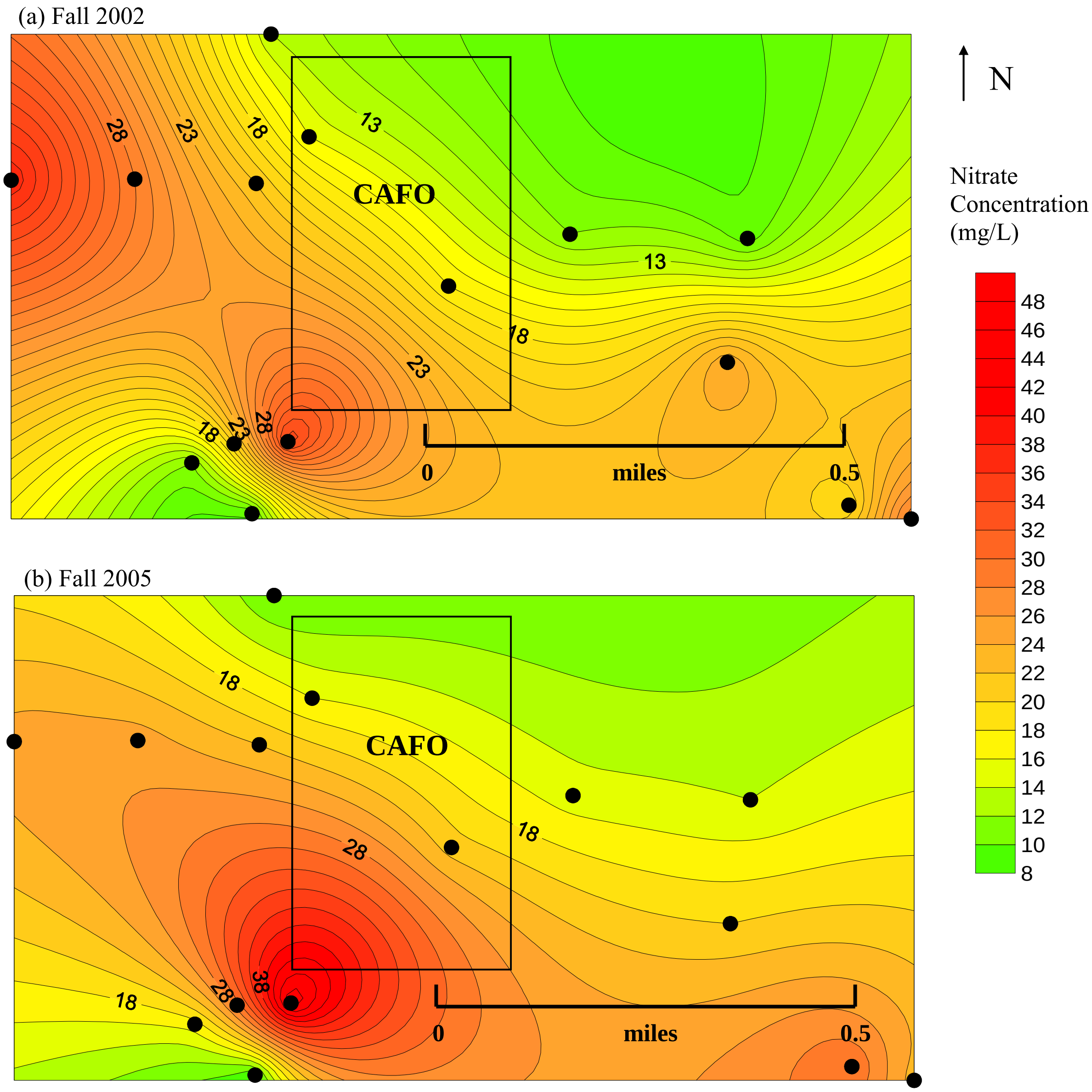

Figure 7. Kriged contour map of ground water nitrate concentrations for a group of the same 15 wells (black dots) sampled in the (a) Fall 2002 and (b) Fall 2005

values for waste sources are greater than +10 $^{0}/_{00}$. $\delta^{15}N$ values between +5 $^{0}/_{00}$ and +10 $^{0}/_{00}$ can indicate an organic or mixed source (Kendall & McDonnell, 1998).

$\delta^{15}N$ testing was used as a possible indicator of nitrate source(s) in ground water. Table 3 exhibits the change in $\delta^{15}N$ data for the same 16 domestic wells tested in the fall of 2002 and the fall of 2005. A majority of wells in November 2005 still indicated an animal or human waste source. Two wells that indicated a mixed source in 2002, one upgradient and one side gradient of the CAFO, now suggest a fertilizer source.

Pesticides

Pesticides have historically been detected throughout the project area. In November 2005, samples were tested for various pesticides utilizing EPA Method 507 by the UIASL. Eight of the nine domestic well samples exhibited varying degrees of contamination ranging from non-detect to low ppb residues for atrazine, desethyl atrazine, bromacil, prometon, and hexazinone. All pesticide detections were below any health standard as set by the EPA or the state of Idaho.

Table 3. $\delta^{15}N$ results for the same 16 domestic wells sampled in November 2002 and November 2005.

$\delta^{15}N$ Values (‰)	Potential NO_3-N Source	November 2002	November 2005
		# wells (% wells)	# wells (% wells)
-5 to +5	Commercial Fertilizer	0 (0%)	2 (12.5%)
+5 to +10	Organic Nitrogen in Soil or Mixed Source	5 (31%)	6 (37.5%)
>10	Animal or Human Waste	11 (69%)	8 (50%)
Total		16 (100%)	16 (100%)

Antibiotic and Steroid Testing

Large livestock CAFOs require the use of pharmaceuticals (e.g., antibiotics, hormones) to prevent epidemics and increase the animal's rate of weight gain. Pharmaceuticals may end up in CAFO wastewater and may be transported to ground water (Lindsey, et. al., 2001).

Sulfamethizine and sulfadimethoxane, members of the sulfonamides class of antibiotics, have been detected in both domestic and monitoring wells downgradient of the feedlot (Figure 8). The sulfonamides are commonly used antibiotics and have been historically administered to cattle at the feedlot. Concentrations of the antibiotics in ground water range from below detection limits to 0.22 parts per billion (ppb) for sulfamethoxazole and below detection limits to 2.3 ppb for sulfamethizine.

The steroid estradiol is another constituent commonly used in the feedlot's operations. Estradiol has been detected downgradient of the feedlot in concentrations ranging from 0.063 to 2.8 ppb. In November 2005, a new detection of estradiol occurred in MW-6 located downgradient of the onion disposal site and land application area (Figure 8).

Two new wastewater lagoons were constructed at the feedlot in the fall of 2003. Wastewater samples were collected from the north lagoon in January 2003 and May 2005. Sulfonamide concentrations were 42 ppb in the old north lagoon (January 2003) and 10 ppb in the new north lagoon (May 2005).

Sulfonamide antibiotics were detected in monitoring wells directly downgradient of the north wastewater lagoon (MW-9 and MW-10, Figure 8) but not in an upgradient monitoring well (MW-3, Figure 8). The north lagoon's upgradient monitoring well (MW3) is downgradient of a large septic system and leach field of a nearby business and has been non-detect for both antibiotics and steroids. Sulfonamide detects, along with the administration of sulfonamides by the feedlot, suggests that the CAFO lagoon has been a source of antibiotics entering ground water.

Though only a few years of data exist on these constituents, it appears that sulfonamide concentrations are generally decreasing over time. Toxicologists from EPA, ISDA, and IDEQ have worked to evaluate potential health issues related to these chemicals. The effects are unknown and more research is needed.

Soil Testing

Soil samples were collected from third party fields by ISDA soil technicians in December 2005 (Figure 9). Two fields downgradient of the CAFO (5 and 10 acre fields) and three fields upgradient (20, 10, and 10 acre fields) were evaluated. The samples were collected for comparison to the phosphorus threshold and were obtained at two depths, 0-12" for surface water resource concerns and 18-24" for ground water resource concerns.

Manure and wastewater from the feedlot is applied to field F1. Alfalfa and grain are grown on fields F1, F2, and F3. Historically, Field AN has been a mix of corn, onions, and grass hay. Field WL was not actively farmed in 2005. Fields exceeding the phosphorus threshold are a concern because of potential leaching of nitrate into ground water.

Samples were initially analyzed by the Idaho Food Quality Assurance Laboratory (IFQAL) in Twin Falls, Idaho for phosphorous. Samples were then sent to the UIASL for an extended fertility analysis including tests for nitrate, ammonia, potassium, boron, organic matter, pH, and sulfur.

According to the Natural Resources Conservation Service (NRCS) Nutrient Management Standard 590, samples collected at 0-12" should not exceed 40 ppm phosphorus. Additionally, samples collected at 18-24" should not exceed 30 ppm for phosphorus with ground water levels greater than five feet. The phosphorus threshold is exceeded at all depths in the three fields

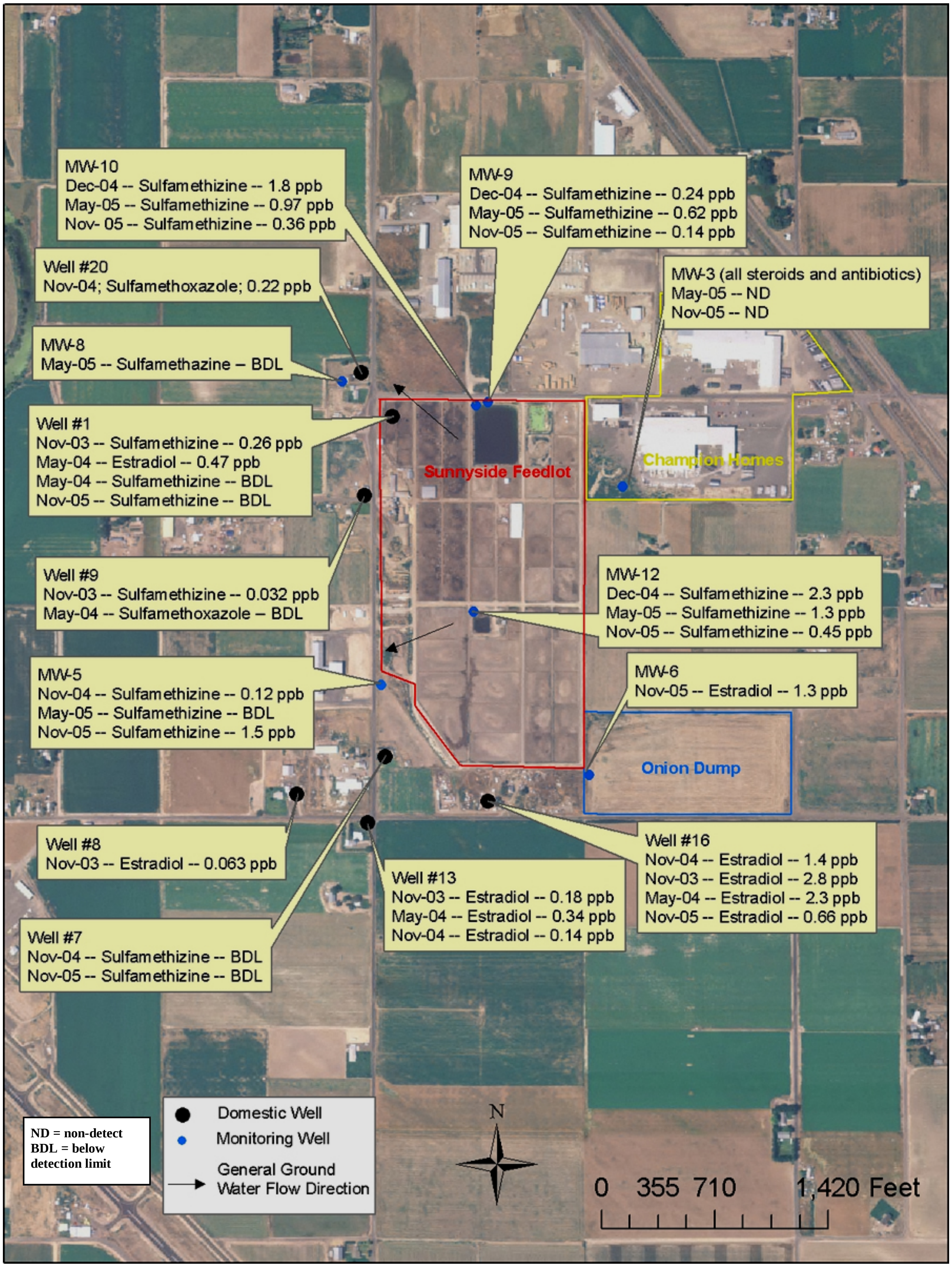

Figure 8. Historic antibiotic and steroid ground water detections

Table 4. Soil test results from first and second foot intervals at five fields in the project area

Field # (soil depth)	Phosphorus IFQAL ppm	Phosphorus UIASL ppm	Nitrate+ Nitrite ppm	Nitrogen-Ammonia ppm	Potassium ppm	Boron ppm	Organic Matter %	pH	Sulfur ppm
AN (0-12”)	43.3	46	24	4.4	330	0.53	0.83	7.5	24
AN (18-24”)	20.8	22	14	3.4	350	0.45	0.39	7.8	23
WL (0-12”)	11.0	13	10	4.2	400	1.0	1.6	8.2	12
WL (18-24”)	5.93	7.6	4.4	2.6	340	0.95	0.57	8.8	31
F1 (0-12”)	72.4	120	26	11	770	1.0	1.4	8.3	35
F1 (18-24”)	50.0	64	16	4.4	590	0.90	0.89	8.4	48
F2 (0-12”)	59.5	86	16	2.6	570	1.0	1.4	8.3	27
F2 (18-24”)	34.7	44	16	2.5	410	0.92	0.69	8.4	44
F3 (0-12”)	50.6	65	13	1.9	370	0.97	1.4	8.3	20
F3 (18-24”)	37.4	46	7.2	2.9	320	0.82	0.66	8.6	42

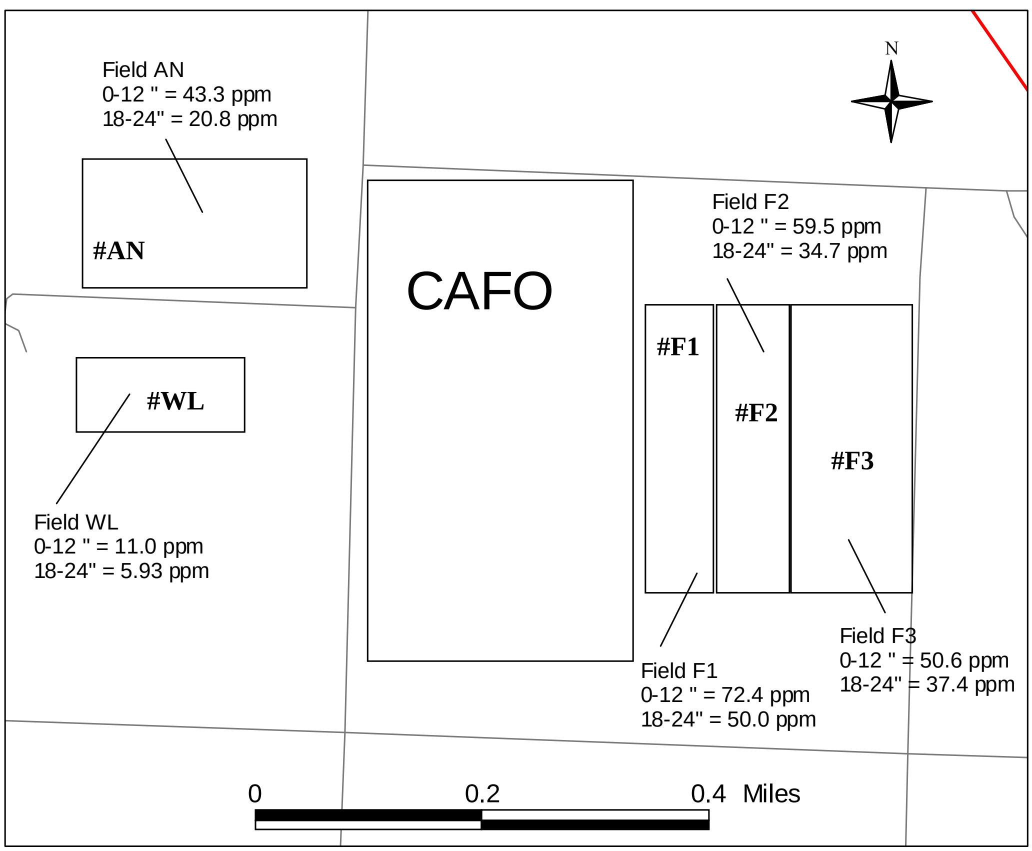

Figure 9. Soil sampling field locations and IFQAL phosphorus data

sampled upgradient of the feedlot and in the top foot of one field downgradient (Table 4). In addition to high phosphorus, Fields F1 and AN also have high nitrate concentrations, indicating the potential historic leaching of nitrate beyond the root zone into ground water. Field F1 also had high ammonia and potassium concentrations.

Conclusions

Ground water within the shallow alluvial aquifer of the project area remains significantly impacted by nitrate. The high nitrate concentrations and the large number of detections both upgradient and downgradient of the feedlot are of concern. The Sunnyside area is highly vulnerable to ground water and surface water contamination due to (1) shallow ground water conditions, (2) shallow subsurface alluvial deposits, primarily sands and gravels, and (3) proximity to the Snake River. In November 2005, 58% of the wells sampled exceeded the EPA MCL of 10 mg/L for nitrate, with a maximum concentration of 48 mg/L.

Antibiotic and steroid detections, $\delta^{15}N$ values, and elevated nitrate downgradient of the CAFO lagoons suggest the feedlot has impacted ground water quality. A majority of wells upgradient of the CAFO also exceed the EPA health standard for nitrate, with many wells exceeding 20 mg/L nitrate. Elevated levels of nitrate upgradient from the CAFO suggest other potential sources of nitrate contamination. These include land applications of manure, applied fertilizer, onion disposal areas, and septic systems.

Sulfonamide antibiotics were detected in monitoring wells directly downgradient of the CAFO's north wastewater lagoon. Sulfonamide detects, along with the administration of sulfonamides by the feedlot, suggests that the lagoon was a source of antibiotics entering ground water. Additionally, estradiol detects in ground water and exceedance of the phosphorus threshold in soil upgradient of the CAFO suggest that land application of manure and wastewater has potentially impacted ground water.

New wastewater lagoons were constructed at the feedlot in the fall of 2003 with liners that exceed state standards. Wastewater samples were collected from the north lagoon in January 2003 and May 2005. Sulfonamide concentrations were 42 ppb in the old north lagoon (January 2003) and 10 ppb in the new north lagoon (May 2005).

Though only a few years of data exist on these constituents, it appears that the sulfonamide concentrations in the ground water are generally decreasing over time. Toxicologists from EPA, ISDA, and IDEQ have worked to evaluate potential health issues related to these chemicals; the affects are unknown and more research is needed.

Testing results also indicated pesticide impacts to the aquifer. Pesticide detections were generally low in concentration; however, there is concern about multiple pesticide detections per well and potentially detrimental health effects. Health risks associated with consuming low level concentrations of multiple pesticide compounds is not well understood.

Soil samples were collected from third party fields in December 2005. The phosphorus threshold is exceeded at all depths in the three fields sampled upgradient of the feedlot and in the top foot of one field downgradient. Manure and wastewater from the feedlot is applied to one of these fields. Exceedance of the phosphorus threshold may result in the movement of nitrate into ground water. ISDA has recommended to growers and agrichemical professionals to conduct nutrient and irrigation water management evaluations. Producers should also follow the NRCS Nutrient Management Standard 590. Fields that exceed the phosphorus threshold should receive nutrient applications to crop uptake only.

ISDA made recommendations to the existing CAFO facility to improve water quality following the water study in November 2002. A majority of the recommendations have been followed. Improvements made by the CAFO facility, with the aid of ISDA and the NRCS, include:

- Berming to contain surface water runoff.
- Recycling of trough overflow water.
- Drainage of lagoons, evaluation of liners, and investigation of ground water table interaction with lagoons after irrigation season began.
- Construction of new lagoons with sizing and liners that exceed state standards.
- Improvement in overall manure management.
- Establishment of a nutrient management plan.
- Severing and plugging of buried pipelines to eliminate potential off-site water drainage.

ISDA and IDEQ will continue sampling domestic and monitoring wells in the Sunnyside project area indefinitely. Monitoring results will help provide further recommendations to producers in the area and ISDA will continue to work with the regulated facilities to protect ground water.

Recommendations

ISDA and IDEQ recommend continued monitoring in the project area.

Testing should include, but not be limited to:

- Continued ground water monitoring for nutrients, isotopes, antibiotics, and steroids.
- Additional static water level measurement.
- Effectiveness monitoring as facility improvements, BMP programs, and/or regulatory changes are implemented.

ISDA and IDEQ further recommend that measures to reduce nitrate impacts on ground water be addressed and implemented. ISDA recommends that the Weiser River Soil Conservation District (SCD) lead an agricultural response related to unregulated nonpoint sources of pollutants in the Sunnyside area. The Weiser River SCD should work with local agrichemical professionals, landowners, agencies, and the IDEQ Weiser Nitrate Ground Water Protection Committee to implement this process and seek funding to support these efforts. Recommendations to other agencies include:

Southwest District Health
- Assessment of impacts from private septic systems.
- Additional public outreach to inform all residents in the area about the water quality of their aquifer.

Weiser River SCD
- Identification of land application in the greater area.
- Soil testing of identified land application areas.

Idaho Soil Conservation Commission
- Assistance in developing BMP implementation projects.
- Technical assistance in developing grant proposals for funding land use improvement projects.

ISDA and IDEQ will support these local partners in seeking funding and implementing a comprehensive program. Additionally, ISDA and IDEQ recommend:

- 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.
- Homeowners assess lawn and garden practices, especially near wellheads.

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