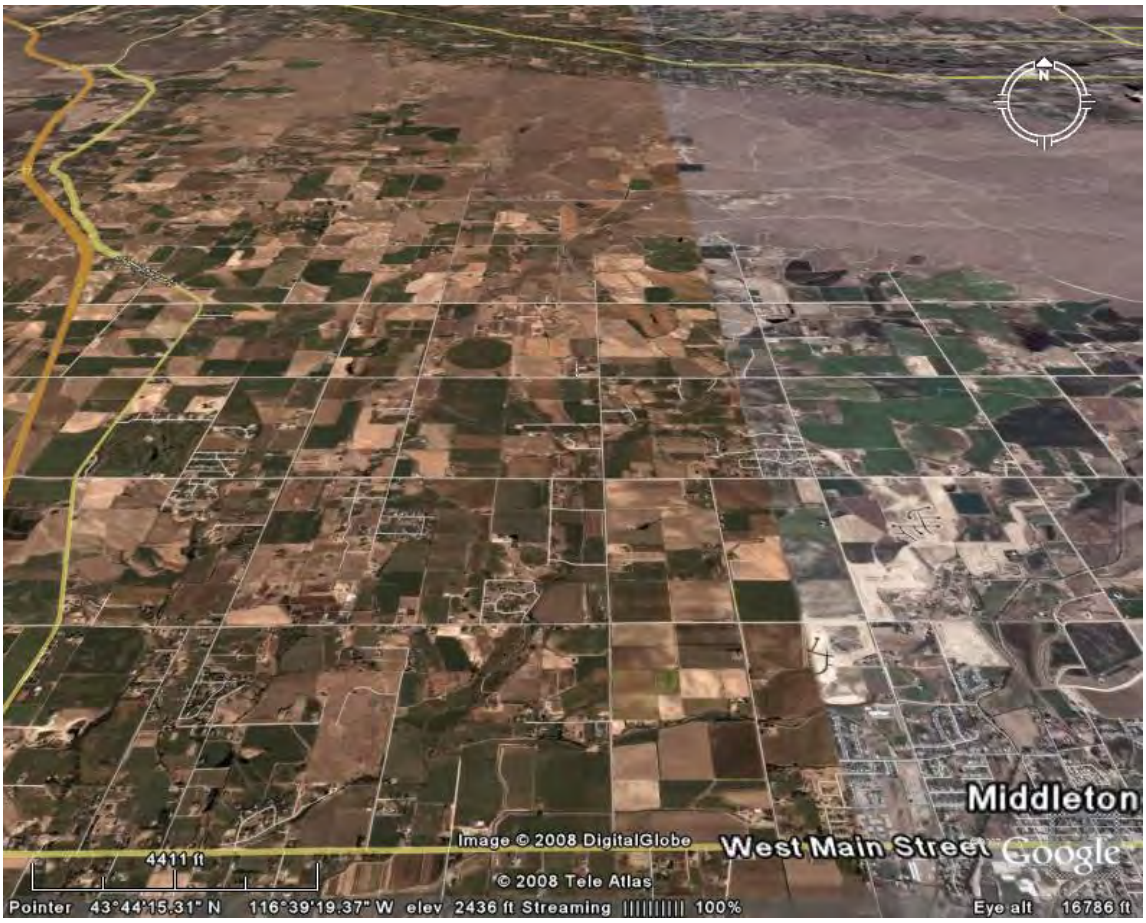
Ground Water Quality Monitoring Results for the Purple Sage Study Area, Canyon County, Idaho



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Summary

This report presents monitoring results for ground water samples collected during 2006, 2007, and 2008 from wells in an area north of Middleton, Idaho known as the Purple Sage area. The project represents the combined efforts of the Idaho Department of Agriculture (ISDA) and the Department of Environmental Quality (DEQ). ISDA established a project area in October 2005 and tested 21 wells for nitrate as nitrogen (NO_3-N). Four wells exceeded the Idaho Ground Water Quality Standard (IDAPA 58.01.11.200) and the maximum contaminant level (MCL) of 10 milligrams per liter (mg/L) for nitrate, established by the U.S. Environmental Protection Agency (EPA). DEQ sample collection in the area began in October 2006 and continued through 2008. Eighteen wells were sampled, with nitrate concentrations ranging from 0.3 to 11.1 mg/L.

Part of the study area lies within the Purple Sage Nitrate Priority Area (NPA). Sample results from the current study confirm that the criterion for designation as an NPA – 25% of wells sampled must have nitrate concentrations greater than 5 mg/L – has been met in the Purple Sage area. Samples for nitrate analysis were collected from two drainages during periods when ground water was the only source of flow in the drainages. Analysis of results indicates the widespread presence of elevated nitrate in the uppermost waterbearing unit, most likely from agricultural activities or livestock sources. Phosphorus concentrations in the drainages exceeded the total maximum daily load (TMDL) for the Snake River-Hells Canyon (Idaho Department of Environmental Quality and Oregon Department of Environmental Quality, 2004). Bacteria detections indicate contributions from warm-blooded animals at some wells. A trend evaluation was conducted at 10 wells where sufficient nitrate data existed. The evaluation showed that there was no trend in nitrate concentrations, either increasing or decreasing, at these wells.

Introduction

Ground water in the Purple Sage area is used primarily for drinking water supplies, although some ground water is also used for agricultural irrigation and at dairy facilities. Drinking water is supplied through private domestic wells and public water system (PWS) wells. Public water system wells are regulated by DEQ and are subject to monitoring and reporting requirements (IDAPA 58.01.08). Drinking water from these sources must meet certain standards, including MCLs established by EPA and adopted by DEQ (IDAPA 58.01.08.550**)**. Over the past several years, nitrate concentrations in some PWS wells in the southern part of the study area have exceeded the nitrate MCL. When nitrate concentrations remain elevated above the MCL, these wells must be abandoned and replaced. Replacement wells must meet the DEQ design criteria for drinking water wells (IDAPA 58.01.08.550). The cost of well replacement and the potential health implications of elevated nitrate and related contaminants in drinking water supplies are

cause for concern. Protection of the ground water source is the primary goal, and well replacement should be used as a last alternative.

Following the initial ISDA sampling event in 2005, and after reviewing elevated nitrate occurrences at PWS wells, DEQ began a sampling program in 2006. ISDA and DEQ conducted joint sampling events in the study area from 2006 through 2008.

Wells in the ISDA sampling network are located in the northern part of the sturdy area, where agricultural activities predominate. The DEQ sampling network covers the southern part of the study area where residential development has mostly occurred. ISDA and DEQ sampling events were conducted annually at domestic, PWS, and dairy wells. Surface water samples were collected once in 2006 and twice in 2007. Figure 1 shows the Purple Sage ground water nitrate study area.

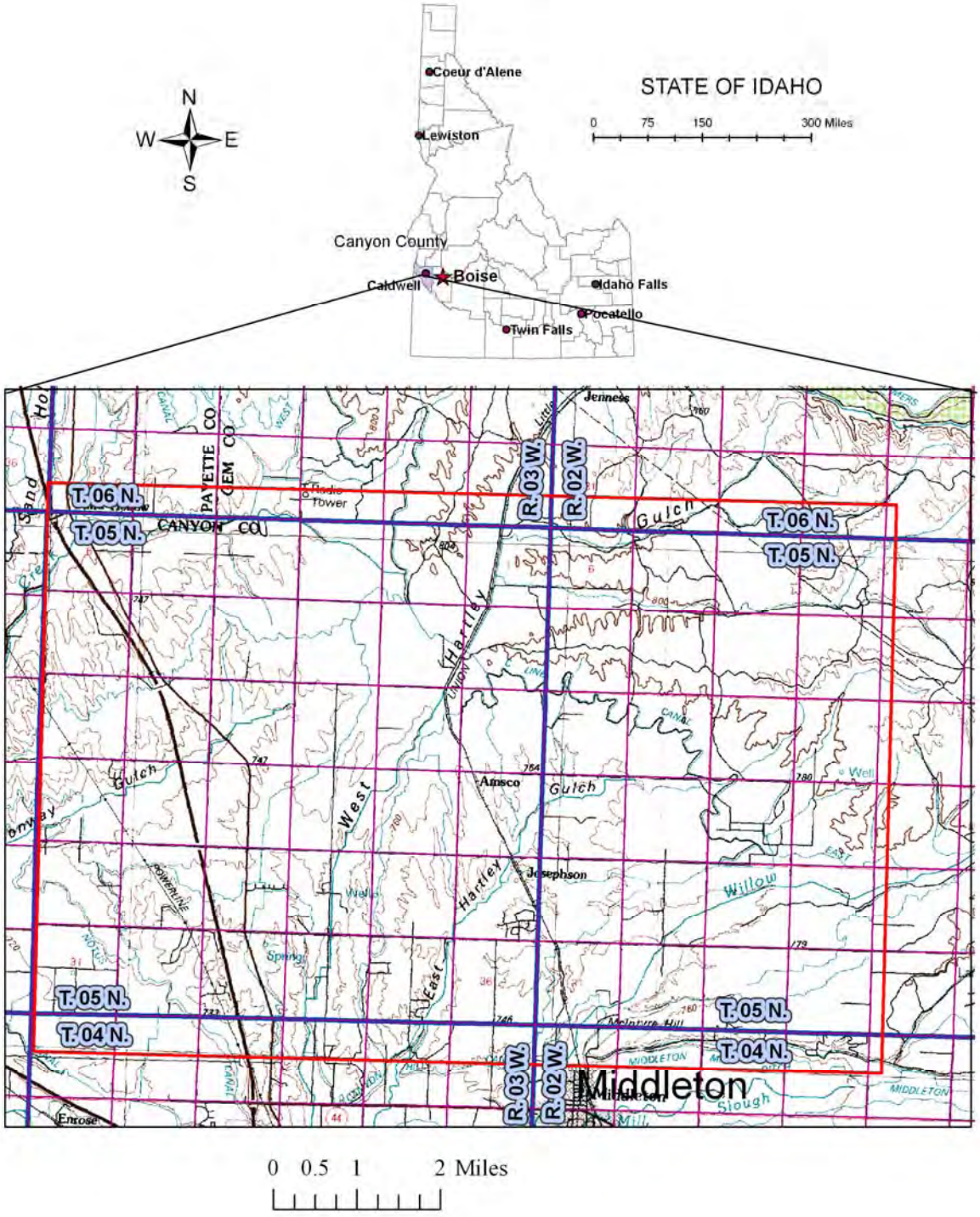

Figure 1. Purple Sage ground water nitrate study area (red boundary), showing township, range, and section lines.

Description of Study Area

The Purple Sage study area is located north of Middleton, Idaho (Figure 1). Land use in the study area includes agricultural, residential, and some commercial development. Land use changes have occurred over the past several years as agricultural land has been converted to residential development. In 2004 there were nine diaries in the study area, but by the 2007 sampling season, only four dairies remained. Land use trends of increased housing accelerated during the housing boom that occurred from 2000 through 2007, but recent economic conditions have resulted in a slowdown.

The study area is characterized by hot, dry summers and mild winters. Climate data from October 8, 2004, to December 31, 2005, are available from the Caldwell weather station, which is located about 6 miles south of the study area. Average annual temperatures range from 65 °F to 37 °F. Precipitation records show that the average annual precipitation for this period was 10.6 inches; most precipitation falls in the winter and spring months, with the mean annual snowfall about 16.5 inches (Western Regional Climate Center, 2009).

Hydrogeology

The Purple Sage area lies within the western Snake River Plain, an intercontinental rift basin that is oriented northwest-southeast. The basin contains up to 6,000 feet of sedimentary fill that is underlain by older volcanic rocks. The sedimentary fill has been divided into two groups: the Idaho Group and the overlying Snake River Group (Petrich and Urban, 2004). The Snake River Group sediments are absent within the study area.

The Idaho Group sediments were deposited in a series of large lakes that once existed in the area. Lake Idaho, as the collective lake system is called, is estimated to have reached a maximum elevation of about 3,600 feet, and extended from Weiser in the west to King Hill in the east. The lake sediments consist mostly of lacustrine (lake-deposited) sediments made up of clay, silt, and sand. Fluvial (river or stream) deposits found within the lake beds several miles from the basin margins indicate that lake levels rose and fell, which enabled rivers to deposit sediments in the central part of the basin at low lake levels (Wood and Clemens, 2002).

In the northwestern part of the Purple Sage area, the Idaho Group sediments are mapped as the Idaho Formation, which consists of clay, silt, sand, volcanic ash, and fine gravel. Caldwell-Nampa sediments, which consist of clay, silt, sand, and gravel, mantle the Idaho Formation in the southeastern three-quarters of the study area (Mitchell and Bennett, 1979). It is generally not possible to distinguish between sediments of the Idaho Formation and the Caldwell-Nampa sediments in the subsurface.

Squires and Wood (2001) named a deltaic sand unit that occurs in the upper part of the Idaho Group the Pierce Park Sand. Recent investigations near Eagle, Idaho, about 6 miles east of the Purple Sage area, have resulted in expansion of the area of occurrence of the Pierce Park Sand. The unit was renamed the Pierce Gulch Sand and designated as a regional aquifer, the Pierce Gulch Sand aquifer. This aquifer is reported to exist at depths

ranging from 480 to 700 feet below land surface in the Eagle area, with a dip to the southwest of about 100 feet per mile. Its existence is inferred in the Purple Sage area from data presented by Squires, et al (2007) and Squires (2008). If the westward dip in the unit is consistent, it may occur at depths of 575 to 600 feet below land surface in the Purple Sage area. A driller's log for a 362 foot deep well located at 05N 03W 28ADD, in the northwestern part of the study area, indicates that from top to bottom there was 15 feet of topsoil, a cumulative thickness of 145 feet of clay, 108 feet of gravel, and 94 feet of sand. The well was test-pumped at 2,400 gallons per minute from a 121 foot screened interval in the lower part of the well. This production rate is potentially one indication of a well completed in the Pierce Gulch Sand aquifer (Squires, et al, 2007), but there is insufficient information to determine if the well at 05N 03W 28ADD actually produces water from that aquifer.

Static water levels in the Purple Sage area range from 15 to 80 feet below ground surface, based on well driller reports. The low foothills in the northern part of the study area form a surface water divide and a ground water divide for shallow ground water (100 to 200 feet deep) between the Payette River to the north and the Boise River to the south (Dion, 1972). Willow Creek, East Hartley Gulch, and West Hartley Gulch are three major surface water drainages that cross the study area, flow to the southwest, and receive discharge from the shallow, alluvial aquifer systems.

In the regional view, several studies have concluded that ground water in saturated units greater than 200 feet deep also moves from the northeast to the southwest with discharge to the Boise River (Dion, 1972; Lindholm et. al, 1987; Petrich and Urban, 2004). Recent studies suggest that this deep ground water moves to the northwest, from the Boise River drainage into the Payette River drainage, at right angles to previously defined ground water flow directions (Squires, et al, 2007). There is insufficient hydrogeologic information within the study area to determine if this interpretation of deep ground water movement is correct.

Ground water flow direction must be known in order to evaluate areas of contaminant contribution to wells in the Purple Sage area. If a well becomes contaminated, sources up-gradient of the well can be evaluated, and land use practices modified or remediated, to reduce contamination. Knowledge of ground water flow direction is essential to make these evaluations, and a scarcity of deep wells to establish the hydrogeology and regional ground water flow direction makes this difficult.

ISDA Sampling Program

ISDA began a sampling program to evaluate the occurrence of elevated nitrate-nitrogen (NO_3-N) in domestic wells in the Purple Sage area in October 2005; additional sampling events were conducted in 2006, 2007, and 2008. Figure 2 shows ISDA ground water sample locations with their corresponding identifications numbers. Field parameters (temperature, pH, specific conductance, and total dissolved solids) were collected at each site, and samples were analyzed in the laboratory for nitrate, chloride, sulfate, ammonia, total coliform, and *E. coli* (Table 5).

ISDA also collected surface water samples at six locations on East Hartley Gulch and West Hartley Gulch in 2006 and 2007 (Figure 2). Samples were analyzed for nitrate, ortho phosphorus, and total phosphorus. Sample results are listed in Table 7.

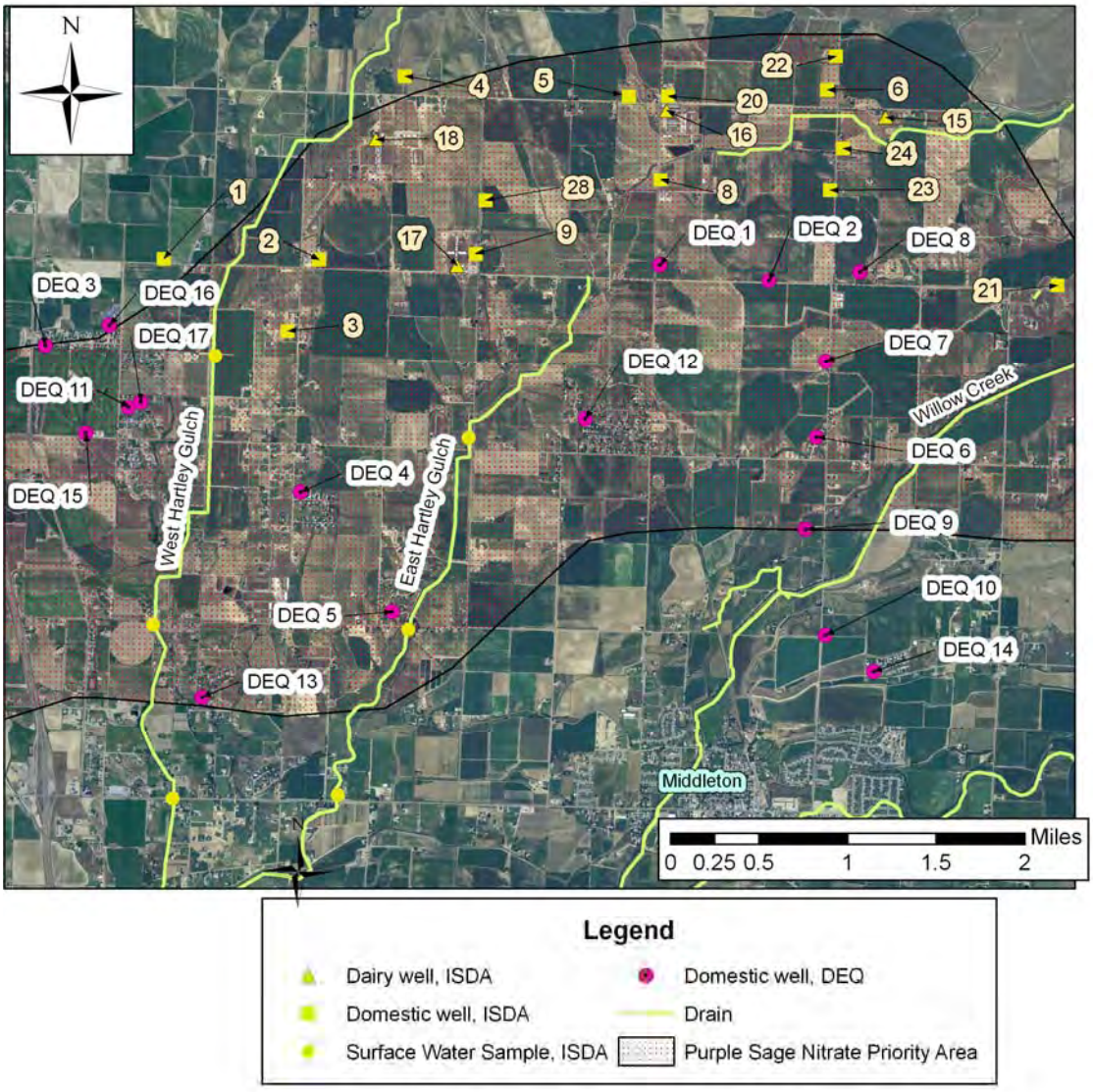

Figure 2. Location map showing DEQ and ISDA ground water sample locations and portion of the Purple Sage Nitrate Priority Area that lies within the study area.

DEQ Sampling Program

The DEQ sampling program began in 2006, and additional sampling events were conducted in 2007 and 2008. DEQ sample locations are shown in Figure 2. Field parameters (pH, specific conductance, dissolved oxygen, and temperature) were collected at each site, and samples from wells were analyzed in the laboratory for ammonia, total phosphorus, chloride, sulfate, nitrate, and total dissolved solids. For the 2006 sampling

event, samples were also analyzed for the stable isotopes of oxygen and deuterium. Since the inception of the project, select samples (typically those with nitrate concentrations greater than 4 mg/L) were also evaluated for the stable isotopes of nitrogen. See Table 6 for a full presentation of nitrate results.

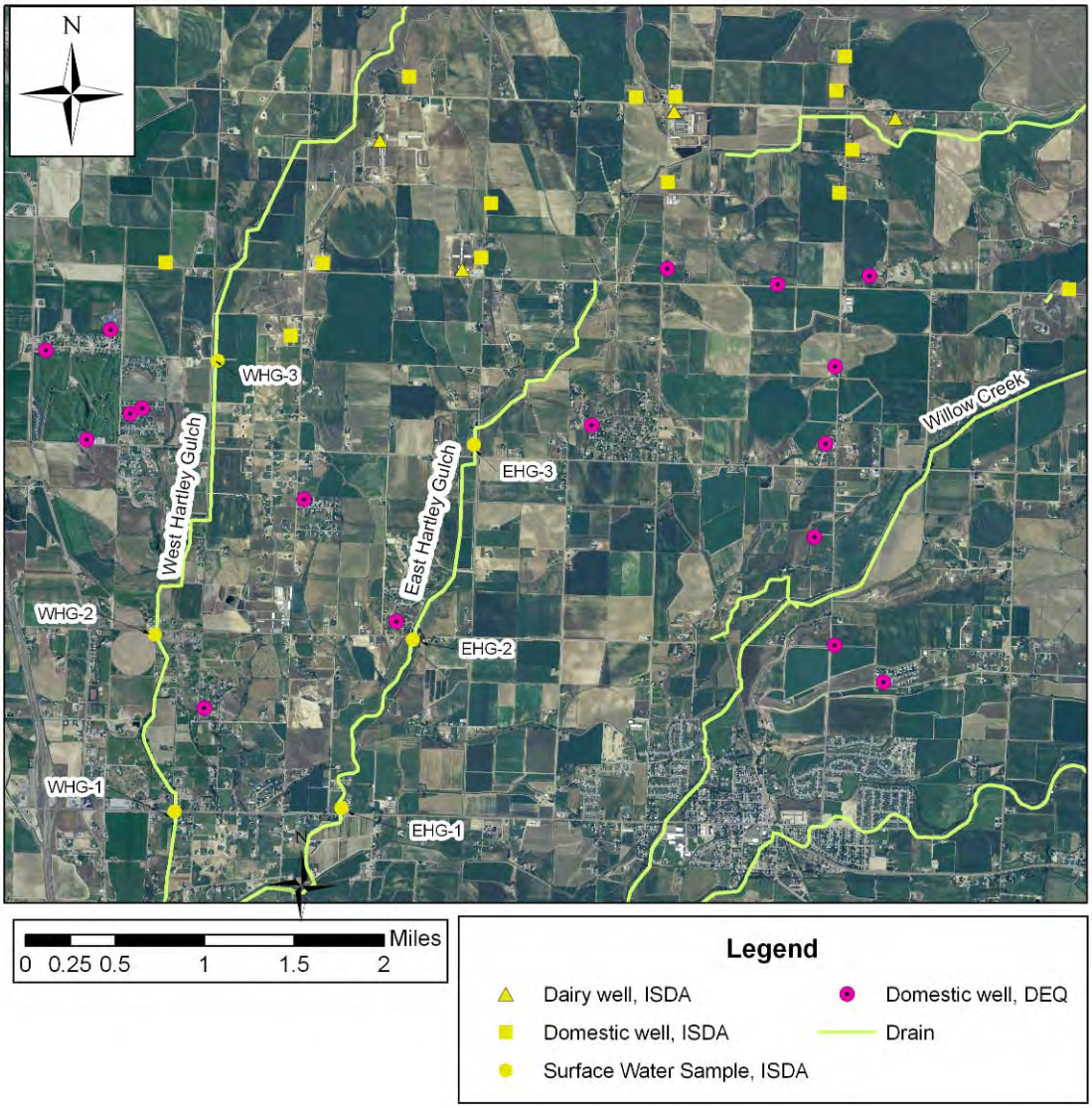

Figure 3. Location map showing six ISDA surface water sample sites on East Hartley Gulch and West Hartley Gulch and the portion of the study area that lies within the Purple Sage Nitrate Priority Area.

Results and Discussion

The ground water constituent of concern in the Purple Sage study area is nitrate, which typically originates from human or animal waste, commercial fertilizer, and/or organic sources. Precipitation also contains nitrate, but the amount of nitrogen in precipitation is very small in comparison to other sources, ranging from 0.4 to 0.6 pounds per acre per

year. Maupin (1995) reported that the total nitrogen content (the sum of ammonia and nitrate) in precipitation at the Craters of the Moon National Monument was estimated to be in the range of 0.18 to 0.27 mg/L. The mineralization of soil organic matter can also contribute nitrate to ground water. The Idaho Ground Water Quality Rule (IDAPA 58.01.11) establishes a standard for nitrate in ground water at 10 mg/L.

Nitrate Results

DEQ has delineated areas within the state, called Nitrate Priority Areas (NPAs), that have elevated nitrate concentrations in ground water. The criteria for the designation of an NPA is that 25% of wells sampled have nitrate concentrations of 5 mg/L or greater. Parts of the Purple Sage study area are included in the Purple Sage NPA (Figure 2). Table 1 lists average nitrate concentrations for wells sampled by DEQ and ISDA in the study area. The results show that 13 of the 38 sites sampled (about 34%) had average nitrate concentrations of 5 mg/L or greater.

Table 1. Average nitrate (NO_3) concentrations for wells sampled by DEQ and ISDA in the Purple Sage study area.

DEQ Well #	n	Ave NO_3 (mg/L)	ISDA Well #	n	Ave NO_3 (mg/L)
DEQ 1	3	4.2	1	4	0.1
DEQ 2	3	2.25	2	4	3.94
DEQ 3	3	0.76	3	2	4.88
DEQ 4	3	2.8	4	4	1.7
DEQ 5	3	5.2	5	4	4.4
DEQ 6	3	3.5	6	4	2.9
DEQ 7	3	3.7	7	1	3.49
DEQ 8	1	1.81	8	3	28.6
DEQ 9	3	2.67	9	3	6.4
DEQ 10	3	0.83	10	1	12.8
DEQ 11	3	6.15	13	2	1.9
DEQ 12	3	6	15	3	7.4
DEQ 13	3	0.38	16	3	14.2
DEQ 14	3	1.63	17	3	9.2
DEQ 15	3	3.8	18	3	4.9
DEQ 16	3	0.68	20	4	6.9
DEQ 17	2	10.4	21	4	1.1
			22	4	3.8
			23	4	1.05
			24	4	15.4
			28	4	7.07

NOTES:

n = number of samples at each well
Two wells were sampled by both agencies – DEQ 15/ISDA 7 and DEQ 17/ISDA 10.

Areal variations in water chemistry can be evaluated by the use of scatter plots where one constituent is plotted versus another. Plots of nitrate and chloride can reveal groupings of wells with similar water chemistry and wells that plot as outliers. A relationship of

increasing chloride concentration with increasing nitrate concentration can be indicative of anthropogenic impacts to ground water. Chloride can be an excellent indicator of seepage because it is readily transported through the soil and is highly mobile in ground water. Anthropogenic sources of chloride include road salt, fertilizer, animal waste, septic systems, and industrial waste applications. Chloride does not have a health-based MCL, and none of the wells sampled in the Purple Sage study area exceeded the EPA secondary MCL of 250 mg/L.

Nitrate versus chloride concentrations were plotted for all wells sampled by ISDA and DEQ for the Purple Sage study area (Figure 4). The value plotted for each well is the mean concentration of the three or four samples collected at each well from 2005-2007.

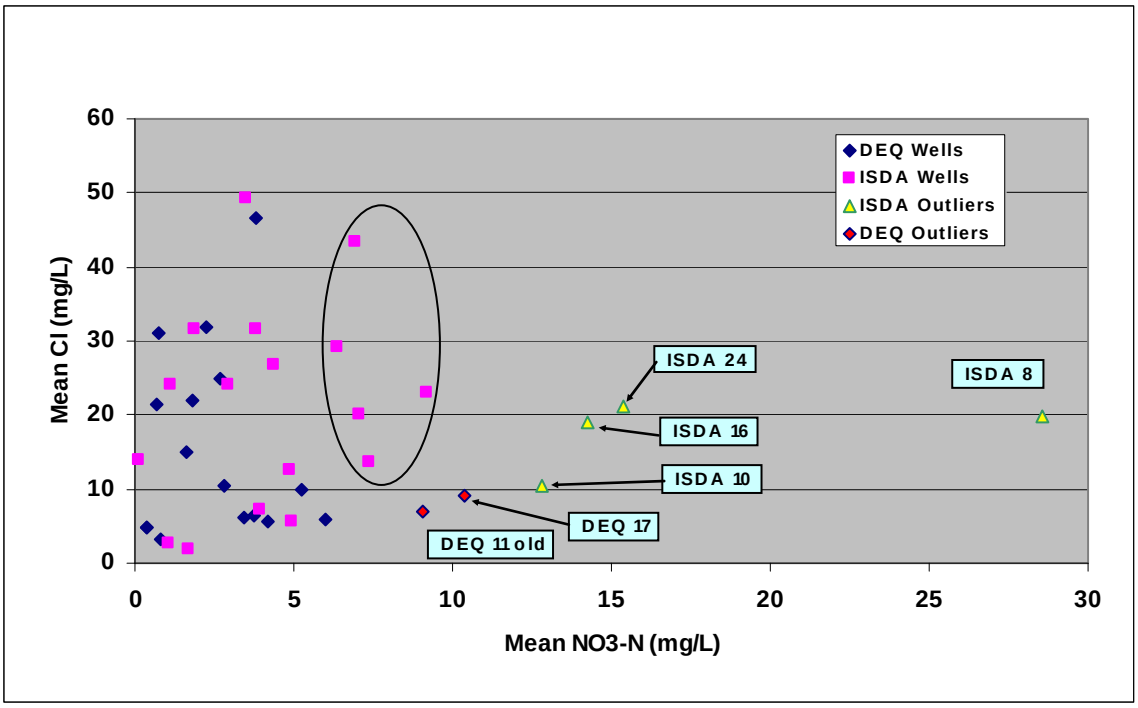

Figure 4. Scatter plot of mean nitrate versus mean chloride concentration for ISDA and DEQ wells sampled in the Purple Sage study area.

Most nitrate concentrations fall in the range of 0.1 to about 5 mg/L, while chloride concentrations range from 1 to about 32 mg/L. This results in a grouping of data points within a narrow vertical band in Figure 4. A positive correlation between nitrate and chloride concentrations has been noted in areas where impacts from on-site wastewater treatment systems have occurred (Boyle, 2003; McQuillan, 2004; Meehan and Welhan, 2005). The Purple Sage nitrate and chloride data do not show this correlation, indicating that nitrate is from a source such as agricultural activities or confined animal feeding operations.

ISDA wells 8, 10, 16, and 24 are designated as outliers because mean nitrate concentrations (28.6, 14.2, and 15.4 mg/L, respectively) are above 10 mg/L and visually plot higher than all other wells. Possible sources for these elevated nitrate concentrations are discussed below.

The group of five wells (wells 9, 15, 17, 20, and 28) indentified in Figure 4 by the shaded oval have nitrate concentrations in the range of about 6 to 9 mg/L and chloride concentrations in the range of approximately 10 to 34 mg/L. These wells, along with wells 8, 16, and 24, lie outside of the main group of data points and are located in the northern part of the study area (T05N, R03W, sec 23 and 24; and T05N, R02W, sec 18, 19 and 20; see Figure 2).

ISDA established six surface water sample locations on East Hartley Gulch and West Hartley Gulch drainages (EHG and WHG, respectively; see Figure 3). Three samples were collected from each location during 2006 and 2007, and results are presented in Table 7 of Appendix 1.

Prior to development of the area, all flow in the drainages was from precipitation, either direct runoff or ground water discharge that originated as precipitation. With the advent of irrigated agriculture, water in the drainages now represents a mixture of precipitation, tail water runoff from fields during the summer irrigation season, and deep percolation of irrigation water that moves to the water table and then migrates laterally to discharge in the drainages. Surface water samples collected from the drainages during the winter months represent water chemistry in the uppermost part of the aquifer.

Samples at all surface water sites exceeded the 5 mg/L nitrate concentration threshold for NPA designation. Nitrate concentrations in the upper part of WHG are higher than in EHG and decrease in the downstream direction (WHG-3 mean nitrate = 12 mg/L, WHG-2 mean nitrate = 6.8 mg/L, WHG-1 mean nitrate = 6.0 mg/L). Nitrate concentrations in EHG were fairly consistent from the upper to the lower sample locations (EHG-3 mean nitrate = 5.5, EHG-2 mean nitrate = 6.2, and EHG-1 mean nitrate = 5.6 mg/L). These results are interesting because the eight ISDA wells with the highest nitrate concentrations are located near the EHG drainage, while the highest surface water nitrate concentrations were in the WHG drainage; the reason for this difference is unknown.

Nitrate concentrations at individual surface water sample locations were variable for repeated sampling events. The nitrate concentration at WHG-3 showed the largest change, decreasing to 9.9 mg/L from 14.3 mg/L over a one-year period. Nitrate concentrations at other surface water locations experienced smaller declines or were mostly stable. Additional samples during an annual period would be required to evaluate seasonality at these sample locations, since water chemistry is most likely strongly impacted by irrigation water. Overall, nitrate concentrations from the surface water sample locations indicate that the shallow aquifer is impacted and support the designation of the area as an NPA.

Phosphorus Results

Phosphorus results are available for the six EHG and WHG sample locations, with the highest total phosphorus concentration at WHG-3 (mean total phosphorus = 0.9 mg/L). Mean total phosphorus concentrations were 0.5 mg/L at both WHG-2 and WHG-1. Mean total phosphorus concentrations were 0.3 mg/L at all three EHG sample locations. Mean ortho phosphorus concentrations were lower, but followed a similar trend.

Samples collected at domestic wells during the 2006 DEQ sampling event were analyzed for phosphorus. Locations with the highest phosphorus concentrations (DEQ wells 1, 4, 6, 8, and 12) are for the most part located on the eastern side of the study area and have concentrations of 0.1 mg/L or above.

EHG and WHG flow into the Boise River, which in turn flows into the Snake River. A total phosphorus target concentration of 0.07 mg/L has been established as part of the total maximum daily load (TMDL) for the Snake River-Hells Canyon (Idaho Department of Environmental Quality and Oregon Department of Environmental Quality, 2004). Phosphorus loads from tributaries must be reduced in order to meet Snake River phosphorus goals. The largest potential source of phosphorus in the study area is from irrigation runoff and other agricultural activities.

Nitrogen Isotopes

Potential sources of nitrogen include animal and human waste, nitrogen fertilizer, organic nitrogen in the soil, and nitrogen in precipitation. Nitrogen isotopes can be used as an indication of the potential source of nitrogen in ground water. Fractionation of nitrogen isotopes occurs during the nitrogen cycle, with the result that certain potential sources of nitrogen contamination have distinguishable isotopic signatures (Clark and Fritz, 1997). The ratio of ^{15}N to ^{14}N, written as $\delta^{15}N$ and expressed as parts per thousand (or per mil, ‰) commonly range from -5 per mil to +20 per mil in ground water (Kendall and McDonnell, 1998). Table 2 lists $\delta^{15}N$ values for common nitrogen sources.

Table 2. Typical $\delta^{15}N$ values from various nitrogen sources (from Seiler, 1996).

Potential Nitrate Source	**$\Delta^{15}N$ (‰)**
Precipitation	-3
Commercial fertilizer	-4 to +4
Organic nitrogen in soil or mixed nitrogen source	+4 to +9
Animal or human waste	Greater than +10

Samples from nine wells were analyzed for nitrogen isotopes by ISDA (Table 3). Sample results from ISDA wells 8, 9, 10 17, 18, and 20 suggest a commercial fertilizer source of nitrate. Results for ISDA wells 16 and 24 suggest that the nitrate is from organic nitrogen in the soil or a mixed source.

Table 3. Nitrogen isotope results for wells sampled by ISDA during October 2005 in the Purple Sage study area.

ISDA Well #	Sample Date	^{15}N (per mil)
8	10/17/2005	3.16
9	10/17/2005	2.41
10	10/18/2005	2.88
16	10/17/2005	6.51
17	10/17/2005	3.90
18	10/18/2005	2.45
20	10/20/2005	3.71
24	10/31/2005	5.17

Samples from two wells were analyzed for nitrogen isotopes by DEQ (Appendix 1, Table 6, wells DEQ 5 and DEQ 12). The results of 5.3 and 5.8 per mil suggest that nitrate at these wells is from organic nitrogen in the soil or a mixed source.

Oxygen and Deuterium Isotopes

The stable isotope of hydrogen (^{2}H), commonly referred to as deuterium, and the stable isotope of oxygen (^{18}O) were analyzed to evaluate differences in ground water recharge sources in the study area. ^{18}O and ^{2}H results are summarized and listed in Table 6 of Appendix 1.

The stable isotope ratios of oxygen and deuterium in atmospheric water vapor are subject to changes that begin when water evaporates from the ocean. Oxygen and deuterium isotope ratios continue to evolve as an air mass moves inland and the water vapor condenses to form precipitation. Oxygen and deuterium isotope ratios in precipitation can vary for different storm events in a particular area and for summer versus winter storm events for the same area. Isotope ratios can also vary for storm events that occur at different latitudes and at differing altitude and/or temperature conditions. Once precipitation infiltrates and enters an aquifer, further changes in oxygen and deuterium ratios are limited because evaporative processes are no longer active. Seasonal isotopic variations in the recharged water become damped out once the water enters an aquifer. Oxygen and deuterium results are often compared to the Global Meteoric Water Line (GWML), which describes the relationship between oxygen and deuterium in fresh surface water samples on a worldwide basis. The equation describing a best fit line for these data is:

$$\delta^{2}H = 8\ \delta^{18}O + 10\ ‰\ SMOW\ (Craig,\ 1961b),$$

where SMOW is Standard Mean Ocean Water, used as a reference. VSMOW (Vienna Standard Mean Ocean Water) has since replaced SMOW as the accepted reference for the GWML (Clark and Fritz, 1997).

Samples from the Purple Sage project were submitted to the University of Arizona Laboratory for Isotope Geochemistry for oxygen and deuterium isotope analysis. The

stated analytical precision at this laboratory is 0.9 ‰ for oxygen isotopes and 0.08 ‰ for deuterium isotopes. A plot of oxygen versus deuterium (Figure 5) show that most data points plot along the GMWL, an indication that ground water from these wells has undergone little or no evaporation prior to recharge. During evaporation, the lighter isotopes of oxygen and hydrogen (^{16}O and ^{1}H) are transferred from the liquid to the vapor form, and the remaining liquid is enriched in the heavier isotopes of oxygen and deuterium (^{18}O and ^{2}H). The remaining water has a more negative value and will plot in the lower left part of an oxygen/deuterium plot. The same effect is noted for temperature and/or elevation at the time of recharge—water recharged under cooler climatic conditions or higher elevations typically has a more negative isotopic signature than water recharged under warmer climatic conditions or at lower elevations. Because of this, oxygen and deuterium isotope values can vary with well depth, where water from a deeper well (deeper aquifer) may represent recharge that occurred under cooler climatic conditions or at higher elevations compared to water from a shallow well. Well depth information was not available for 9 of the 18 wells sampled by DEQ, and so conclusions regarding well depth and recharge conditions could not be made.

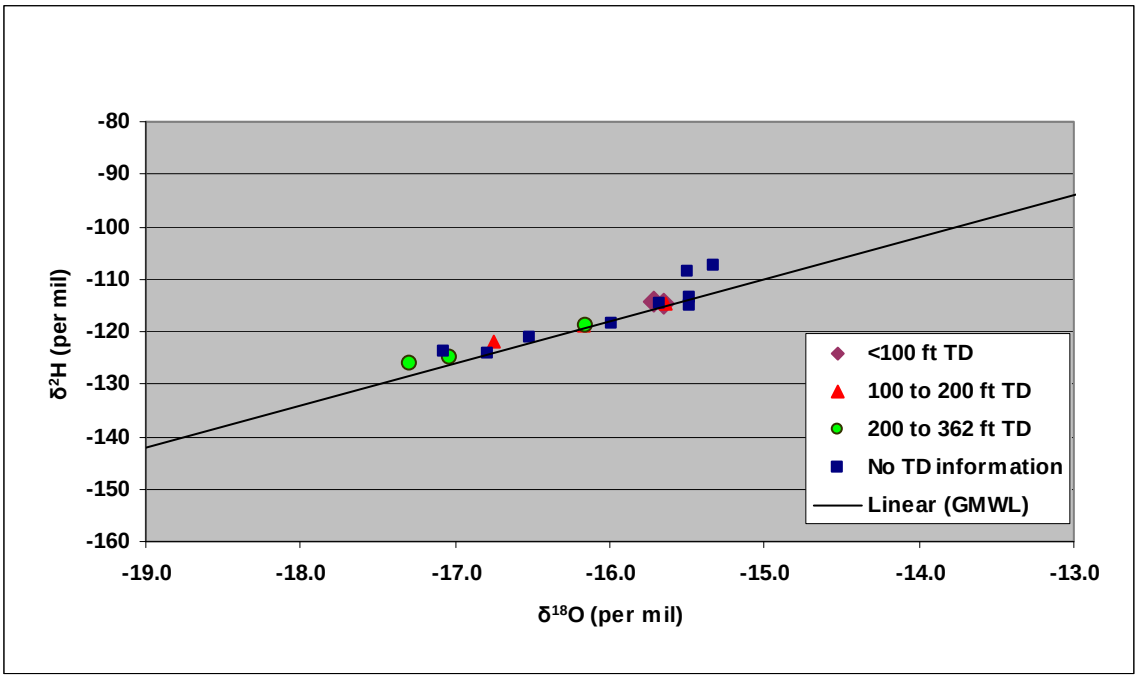

Figure 5. Plot of oxygen versus deuterium values for samples collected by DEQ during the October 2006 sampling event. (TD = Total Depth)

Bacteria Results

Samples were analyzed for total coliform and Escherichia (*E. coli*) bacteria by ISDA, and results are listed in Table 5 of Appendix 1. A DEQ fact sheet on bacteria in ground water (Idaho Department of Environmental Quality, no date) states that total coliform bacteria are commonly found in the environment, such as soil, and in the intestines of animals, and generally are not considered to be harmful. *E. coli* bacteria are a subgroup of fecal

coliform bacteria, and detection of *E. coli* bacteria is a strong indication of fecal contamination from warm-blooded animals.

ISDA wells 1, 4, 7, and 28 had low total coliform detections for one sampling event only (well 1 = 4.1 colony-forming units (cfu)/100 mL, well 4 = 2 cfu/100 mL, well 7 = 3.1 cfu/100 mL, and well 28 = 1 cfu/100 mL). These results may represent contamination during sample collection or laboratory analysis, since total coliform were not detected during repeat samples.

ISDA wells 6, 17, 20, and 24 had elevated total coliform detections for the initial and follow-up samples, and ISDA well 6 also had detections of *E. coli* bacteria. These results indicate that the wells were potentially contaminated by a human or animal waste source.

Nitrate Trend Evaluation

An assessment of nitrate trends for wells sampled at least four times was conducted using the Mann-Kendall nonparametric statistical test. The 90% confidence level and a spreadsheet adapted from the State of Wisconsin Department of Natural Resources, Remediation and Redevelopment Program Form 4400-215, were used in this evaluation. Ten wells sampled by ISDA had four sets of nitrate results, and the trend evaluation (Table 4) shows that for all ten wells, there was no trend in nitrate concentrations, either increasing or decreasing. Additional data collected over a longer time period would provide more information on nitrate trends in the study area.

Table 4. Mann-Kendall statistical evaluation of nitrate data from ISDA monitoring wells in the Purple Sage study area (90% confidence level).

ISDA Well #	No. of obs. (n)	MK Statistic (S)	Trend Description
2	4	5	No Trend
4	4	-4	No Trend
5	4	5	No Trend
6	4	1	No Trend
20	4	3	No Trend
21	4	-1	No Trend
22	4	4	No Trend
23	4	0	No Trend
24	4	2	No Trend
28	4	-4	No Trend

Nitrate Impacts at PWS Wells

Replacement wells have been drilled for two PWSs in the Purple Sage area over the past several years due to elevated nitrate. When nitrate exceeds 10 mg/L, a PWS is required by DEQ to submit a confirmatory sample. If this sample also exceeds the MCL, mitigation is required, either through treatment or by well replacement. Both systems elected to replace the existing wells. One replacement well is located at 05N 03W 28ACC, sample location DEQ 3. The replacement well was completed in 1998. The other replacement involved drilling a new well at 05N 03W 27CCB3 (sample location DEQ

11b) that replaced wells 05N 03W 27CCB1 (ISDA well 10/DEQ 17) and 05N 03W 27CCB2 (DEQ 11a).

Nitrate concentrations at ISDA well 10/DEQ 17 ranged from 12.8 mg/L in 2005 to 9.6 mg/L in 2007. It is believed that the casing seal at this well was inadequate, allowing contaminated water to migrate down to the well intake zone. An inadequate casing seal also was believed to resulted in elevated nitrate concentrations at well DEQ 11a (9.8 and 8.3 mg/L in 2006 and 2007 respectively). Replacement well DEQ 3 was completed to a depth of 321 feet, and replacement well DEQ 11b was completed to a depth of 362 feet; nitrate concentrations at these wells were less than 1 mg/L (Table 6). The design for the replacement wells was provided by a professional engineer registered in the State of Idaho and approved by DEQ engineering staff prior to construction to insure an adequate well construction.

These results, along with nitrate results from other deep wells in the study area, provide evidence that the deeper water-bearing units are not contaminated, and that properly constructed wells will continue to produce good quality water even though they may have been drilled through shallow contaminated zones. Costs for the replacement wells are passed on to the water users, so these results point out the economic costs associated with nitrate contamination.

Conclusions

ISDA and DEQ conducted sampling at 38 wells and 6 surface water sites in the Purple Sage area from 2005 through 2008. Field parameters (pH, specific conductance, dissolved oxygen, and temperature) were collected at each site, and samples from wells were analyzed in the laboratory for ammonia, total phosphorus, chloride, sulfate, nitrate, total dissolved solids, and bacteria. Additionally, limited nitrogen, oxygen, and deuterium isotope testing was conducted to help determine contaminant sources.

Thirty-four percent of the wells sampled (13 of 38 wells) had nitrate concentrations of 5 mg/L or greater, which meets the criteria for a Nitrate Priority Area. Eight wells with the highest nitrate concentrations are located in the northern part of the study area. Nitrogen isotope results in 7 of 9 wells (78%) suggest a commercial fertilizer source of nitrate. Some wells, however, have tested positive for bacteria, which suggests localized impacts from human or animal waste sources, or potential well construction issues. A better understanding of ground water flow direction in the project area will assist in identifying contaminant sources.

Six surface water sites along the EHG and WHG drainages were sampled for nitrate, ortho phosphorus, and total phosphorus during periods when ground water was the only contribution to flow in the drainages. Both drainages had nitrate concentrations above 5 mg/L and phosphorus concentrations ranging from 0.25 to 1.0 mg/L total phosphorus. All phosphorus results exceeded the target TMDL phosphorus concentration of 0.075 mg/L for the Snake River-Hells Canyon TMDL area. Elevated phosphorous and nitrate concentrations at all EHG and WHG sample locations indicate that contamination in the uppermost water-bearing unit is widespread and is most likely from agricultural activities

or livestock operations. Bacteria detections at some wells indicate a contaminant source from warm-blooded animals. Phosphorus loads from drainages in the study area that are tributaries to the Boise River must be reduced in order to meet Snake River phosphorus goals.

A trend evaluation using the Mann-Kendall nonparametric statistical test at the 90% confidence level indicated there was no trend in nitrate concentrations, either increasing or decreasing, for 10 wells where sufficient sample data were available.

Ground water within the shallow alluvial aquifer of the project area remains significantly impacted by nitrate. The high nitrate concentrations, large number of detections, cost of well replacement, and potential health implications remain a cause for concern.

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Appendix 1 – Analytical Results

Table 5. Analytical results for ISDA samples collected from wells in the Purple Sage study area. (See table notes directly following the table on page 23.)

				Field Parameters				Laboratory Prameters					
ISDA Well ID	**Well #**	**TRS**	**Sample Date**	**Temp deg C**	**pH SU**	**Sp Cond µS/cm**	**TDS mg/L**	**NO_3-N mg/L**	**Cl mg/L**	**SO_4 mg/L**	**NH_4 mg/L**	**T Coliform cfu/100 mL**	***E. coli* cfu/100 mL**
4250101	1	05N 03W 22ADA	10/18/2005	14.8	7.6	284	138	**0.1**	14.7	27.7	**0.01**	ND	ND
4250101	1	05N 03W 22ADA	10/24/2006	14.7	7.67	243	121	**0.1**	13.7	30.8	**0.01**	ND	ND
4250101	1	05N 03W 22ADA	10/17/2007	14.4	7.69	261.6	128	**0.1**	13.8	31	**0.01**	4.1	ND
4250101	1	05N 03W 22ADA	12/2/2008	14.2	8.28	260	129	**0.1**	13.5	32.3			
4250201	2	04N 03W 23CCC	10/18/2005	14.9	7.41	339	169	3.56	7.8	27.7	0.008	ND	ND
4250201	2	04N 03W 23CCC	10/24/2006	14.7	7.44	297	149	4	8.06	29.3	**0.01**	ND	ND
4250201	2	04N 03W 23CCC	10/17/2007	14.5	7.47	334	164	4	6.92	25.1	**0.01**	ND	ND
4250201	2	04N 03W 23CCC	12/2/2008	11.7	8.08	288	142	4.2	6.53	22.9			
4250301	3	05N 03W 27ADA	10/18/2005	15	7.55	400	197	4.36	12	35.5	**0.01**	ND	ND
4250301	3	05N 03W 27ADA	10/24/2006	15.6	7.55	354	177	5.4	13.3	34.4	**0.01**	ND	ND
4250401	4	05N 03W 14DCC	10/18/2005	15.9	7.98	162	81.3	1.82	3.58	4.31	**0.01**	ND	ND
4250401	4	05N 03W 14DCC	10/24/2006	15.4	8.03	150.6	74.9	2.8	**1**	4.22	**0.01**	ND	ND
4250401	4	05N 03W 14DCC	10/17/2007	15.3	8.03	132.2	65	1.4	1.52	2.78	**0.01**	2	ND
4250401	4	05N 03W 14DCC	12/2/2008	14.6	8.34	109.2	54	0.65	**1**	1.99			
4250501	5	05N 03W 13DDC	10/18/2005	15.3	7.19	718	364	4.03	25.9	83.2	**0.01**		
4250501	5	05N 03W 13DDC	10/24/2006	14.3	7.32	589	289	4.4	27.9	85	**0.01**	ND	ND
4250501	5	05N 03W 13DDC	10/17/2007	14	7.26	671	329	4.4	26.4	82	**0.01**	ND	ND
4250501	5	05N 03W 13DDC	12/2/2008	13.6	7.58	652	321	4.6	27.1	80.8			
4250601	6	05N 02W 18DDD	10/18/2005	15.1	7.03	496	248	2.79	25.7	60.1	**0.01**	25	9.8
4250601	6	05N 02W 18DDD	10/20/2005	14.8	6.95	647	324					770	200

Table 5, continued. Analytical results for ISDA samples collected from wells in the Purple Sage study area. (See table notes directly following the table on page 23.)

				Field Parameters				Laboratory Prameters					
ISDA Well ID	Well #	TRS	Sample Date	Temp deg C	pH SU	Sp Cond µS/cm	TDS mg/L	NO_3-N mg/L	Cl mg/L	SO_4 mg/L	NH_4 mg/L	T Coliform cfu/100 mL	*E. coli* cfu/100 mL
4250601	6	05N 02W 18DDD	10/31/2005	14.7	6.98	475	236					6.3	1
4250601	6	05N 02W 18DDD	11/9/2005	14.6	7.16	418	209					3	ND
4250601	6	05N 02W 18DDD	10/24/2006	14.8	7.02	428	206	3.1	25.3	62.3	**0.01**	ND	ND
4250601	6	05N 02W 18DDD	10/17/2007	14.6	7.03	520	255	2.9	23.4	60.1	**0.01**	19.9	ND
4250601	6	05N 02W 18DDD	12/3/2008	14.7	7.25	418	205	2.9	22.4	57.3			
4250701	7	05N 03W 28DDC	10/18/2005	15.1	7.18	832	415	3.49	49.3	129	**0.01**	3.1	ND
4250801	8	05N 02W 19BCC	10/17/2005	14.3	6.84	586	293	22.7	16	34.4	**0.01**	ND	ND
4250801	8	05N 02W 19BCC	10/24/2006	14	6.88	601	300	36	23.2	46.4	**0.01**	ND	ND
4250801	8	05N 02W 19BCC	10/17/2007	13.9	6.9	682	334	27	20.2	46.6	**0.01**	ND	ND
4250901	9	05N 03W 23DDD1	10/17/2005	14.6	7.39	817	406	6.3	25.3	117	**0.01**	ND	ND
4250901	9	05N 03W 23DDD1	10/24/2006	13.8	7.39	717	358	6.5	30.6	123	**0.01**	ND	ND
4250901	9	05N 03W 23DDD1	10/17/2007	13.8	7.36	861	422	6.4	31.4	120	**0.01**	ND	ND
4251001	10	05N 03W 01	10/18/2005	14.3	7.12	454	226	12.8	10.4	29.2	0.247	ND	ND
4251301	13	05N 02N 20	10/18/2005	14.8	7.17	738	368	1.91	33	125	**0.01**	ND	ND
4251301	13	05N 02N 20	12/3/2008	14.3	7.4	641	314	1.9	30	117			
4251501	15	05N 02W 20BAB	10/17/2005	13.9	7.15	700	349	7.2	13.1	51.9	**0.01**	ND	ND
4251501	15	05N 02W 20BAB	10/24/2006	13.4	7.23	566	283	7.7	13.4	47.8	**0.01**	ND	ND
4251501	15	05N 02W 20BAB	10/17/2007	13.6	7.18	674	330	7.3	14.6	45.1	**0.01**	ND	ND
4251601	16	05N 02W 19BBB	10/17/2005	13.9	7.39	910	444	14.7	20.9	63.1	**0.01**	ND	ND
4251601	16	05N 02W 19BBB	10/24/2006	14	7.45	814	407	16	20.5	64.3	**0.01**	ND	ND
4251601	16	05N 02W 19BBB	10/17/2007	14.6	7.5	881	432	12	15.5	54.1		ND	ND

Table 5, continued. Analytical results for ISDA samples collected from wells in the Purple Sage study area. (See table notes directly following the table on page 23.)

				Field Parameters				Laboratory Prameters					
ISDA Well ID	Well #	TRS	Sample Date	Temp deg C	pH SU	Sp Cond µS/cm	TDS mg/L	NO_3-N mg/L	Cl mg/L	SO_4 mg/L	NH_4 mg/L	T Coliform cfu/100 mL	*E. coli* cfu/100 mL
4251701	17	05N 03W 23DDD2	10/17/2005	14.3	7.38	870	435	8.38	22.3	113	**0.01**	ND	ND
4251701	17	05N 03W 23DDD2	10/24/2006	13.8	7.41	759	380	9.5	23.2	121	**0.01**	ND	ND
4251701	17	05N 03W 23DDD2	10/17/2007	13.8	7.43	910	446	9.6	23.9	119	**0.01**	1011.2	ND
4251801	18	05N 03W 23BDA	10/17/2005	15.7	7.58	284	141	5.02	5.75	14.3	**0.01**	ND	ND
4251801	18	05N 03W 23BDA	10/24/2006	14.9	7.74	245	122	5.4	5.7	14.9	**0.01**	ND	ND
4251801	18	05N 03W 23BDA	10/17/2007	15	7.82	282	138	4.3	5.75	17.1	**0.01**	ND	ND
4252001	20	05N 02W 18CCC	10/20/2005	13.9	7.22	925	466	6.43	44.1	112	0.018	17	ND
4252001	20	05N 02W 18CCC	10/24/2006	13	7.33	807	403	7.2	44.9	113	**0.01**	14	ND
4252001	20	05N 02W 18CCC	10/17/2007	13.3	7.27	892	437	6.9	42.6	109	**0.01**	920.8	ND
4252001	20	05N 02W 18CCC	12/2/2008	11.7	7.46	871	425	7.2	42	107	NA		
4252101	21	05N 02W 21DCD	10/20/2005	15.4	6.98	274	136	1.15	22.9	43.9	**0.01**	ND	ND
4252101	21	05N 02W 21DCD	10/24/2006	15.1	7.15	277	139	1.2	24.8	45.5	**0.01**	ND	ND
4252101	21	05N 02W 21DCD	10/17/2007	15	7.09	309	152	1.2	24.4	46.4	**0.01**	ND	ND
4252101	21	05N 02W 21DCD	12/3/2008	15.1	7.33	282	137	1	24.7	45			
4252201	22	05N 02W 18DAD	10/31/2005	14.2	7.38	903	451	3.37	35.3	86.6	**0.01**	ND	ND
4252201	22	05N 02W 18DAD	10/24/2006	14.5	7.46	656	328	3.9	34.2	84.7	**0.01**	ND	ND
4252201	22	05N 02W 18DAD	10/17/2007	14.6	7.42	730	357	3.7	29.6	80.4	**0.01**	ND	ND
4252201	22	05N 02W 18DAD	12/2/2008	13.2	8.02	710	347	4.2	27.2	77.7			
4252301	23	05N 02W 19ADD	10/31/2005	14.9	7.62	451	225	1.27	3.99	15.9	**0.01**	ND	ND
4252301	23	05N 02W 19ADD	10/24/2006	15.7	7.79	298	149	0.72	3.18	12.9	**0.01**	ND	ND
4252301	23	05N 02W 19ADD	10/17/2007	15.6	7.88	260.1	127	0.61	1.58	10	**0.01**	ND	ND
4252301	23	05N 02W 19ADD	12/3/2008	14.8	8.15	263	128	1.6	2.37	14			

Table 5, concluded. Analytical results for ISDA samples collected from wells in the Purple Sage study area.

				Field Parameters				Laboratory Prameters					
ISDA Well ID	Well #	TRS	Sample Date	Temp deg C	pH SU	Sp Cond µS/cm	TDS mg/L	NO_3-N mg/L	Cl mg/L	SO_4 mg/L	NH_4 mg/L	T Coliform cfu/100 mL	*E. coli* cfu/100 mL
4252401	24	05N 02W 20ACC	10/31/2005	14.3	7.84	762	368	14.4	22.9	35.4	**0.01**	2400	ND
4252401	24	05N 02W 20ACC	11/9/2005	14.3	7.97	605	302					2400	ND
4252401	24	05N 02W 20ACC	11/17/2005	14	7.86	660	330					40	ND
4252401	24	05N 02W 20ACC	10/24/2006	14.5	7.83	686	342	16	22.1	52.7	**0.01**	ND	ND
4252401	24	05N 02W 20ACC	10/17/2007	15.3	7.84	823	403	13	18.1	61.3	**0.01**	ND	ND
4252401	24	05N 02W 20ACC	12/3/2008	15.1	7.94	707	346	18	21.1	53.6			
4252801	28	05N 03W 24CBB	10/18/2005	13.9	7.38	756	378	7.06	17.7	92.3	**0.01**	1	ND
4252801	28	05N 03W 24CBB	10/24/2006	13.5	7.5	647	323	7.4	20.5	101	**0.01**	ND	ND
4252801	28	05N 03W 24CBB	10/17/2007	13.3	7.46	722	354	7	20.2	98.9	**0.01**	ND	ND
4252801	28	05N 03W 24CBB	12/2/2008	12.8	7.87	720	352	6.8	22.4	101			

NOTES:

TRS = township, range, and section
deg C = degrees Celsius
SU = standard pH units
Sp Cond = specific conductivity
µS/cm = micro Siemens per square centimeter
TDS = total dissolved solids
NO_3-N = nitrate as nitrogen
Cl = chloride
SO_4 = sulfate
NH_4 = ammonia
cfu/100 mL = colony forming units per 100 milliliter
Blank indicates no data are available.
Values in bold indicate analyte was not detected at laboratory detection limit.

Table 6. Analytical results for DEQ samples collected from wells in the Purple Sage study area. (See table notes directly following the table on page 26.)

				Field Parameters				Lab Parameters						Isotopes		
Well Number	TRS	Sample Date	Well TD (feet)	pH S.U.	S. C. µS/cm	D.O. mg/L	Temp °C	NH_4 mg/L	Total P (mg/L)	Cl^- mg/L	SO_4 mg/L	NO_3 mg/L	TDS mg/L	^{18}O per mil	^{2}H per mil	^{15}N per mil
DEQ 1	05N 02W 19CCC	10/25/2006		7.06	443	2.39	13.9	**0.04**	0.13	6	26	4.2	250	-15.5	-114	
DEQ 1	05N 02W 19CCC	10/23/2007		7.13	413	3.51	14.6					4.3				
DEQ 1	05N 02W 19CCC	12/2/2008		6.71	434	5.33	14.70			5.20	33	4	270			
DEQ 2	05N 02W 19DCD	10/25/2006	205	6.96	636	7.54	14.2	**0.04**	0.05	33	90	3.2	430	-16.1	-119	
DEQ 2	05N 02W 19DCD	10/25/2007	205	7.03	632	5.17	14.6					0.44				
DEQ 2	05N 02W 19DCD	12/2/2008	205	6.77	698	8.86	14.30			31.00	89.00	3.1	440.00			
DEQ 3	05N 03W 28ACC	10/24/2006	321	7.37	387	2.97	16.3	**0.04**	**0.05**	30	60	0.69	238	-17.1	-124	
DEQ 3	05N 03W 28ACC	10/23/2007	321	7.7	402	6.4	15.9					0.75				
DEQ 3	05N 03W 28ACC	12/2/2008	321	6.74	446	2.87	15.90			32.00	65.00	0.85	160.00			
DEQ 4	05N 03W 35BCB	10/24/2006	120	7.41	649	8.18	15.4	0.06	0.1	11	52	4.8	368	-15.6	-115	
DEQ 4	05N 03W 35BCB	10/25/2007	120	7.41	655	7.46	15.0					3.1				
DEQ 4	05N 03W 35BCB	12/2/2008	120	6.8	635	9.78	15.20			10.00	52	0.5	350			
DEQ 5	05N 03W 35DCC	10/24/2006		7.38	676	6.41	14.1	0.05	0.08	11	51	5.4	550	-15.7	-115	
DEQ 5	05N 03W 35DCC	10/23/2007		7.34	690	7.59	14.5					5				
DEQ 5	05N 03W 35DCC	12/2/2008		6.74	728	8.67	14.70			8.70	42.00	5.3	340.00			5.30
DEQ 6	05N 02W 30DDD	10/24/2006	66	7.35	584	7.63	14.4	**0.04**	0.22	6	36	3.3	388	-15.7	-114	
DEQ 6	05N 02W 30DDD	10/25/2007	66	7.38	566	8.47	14.2					3.4				
DEQ 6	05N 02W 30DDD	12/2/2008	66	7.33	584	8.4	14.00			6.20	41.00	3.7	370.00			
DEQ 7	05N 02W 30ADD	10/24/2006		6.88	698	12.5	13.5	**0.04**	0.06	35	105	4.0	408	-16.0	-119	
DEQ 7	05N 02W 30ADD	10/25/2007		6.86	689	12.93	13.5					3.6				
DEQ 7	05N 02W 30ADD	12/2/2008		6.68	717	11.99	13.70			29.00	100.00	3.6	450.00			
DEQ 8	05N 02W 20CCC	10/24/2006		7.09	464	7.03	14.9	**0.04**	0.13	22	28	1.81	266	-15.3	-107	
DEQ 8	05N 02W 20CCC	**No sample**														
DEQ 8	05N 02W 20CCC	**No sample**														

Table 6, continued. Analytical results for DEQ samples collected from wells in the Purple Sage study area. (See table notes directly following the table on page 26.)

				Field Parameters				Lab Parameters						Isotopes		
Well Number	TRS	Sample Date	Well TD (feet)	pH S.U.	S. C. µS/cm	D.O. mg/L	Temp °C	NH_4 mg/L	Total P (mg/L)	Cl^- mg/L	SO_4 mg/L	NO_3 mg/L	TDS mg/L	^{18}O per mil	^{2}H per mil	^{15}N per mil
DEQ 9	05N 02W 31ADD	10/24/2006	196	6.9	424	9.8	13.6	**0.04**	**0.05**	27	51	1.72	360	-16.7	-122	
DEQ 9	05N 02W 31ADD	10/25/2007	196	6.93	437	10.29	13.5					4.5				
DEQ 9	05N 02W 31ADD	12/2/2008	196	6.69	449	10.47	14.80			23.00	50.00	1.8	230.00			
DEQ 10	05N 02W 32CCC	10/24/2006	236	7.43	152	0.89	13.4	**0.04**	**0.05**	3	8	0.31	88	-17.3	-126	
DEQ 10	05N 02W 32CCC	10/25/2007	236	7.54	154	0.82	13.4					1.8				
DEQ 10	05N 02W 32CCC	12/2/2008	236	7.5	171	1.17	13.20			3.50	8.10	0.37	56.00			
DEQ 11a	05N 03W 27CCB2	10/25/2006		7.22	440	7.79	13.9	**0.04**	0.07	7	28	9.8	214	-15.5	-115	
DEQ 11a	05N 03W 27CCB2	10/23/2007		7.25	419	4	11.3					8.3				
DEQ 11a	05N 03W 27CCB2	12/2/2008		**No sample**												
DEQ 11b	05N 03W 27CCB3	1/6/2009	362	8.41	140	8.16	16.30			4.70	8.4	0.35	76			
DEQ 12	05N 03W 25DCB	10/25/2006	79	7.36	703	8.37	14.7	**0.04**	0.15	6	41	5.5	364	-15.7	-115	
DEQ 12	05N 03W 25DCB	10/23/2007	79	7.44	684	6.63	14.9					6.4				
DEQ 12	05N 03W 25DCB	12/2/2008	79	6.96	692	8.56	14.70			5.60	35	6.1	230			5.8
DEQ 13	04N 03W 03ACC	10/23/2006		7.18	208	4.55	15.1	**0.04**	0.06	5	13	0.47	110	-16.5	-121	
DEQ 13	04N 03W 03ACC	10/25/2007		7.31	194	3.96	14.7					0.32				
DEQ 13	04N 03W 03ACC	1/6/2009		7.47	189	3.85	14.70			4.70	8.40	0.35	76.00			
DEQ 14	04N 02W 05BAC	10/23/2006		6.8	337	10.67	13.6	**0.04**	**0.05**	15	38	1.56	182	-16.8	-124	
DEQ 14	04N 02W 05BAC	11/1/2007		6.06	299	8.4	13.4					1.7				
DEQ 14	04N 02W 05BAC	12/2/2008		**No sample**												
DEQ 15	05N 03W 28DDC	10/24/2006	195	7.1	836	10.79	14.7	0.05	**0.05**	48	134	3.7	492	-16.2	-119	
DEQ 15	05N 03W 28DDC	10/23/2007	195	7.22	771	6.62	15.9					3.8				
DEQ 15	05N 03W 28DDC	102/02/2008	195	6.82	851	8.36	13.40			45.00	130	4	540			

Table 6, concluded. Analytical results for DEQ samples collected from wells in the Purple Sage study area.

				Field Parameters				Lab Parameters						Isotopes		
Well Number	TRS	Sample Date	Well TD (feet)	pH S.U.	S. C. µS/cm	D.O. mg/L	Temp °C	NH_4 mg/L	Total P (mg/L)	Cl^- mg/L	SO_4 mg/L	NO_3 mg/L	TDS mg/L	^{18}O per mil	^{2}H per mil	^{15}N per mil
DEQ 16	05N 03W 28ADD	10/24/2006	362	7.12	98	10.52	15.4	**0.04**	**0.05**	6	16	0.6	128	-17.0	-125	
DEQ 16	05N 03W 28ADD	10/23/2007	362	7.41	200	1.24	15.3					0.68				
DEQ 16	05N 03W 28ADD	12/2/2008	362	6.85	230	1.76	14.30			6.60	16	0.76	170.00			
DEQ 17	05N 03W 27CCB1	10/25/2006		7.08	428	7.86	13.8	**0.04**	0.09	9	31	11.1	80	-15.5	-109	
DEQ 17	05N 03W 27CCB1	10/23/2007		7.1	426	5.99	14.0					9.6				
DEQ 17	05N 03W 27CCB1	12/2/2008		**No sample**												

NOTES:

TRS = township, range, and section
TD = total depth
S.U. = standard pH units
S.C. = specific conductivity
µS/cm = micro Siemens per square centimeter
D.O. = dissolved oxygen
mg/L = milligrams per liter
Temp = temperature
NH_4 = ammonia
Total P = total phosphorus
Cl = chloride
SO_4 = sulfate
NO_3 = nitrate
TDS = total dissolved solids
per mil = parts per thousand
Blanks indicate no data are available.
Values in bold indicate analyte was not detected at laboratory detection limit.

Table 7. Analytical results for six ISDA surface water sample locations on East Hartley Gulch (EHG) and West Hartley Gulch (WHG), Purple Sage study area.

Site ID	Sample Date	NO_3-N mg/L	ortho P mg/L	Total P mg/L
WHG-1	11/1/2006	6.4	0.374	0.605
WHG-1	1/25/2007	5.81	0.437	0.47
WHG-1	11/29/2007	5.7	0.364	0.428
WHG-2	11/1/2006	7.6	0.404	0.636
WHG-2	1/25/2007	6.71	0.256	0.42
WHG-2	11/29/2007	6.1	0.394	0.484
WHG-3	11/1/2006	14.3	0.641	1
WHG-3	1/25/2007	11.8	0.419	0.77
WHG-3	11/29/2007	9.9	0.784	0.995
EGH-1	11/1/2006	5.4	0.221	0.304
EGH-1	1/25/2007	5.66	0.237	0.29
EGH-1	11/29/2007	5.8	0.252	0.335
EHG-2	11/1/2006	6.1	0.237	0.312
EHG-2	1/25/2007	6.38	0.24	0.25
EHG-2	11/29/2007	6.1	0.263	0.296
EHG-3	11/1/2006	5.6	0.274	0.343
EHG-3	1/25/2007	5.42	0.27	0.29
EHG-3	11/29/2007	5.4	0.291	0.324

NOTES:

NO_3-N = nitrate
ortho P = ortho phosphorus
Total P = total phosphorus

Appendix 2 – Well Numbering System

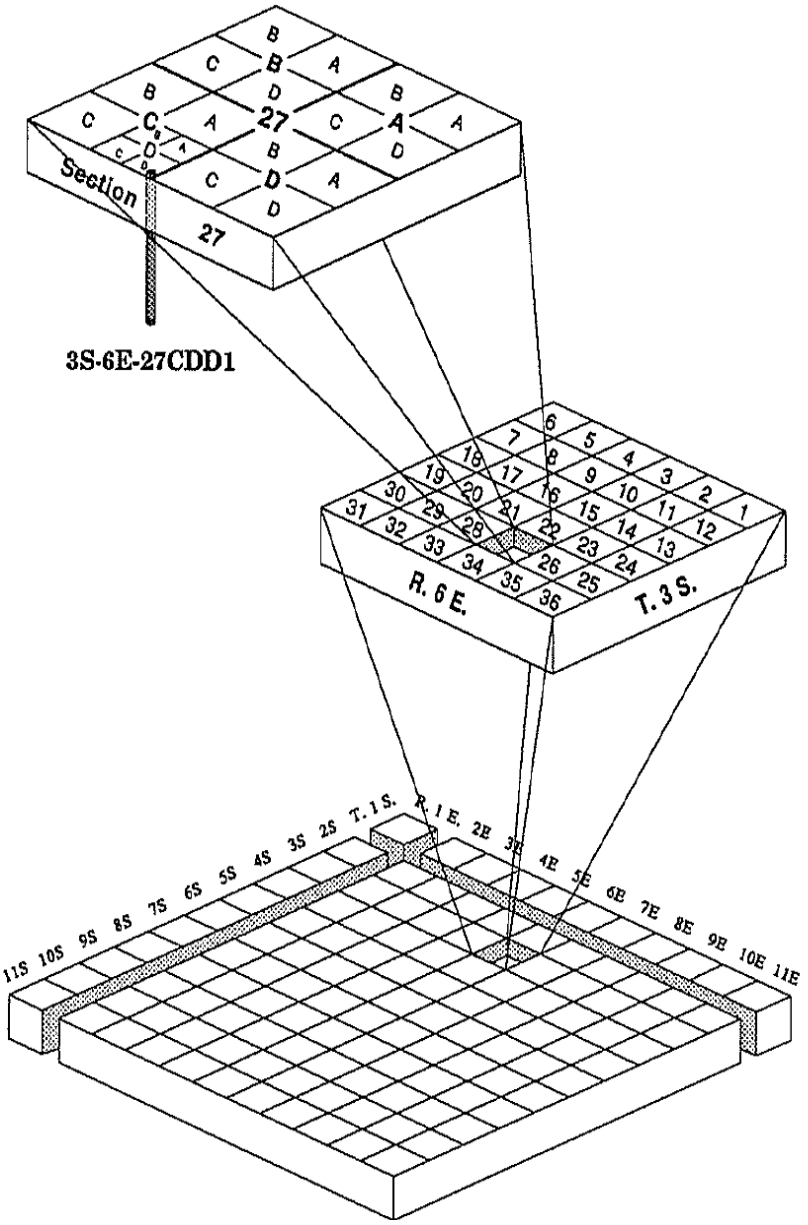

Figure 6. Example of using the well numbering system to uniquely identify a well location (adapted from Parliman and Young, 1990).

The well numbering system used in this investigation derives from the township and range system of identifying land parcels. In the example shown in Figure 6, the first grid (bottom) shows a land parcel identified as Boise Township 3 South (03S), Range 5 East (05E). The second (middle) grid identifies Section 27 within 03S – 05E. In the third (upper) grid, the southwest quarter of Section 27 is 27C, the southeast quarter of 28C is 28CD, and the southeast quarter of

27CD is 27CDD. Where more than one well is identified in a particular quarter-quarter-quarter section, numerical identifiers are added.