Ground Water Quality Technical Report No. 18

A Reconnaissance of Ground Water Nitrite/Nitrate in the Cow Creek Watershed

Latah and Nez Perce County, Idaho

Volume I of II

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Volume II is available only in hard copy. You can obtain a copy by calling DEQ's Lewiston Regional Office at (208) 799-4370.

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ABSTRACT

During the summer of 2001 the Idaho Department of Environmental Quality (DEQ), Lewiston Regional Office, sampled 32 domestic drinking water wells, one municipal well, and five springs located in and around the Cow Creek watershed. Samples from the wells and springs were analyzed for nitrite plus nitrate as N (nitrite plus nitrate as N will be referred to as nitrate for convenience in the rest of this report) to collect information concerning ground water conditions in the area. In addition to nitrate analysis, nine wells with elevated nitrate concentrations were analyzed for nitrogen and oxygen isotopes. The results of the isotope analysis were used to help identify probable sources of nitrate in the watershed.

The objectives of this study include:
1) Sample at least 30 wells and springs in the Cow Creek watershed and analyze for nitrate concentrations.
2) Describe nitrate concentrations in potable aquifers.
3) Provide additional information, which can be used by the Statewide Ambient Ground Water Monitoring Network
4) Provide information to determine additional monitoring needs.
5) Conduct a reconnaissance of potential nitrate sources.

The Cow Creek watershed is approximately 51.1 square miles in size and is located primarily in southwestern Latah County, Idaho extending into the northwest portion of Nez Perce County, Idaho. The cities of Lewiston and Moscow, Idaho are 15 miles to the south and 10 miles to the north of the watershed, respectively. The headwaters of Cow Creek originate on the south slopes of Paradise Ridge, south of Moscow. From Paradise Ridge, the stream flows south through the city of Genesee, then flows west, finally entering Union Flat Creek in the state of Washington.

The 33 wells and five springs sampled in the Cow Creek watershed exhibited varied results. Nitrate concentrations ranged from below detection limits (less than 0.05 milligrams per liter) to over 14 milligrams per liter (mg/L). Of the sample sites, 66% (25 sites) had nitrate concentrations below background concentrations of 2 mg/L while 11% (four sites) had nitrate concentrations over the Idaho Ground Water Quality Rule maximum contaminant level (MCL) of 10 mg/L for ground water. Four of five spring samples had nitrate concentrations above 10 mg/L; one of 33 well samples had nitrate above 10 mg/L. Overall, nitrate concentrations in this study were generally lower than previous data indicated.

The following recommendations are based on the results of this study:
- Discourage the use of springs as a source of drinking water.
- Closely monitor wells and springs with nitrate concentrations greater than 5 mg/L if used as a source of drinking water.
- Provide a buffer strip (100 feet) around well heads where possible.
- Continue to collect data from new and existing sites throughout the Cow Creek watershed.

- Provide guidance to well owners concerned with the quality of their ground water.
- Work with producers and fertilizers to fine-tune timing and amount of fertilizer applications.

INTRODUCTION

The Cow Creek watershed is located in southern Latah County and northern Nez Perce County in northern Idaho (Figure 1). The 51.1 square mile watershed has its origins on the southern slopes of Paradise Ridge, located just south of Moscow, Idaho. From Paradise Ridge the stream flows south, weaving through the hilly Palouse region into the City of Genesee, Idaho. From Genesee the stream flows in a westerly direction until it joins with Union Flat Creek one mile from the Idaho-Washington border.

The Palouse region in eastern Washington and northern Idaho is an area of very rich loess farmland. Dry land agriculture dominates land use and crops such as wheat and peas grow well in the fertile loess soils of the Cow Creek valley and surrounding hills. Genesee, with a population of approximately 1000, is the only incorporated city in the Cow Creek watershed. Ground water is the only source of drinking water for people living in the Cow Creek watershed.

The city of Genesee has several municipal wells in which previous tests indicated elevated nitrate-N (hereafter nitrate) concentrations. Excess nitrate in drinking water can be unhealthy, especially for small children. Elevated nitrate concentrations in drinking water can cause methemoglobinemia (blue baby syndrome), which primarily affects infant children. In the human digestive system nitrate is converted to nitrite, which causes iron in hemoglobin to oxidize. This reduces the blood's capacity to carry oxygen, and can result in cyanosis, characterized by bluish skin and lips. Researchers also have implicated nitrate in drinking water supplies as a possible risk factor associated with non-Hodgkin's lymphoma, gastric cancer, hypertension thyroid disorder and birth defects (West, 2001).

The Environmental Protection Agency (EPA) established a maximum contaminant level (MCL) for drinking water of 10.0 mg/L of nitrate; this MCL was adopted in the Idaho Ground Water Quality Rule (IDAPA 58.01.11). Municipal records for the Genesee city wells and data from the Idaho Statewide Ambient Ground Water Monitoring Network (AMN) indicated that Cow Creek ground water exceeded the nitrate MCL at some locations.

Data for the AMN was taken from nine domestic wells surrounding the Genesee area and from the city of Genesee municipal wells. Of the nine domestic wells, seven are still actively monitored. While these data provided a general knowledge of ground water quality in the Cow Creek watershed, more information was needed to better understand ground water nitrate concentrations in the entire watershed.

In the summer of 2001, the DEQ, Lewiston Regional Office, sampled 32 domestic drinking water wells, one municipal well, and five springs for a total of 38 sampling locations in and around the Cow Creek watershed. The samples from the wells and springs were tested for nitrate in order to collect information on ground water quality in the area. In addition to nitrate sampling, nine wells with the highest concentration were tested for nitrogen and oxygen isotopes along with common ions (calcium, magnesium, sodium, potassium, bicarbonate, chloride and sulfate). Together, this information was used to evaluate possible sources of nitrate in the watershed. This study will aid in the assessment of ground water quality in the Cow Creek watershed and will assist planning efforts to protect municipal drinking water supplies for the city of Genesee.

Purpose and Objectives

The purpose of this study is to assess the extent of nitrate ground water contamination in the Cow Creek watershed.
The objectives include:

1) Sample at least 30 wells in the Cow Creek area and analyze for nitrate concentrations.
2) Describe nitrate concentrations from potable aquifers.
3) Provide additional information that can be used by the Statewide Ambient Ground Water Monitoring Network
4) Provide information to determine additional monitoring needs.
5) Conduct a reconnaissance of potential nitrate sources. This information is presented in Volume 2 of the report.

Ambient Ground Water Monitoring Network Data

The Idaho Department of Water Resources (IDWR) provided data from the Ambient Ground Water Monitoring Network (AMN). IDWR has been sampling wells in the Cow Creek watershed since 1991; currently, seven wells are regularly sampled. The Results and Discussion section includes a summary of the data.

Public Water System Data

The city of Genesee has the only public water system in the Cow Creek watershed. Ground water data on file at the Lewiston Regional Office of DEQ included nitrate concentrations for Genesee municipal wells dating back to the 1980's. The data were tabulated and analyzed for inclusion in this report. The Results and Discussion section of this paper includes a summary of the data.

Literature Review and Data Sources

There are no known comprehensive qualitative ground water studies of the watershed; however, several studies were reviewed that describe the geological and hydrogeological characteristics of the area.

Hydrogeological Assessment of the Potential for Future Ground-Water Development in Genesee, Idaho (Lawrence, 1995) describes ground water development of the Genesee area and explores options for aquifer development by the City of Genesee. In 1993, nitrate contamination of ground water led to the closure of one city water supply well, which left the city exploring options for other water supplies. Lawrence's thesis provided much needed background information on ground water occurrence in the Genesee and

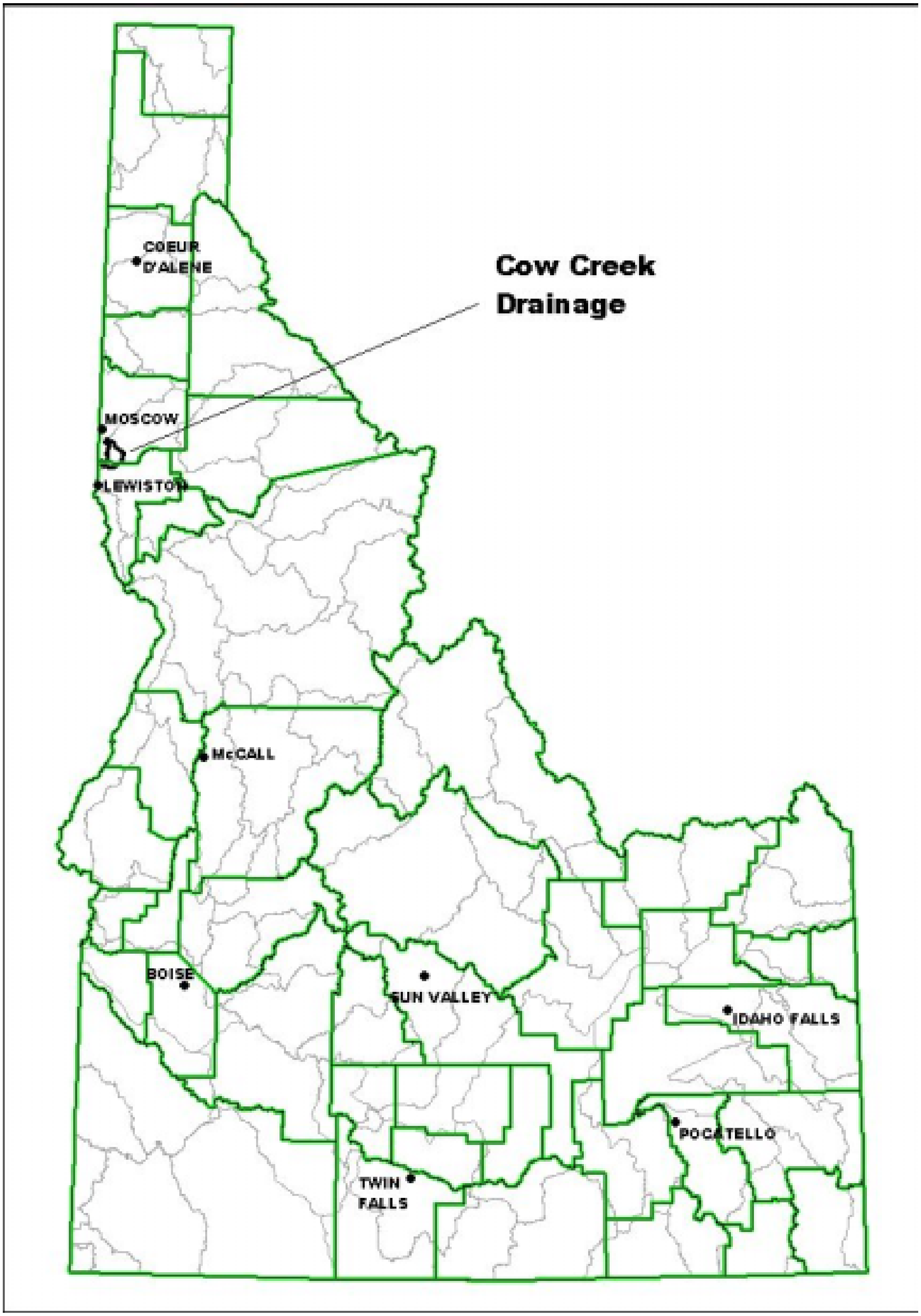


Figure 1. Location of Cow Creek water shed.

Cow Creek areas. The thesis describes geological and hydrogeological conditions along with historical information for Genesee city wells.

The United States Department of Agriculture (USDA) Soil Survey for Latah County, Idaho (Barker, 1981) provides a description of the soils, topography, and climate of the Cow Creek watershed.

Nitrates in Ground water: A Continuing Issue for Idaho Citizens (West, 2001) is a valuable source of information on the occurrence and health effects of nitrate in Idaho's ground water. It also provides background information on ground water in the state and describes areas with elevated nitrate contamination. Cow Creek was one of 33 areas in the state identified as having ground water degraded by nitrate.

Ground water and Wells (Driscoll, 1986), presents a basic understanding of well construction and hydrogeology and also describes in detail the hydrogeologic aspects of aquifers.

A Reconnaissance of Nitrite/Nitrate in Camas Prairie Ground water, (Bentz, 1998) was used as the format for this study.

Idaho Department of Environmental Quality *Policy for Addressing Degraded Ground Water Quality Areas PM00-04* describes agency action to identify, prioritize, and manage areas with significant ground water degradation. The Cow Creek watershed was identified as a Nitrate Priority Area with this process.

STUDY AREA

The Cow Creek watershed is located primarily in southwestern Latah County, Idaho extending into the northwest section of Nez Perce County and is approximately 51.1 square miles in size (Figure 1). The cities of Lewiston and Moscow, Idaho are 15 miles to the south and 10 miles to the north of the watershed, respectively. Cow Creek's headwaters are on the south slopes of Paradise Ridge, located south of Moscow. From Paradise Ridge the stream flows south towards the City of Genesee. After Genesee, the stream flows to the west, entering Union Flat Creek in the state of Washington.

Climate

The climate of the Cow Creek watershed is typical for the Palouse region, located in southeastern Washington and northern Idaho. Due to the high elevation (greater than 2000 feet), this area receives higher precipitation than much of the surrounding lower area. Abundant rainfall in combination with loess soil produces a very fertile area for agriculture. Temperatures range from average daily high temperatures of 85 degrees Fahrenheit in the summer to 35 degrees in the winter. Average daily minimum temperatures are around 50 degrees in the summer, reaching as low as 23 degrees in the winter. Precipitation for the area ranges from 20 to 27 inches per year. The greatest amount of rainfall occurs in the months of November, December and January. The summer months of July and August receive the least amount of precipitation, usually less than one inch per month (Barker, 1981).

Ecoregion

The entire Cow Creek watershed is located within the extremely variable Columbia Basin ecoregion, which is surrounded by high mountain ranges, namely the Northern Rocky Mountains including the Clearwater Mountains, Wallowa Mountains, Blue Mountains, and Cascade Mountains. The Columbia Basin ecoregion is very large covering about 34,000 square miles and is characterized by deep, dry channels cut into the Columbia River Basalt Group (Omernik and Gallant, 1986).

Intermittent and ephemeral streams drain most of the area. Some streams such as Cow Creek flow year-round due to discharge from aquifers (Omernik and Gallant, 1986).

Natural vegetation consists primarily of grass and sagebrush with forests on higher slopes. Small trees and brush grow around springs where water is more plentiful. The Cow Creek area supports agriculture in the form of wheat grasses and peas. Crop production is successful due to the large amount of rainfall the area receives in combination with the capacity of the loess soil to retain moisture. The Cow Creek watershed lies on the eastern portion of the Columbia Basin ecoregion, which receives more rainfall than most of the ecoregion (Omernik and Gallant, 1986).

Soils

Three major soil groups exist in the Cow Creek watershed. The primary soil group is the Palouse-Naff soil group. The other two soil groups, the Latahco-Lovell and Palouse Silt Loam groups, occur less frequently. Soil variation in the Cow Creek area is primarily due to changing landforms. The uplands and lowlands in the area are a result of the stream winding through the Palouse region. The lowlands in the valley of Cow Creek constitute the floodplain. The soils in the floodplain are primarily of the Latahco-Lovell group with small quantities of Palouse Silt Loam soils. These soils, especially the Latahco-Lovell soil, generally occur in flat areas. The uplands surrounding the stream, composing most of the watershed, primarily have soils in the Palouse-Naff soil group (Barker, 1981). The characteristics of soil groups found in the area are discussed below.

Palouse-Naff soil group: These are very deep, well drained soils. They exist on gently sloping to moderately sloping landscapes. These soils are generally formed from a loess base (Barker, 1981).

Latahco-Lovell soils: These are very deep and somewhat poorly drained soils. They are formed from alluvium. Permeability is moderately slow. Available water capacity is high. Soil is usually subject to brief periods of flooding in the winter and spring seasons (Barker, 1981).

Palouse Silt Loam soil: A very deep soil that is well drained and usually lies on the south slopes of uplands. Soil is formed from loess. Permeability is moderate and the soil has a high available water capacity. Runoff is usually rapid, thus increasing the hazard of soil erosion (Barker, 1981).

Geology

The Cow Creek area lies on the eastern edge of the Columbia River Plateau. The Columbia River Plateau consists of a series of basalt flows over older granitic and metamorphic rock bases. These flows, termed the Columbia River Basalt Group (CRBG), consists of multiple layers of basalt flows with sedimentary interbeds. These interbeds can greatly enhance the capability of basalt to store water (Driscoll, 1986). The CRBG forms the basic geology of the area around Cow Creek. The flows end just east of the watershed as the Rocky Mountains are approached (Lawrence, 1995).

The underlying metamorphic rock or basement rock is mostly granite from the Belt Supergroup, which is pre-Cambrian meta-sedimentary rock, and the Idaho Batholith, consisting of Mesozoic intrusive rocks (Lawrence, 1995).

There are four major layers to the CRBG that are Miocene basalt flows. These are the Imnaha, Grande Ronde, Wanapum, and Saddle Mountain formations starting with the Imnaha as the deepest. An individual flow can be as thick as 300 feet (Lawrence, 1995).

Hydrology and Hydrogeology

The major aquifers underlying the Cow Creek area are located in the deep loess soil layer and in the basalt layers that make up the CRBG. The alluvial aquifer consists of loess soil formations and constitutes an important drinking water supply in the area. The loess deposits are primarily composed of silty clays, which do not have an extremely high water yielding capacity. Despite this, the water holding capacity of loess can be quite high, especially when penetrated by roots and animal burrows (Pierce 1998).

The direction of ground water flow in the alluvial aquifer is from areas of high to low elevation areas. Some ground water in this aquifer discharges to small tributaries and local drainages, but Cow Creek serves as the main discharge area for ground water in the alluvial aquifer.

Deeper wells in the area penetrate the basalt flows that underlie the loess. The basalt flows hold water in the sedimentary interbeds and in fractured areas within individual flow units. Fractures formed during cooling of lava and also from stresses to the formations. These fractures then become open or sediment filled spaces where water can collect (Driscoll, 1986). The Wanapum aquifer, found in the Wanapum basalt, is found at depths up to 300 feet under the Palouse soil. The Wanapum aquifer provides adequate drinking water supplies for households but cannot support large systems as required by cities such as Moscow and Pullman.

The Grande Ronde aquifer, found in the Grande Ronde basalt, is the other major aquifer beneath the Wanapum basalt. The Grande Ronde aquifer is found at depths ranging from 300 to 600 feet below the surface of the Palouse. Well yields from this aquifer range from 900 to 2500 gallons per minute (gpm) (Lawrence, 1995).

The direction of ground water movement in the Wanapum aquifer, described by Lawrence (1995) is predominantly from north to south (Figure 3). Ground water flow information is not available for the Grand Ronde aquifer, but the general flow direction is probably from north to south.

Land Use

The Cow Creek watershed consists of mostly rural area. Figure 2, a 1997/1998 Landsat image, shows major drainage and land use features in the watershed. Land use is dominated by agricultural crops such as wheat and barley, and pea crops including peas, lentils, and garbanzos. Some land is used as pasture for grazing animals, but not in large numbers, generally only a few livestock. The City of Genesee, most of which lies to the west of Cow Creek, is the only incorporated city in the watershed. Genesee was once a fairly active town with many businesses that supported local farmers. The town has since become a bedroom community for nearby larger cities on the Palouse and has a population of approximately 1000 residents. The City of Genesee treats its municipal wastewater with a lagoon located southwest of town, just north of Cow Creek. Most rural residents treat their wastewater with septic systems and drain fields.

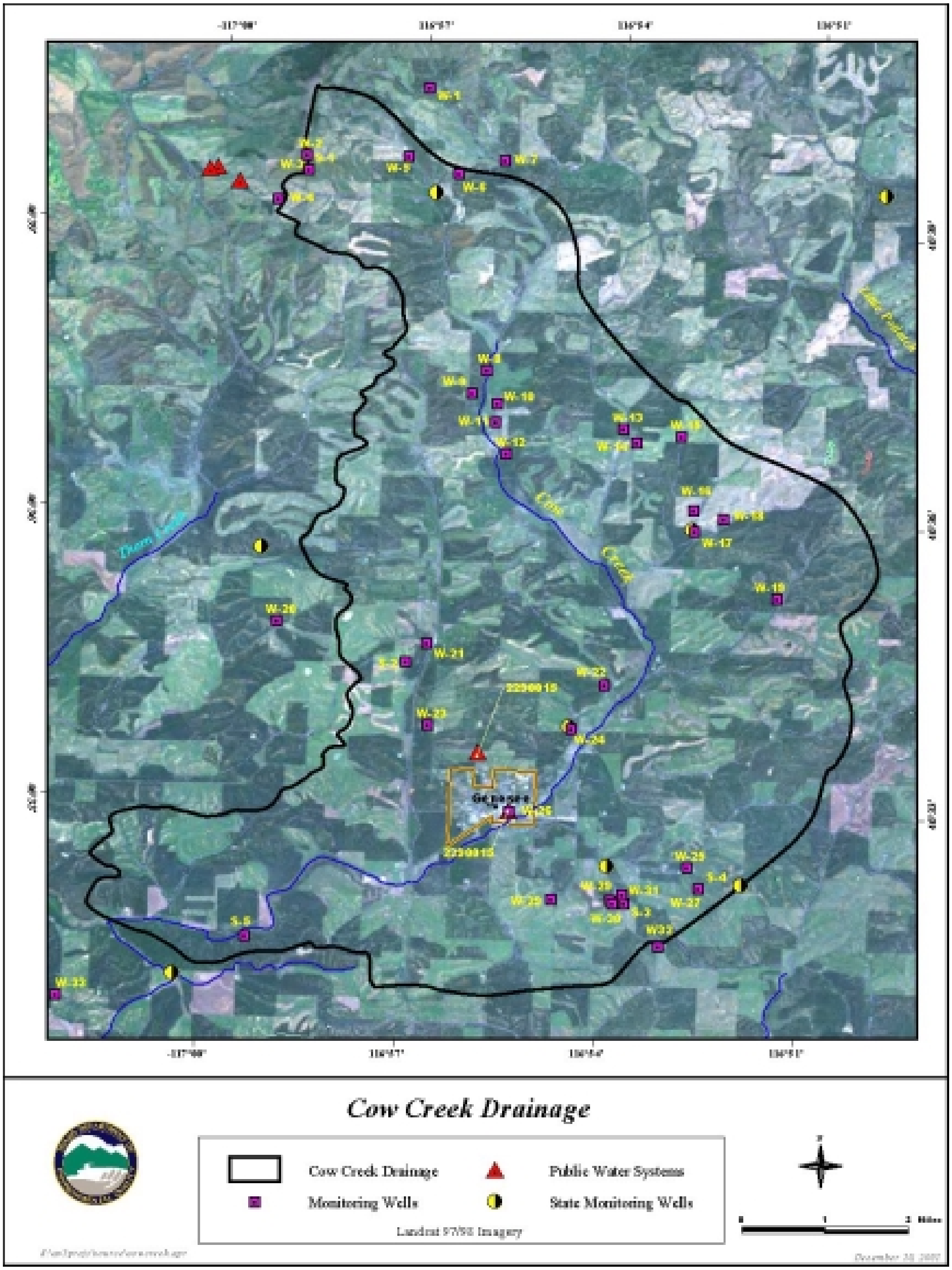


Figure 2. Landsat imagery from 1997/1998 showing Cow Creek watershed boundary, major land use features and location of wells springs sampled.

Water Use

Within the Cow Creek watershed, most wells are for domestic use. No large-scale irrigation is practiced in the watershed. The city of Genesee has the only municipal drinking water system in the area and is fairly small, using less than one million gallons of water per day.

MATERIALS AND METHODS

Site Selection

Few drinking water wells in the Cow Creek watershed have been tested for nitrate; therefore, nitrate concentrations in the watershed have not been adequately described. To obtain additional ground water information, samples were collected and analyzed during the summer of 2001.

The Cow Creek watershed was first delineated on a map to determine its size and boundaries. Well logs in the watershed area were requested from the IDWR. The township-range-section and quarter section information on the well log was used to approximate each well location. Assessor's offices in Latah and Nez Perce counties were contacted to determine well ownership. After obtaining the owner's address, a form letter and permission slip were sent to each well owner. A copy of each of these documents is found in Appendix A.

Sampling permission request letters were sent to 35 well owners, some of which were believed to have more than one well. Nearly fifty percent of the permission request letters were returned granting permission to sample, but additional wells were needed to increase sample size. To locate other wells in the area, those who had previously given testing permission were asked for the names of other area well owners. In addition, addresses were taken from mailboxes and permission slips were sent. The varied methods of finding sample wells gave a wide distribution of data points. A total of 33 wells and five springs were sampled for nitrate. Locations of wells sampled for the AMN project and wells and springs sampled for this project are shown on Figure 3.

Methods

Samples were collected from domestic wells, springs, and one municipal well owned by the City of Genesee. This particular city well is no longer used for drinking water supply. Land uses surrounding each well or spring were inventoried and noted on the forms shown in Appendix A. Each well inventory included a description of the area surrounding the well, the UTM Northing and Easting location, and physical information about the well such as diameter and depth. Samples were generally collected from outside faucets after 5 minutes of purging. Specific conductance and temperature of the water was measured at each site. For initial nitrate analysis, one sample was taken at each site. For the isotope analysis, two additional one-liter samples were collected at nine sites where nitrate concentrations exceeded 2 mg/L. After the samples were collected, they were sent to the lab for analysis.

Quality Assurance/Quality Control

In order to maintain accurate and precise results, several quality assurance/quality control (QA/QC) steps were used when collecting samples. Each well was purged for 5 minutes before taking a sample and each sample bottle was properly labeled and dated. Samples

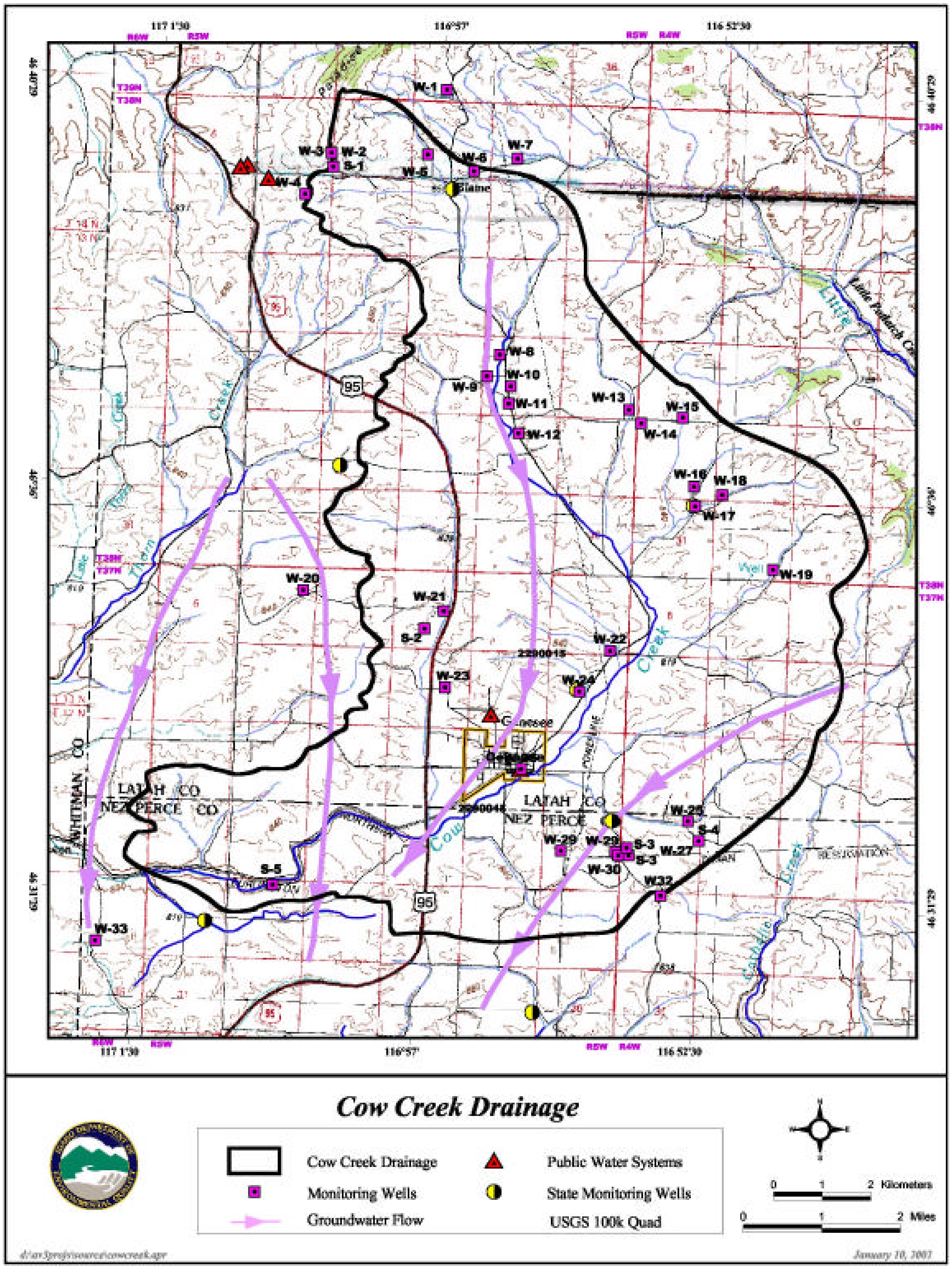


Figure 3. Location of Statewide Ambient Monitoring Network (State Monitoring Wells) and wells and springs sampled for this study. Arrows show ground water flow direction shown for Wanapum aquifer.

were collected in either 1 liter cubic containers or 4 ounce bottles and were cooled to 4 degrees Celsius. Samples collected for nitrate analysis were preserved with sulfuric acid upon receipt by the lab. Samples collected for common ion analysis (calcium, magnesium, sodium potassium, alkalinity, sulfate and chloride) were cooled to 4 degrees Celsius and shipped to the lab. The lab used its internal QA/QC methods during sample analysis. These included using various nitrate spikes with each batch of samples. Samples for isotope analysis were frozen the day of collection and shipped to the University of Waterloo Environmental Isotope Lab for analysis.

Three replicate samples were also collected at three separate sites. These were sent to the lab and the results were analyzed using the relative percent difference (RPD) method as outlined by the EPA (Bentz, 1998). The equation for calculation of RPD is shown below:

$$RPD = 100\left(\frac{(ValueA - ValueB)}{\frac{1}{2}(ValueA + ValueB)}\right),$$

where: RPD = relative percent difference
Value A = larger of the two observed values
Value B = smaller of two observed values.

The three sites at which replicates were taken were sites W-19, W-22, and W-24. The first site, W-19 had results of 0.6 and 0.7 mg/L of nitrate. Results at W-22 were 6.5 and 6.2 mg/L. Both samples from W-24 came back as ND, or no detection. The first and second sites had RPD's of 3.8 and 1.2 percent, respectively, while the third site had an RPD of zero since both of its samples came back with the same result. These results are consistent with the EPA's QA/QC standard of 20 percent relative difference (Bentz 1998).

RESULTS AND DISCUSSION

Municipal Well Data

The City of Genesee is the only municipal water system in the Cow Creek watershed. Genesee has two wells that are used for public water supply and several others that are no longer used for the municipal water system. One of the wells, referred to as Well #1, was tested, and is included in the Cow Creek Data section of the report. The well is currently used to irrigate a ball field. In the early 1990's, nitrate concentrations in this well exceeded the 10 mg/L MCL drinking water standard and its use for drinking water was discontinued. The two municipal wells currently used for public water supply are referred to as Well #3 and Well #5.

The elevated nitrate concentrations seen in Well #1 in the early nineties were also seen in nearby Well #3, which exceeded the MCL for nitrates in September of 1993. Yearly sampling is required for public water supply wells that meet EPA standards; the well was tested weekly after the nitrate spike was discovered. Nitrate concentrations were declining and in 1994, testing was performed monthly. Nitrate concentrations continued to decline in 1995 and testing of Well #3 was reduced to four times per year. Currently the nitrate concentrations from Well #3 range from around 0.5 mg/L to 6 mg/L. Well #5 has never exceeded the MCL for nitrate and is tested on an annual basis. A summary of nitrate concentrations in Genesee municipal wells is shown in Table 1.

Table 1. Nitrate concentrations for Genesee city wells 3 and 5.

City of Genesee Municipal Wells								
			Nitrate Yearly Averages in mg/L					
Well No.	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
3	9.14	7.01	4.57	5.90	5.12	5.81	2.86	4.30
5	DM	DM	0.40	DM	0.40	0.42	0.65	0.88
	DM=Data Missing for that year							

Well #3 exceeded the 2 mg/L background concentration every year for the past eight years. Well #5 is an order of magnitude lower but is beginning to show increasing nitrate concentration. This trend should be watched closely.

Ambient Ground Water Monitoring Network Data

The Idaho Department of Water Resource's ambient ground water monitoring network (AMN) has limited well sampling coverage in the Cow Creek watershed, dating back to 1991. A total of seven privately owned wells are currently sampled in the area. The location of these wells is shown on Figure 3. Most of the wells are tested once every four years; however Well #7 has been tested annually since 1995. Nitrate concentrations have increased in some cases and declined or remained the same in others. The data do not show a definitive trend toward increasing or decreasing nitrate concentrations. None of the wells sampled exceeded the EPA drinking water standard of 10 mg/L, although the average concentration in two of the wells were above the background concentration of 2 mg/L. The average in the other five wells were below this concentration, although one of these wells was slightly above background concentration for one of the years it was sampled. The results are as shown in Table 2.

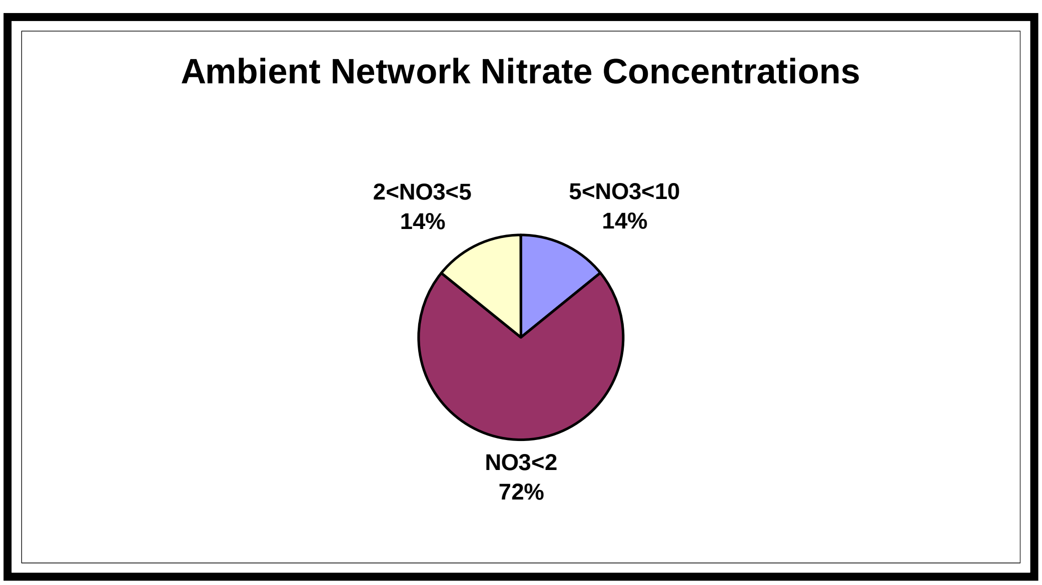
Table 2. IDWR ambient network nitrate concentrations.

					Nitrate Results (mg/L)							
Well Number	Well Location*	1991	1992	1993	1995	1996	1997	1998	1999	2000	2001	**Average**
1	37.05.12BDD1			3.01			7.07				4.38	4.82
2	37.05.24AAA1		ND			0.06				ND		0.06
3	37.05.30DAB1			5.10			7.57					6.34
4	37.05.35AAD1	ND			ND				ND			ND
5	38.04.31AAB1		ND			0.06				0.06		0.06
6	38.05.10ABC1		1.80			0.99				2.10		1.63
7	38.05.28CBD1	0.20			0.23	0.25	0.23	0.22	0.21	0.21	4.38	0.74

* Well location is listed as Township, Range and Section, followed by the ¼, ¼, ¼ section location.
ND - Non Detectable. Nitrate not detected above a minimum detection level of 0.05 mg/L.

The nitrate concentrations listed in Table 2 are also shown graphically in Figure 4 for nitrate ranges of less than 2, 2 to 5 and 5 to 10 mg/L.

Figure 4. Ambient monitoring network data for 7 wells in Cow Creek watershed area.



Cow Creek Data

Thirty-three wells and five springs were sampled in and around the Cow Creek watershed between June 6, 2001 and July 19, 2001. Sample locations for these wells and springs are shown in Figure 3. The wells ranged in depth from 8.5 feet to 484 feet and are completed into multiple water bearing zones. Wells completed to an approximate depth of 200 feet generally withdraw water from alluvial aquifers, though in areas where the loess soil cover is thin, some wells extend into the basalt Wanapum aquifer. Several of the wells located close to Paradise Ridge, a granite outcropping, are completed in granite according to well log lithologies. The springs that were sampled indicate the quality of local surface and near-surface water. Additional well attributes and characteristics examined are listed in Appendix B. The raw data and well surveys taken for each site are included in Volume 2 of this report.

As stated earlier, the background concentration for nitrate in ground water is considered to be 2 mg/L (West, 2001, p. 1). However, some aquifers have ground water nitrate concentrations less than 2 mg/L. For the Cow Creek data, 66% or 25 of the wells had nitrate concentrations less than 2 mg/L. Of these 25 wells, 23 wells or 61 percent of the 38 wells and springs had nitrate concentrations below 1.0 mg/L. Thirty four percent were below the detection capabilities of the laboratory, which was <0.05 mg/L.

The largest nitrate concentration found was 14.2 mg/L in the City of Genesee Well #1, which is no longer used for municipal service; the lowest concentration was below the detection limit. All of the springs sampled exhibited high nitrate concentrations with several exceeding 10 mg/L. None of the wells or springs found to have nitrate concentrations above 10 mg/L were being used for drinking water. Approximately 66% of the wells and springs were below 2 mg/L, 5% were between 2 mg/L and 5 mg/L, 18% were between 5mg/L and 10 mg/L, and 11% were above 10 mg/L. The nitrate ranges are represented graphically in Figure 5.

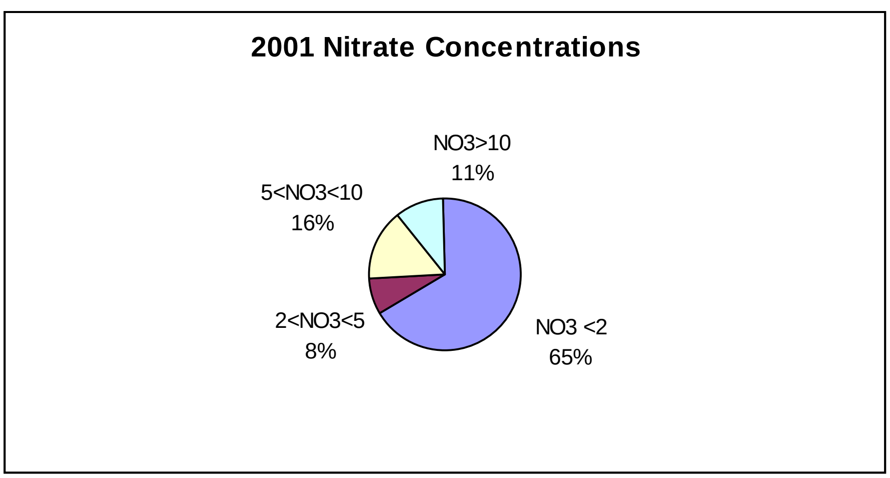
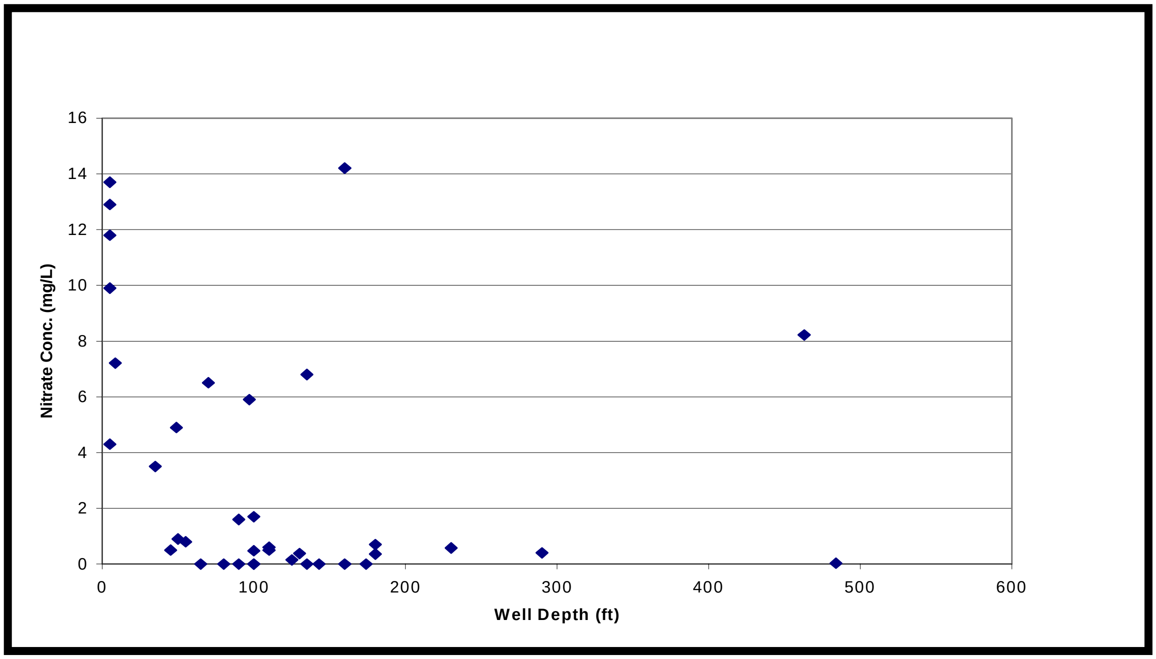


Figure 5. Graphical representation of Cow Creek nitrate concentrations, 2001 data.

The DEQ Cow Creek data closely parallels the AMN data regarding the nitrate concentration groups of less than 2 mg/L. For example, the AMN data shows that 71% of wells sampled had nitrate concentrations less than 2 mg/L while the Cow Creek data shows 66% of wells sampled were below 2 mg/L. Other relationships are difficult to determine due to the limited AMN data population.

The Cow Creek data were examined to find a possible relationship between well depths and nitrate concentrations. Figure 6 displays a comparison between nitrate concentrations and well depths for the 2001 Cow Creek data. The figure shows there is no apparent relation ship between well depth and NO3 concentration.

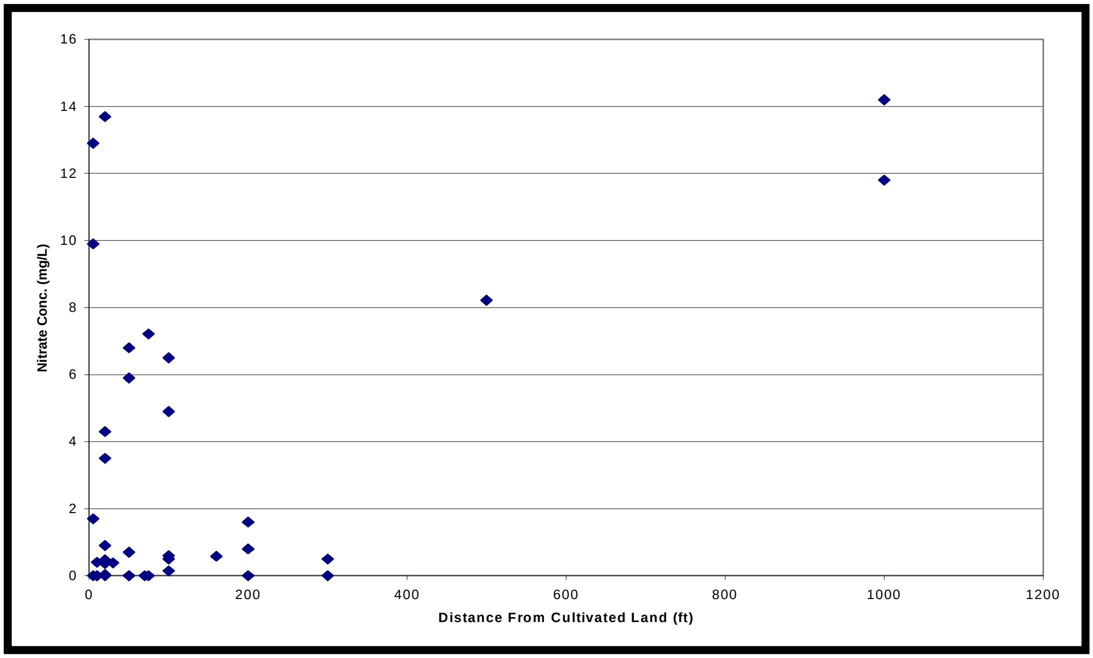
Figure 6. Nitrate concentrations versus well depth for wells sampled during 2001.



Vulnerability Due to Local Land Use

A land use inventory form (Appendix A) was completed for each well and spring sampled. The purpose of the form was to assess potential sources of nitrate contamination. The primary source of potential contamination in the Cow Creek watershed appears to be nitrogen based fertilizer application. Twenty-eight of the 33 wells sampled are within 200 feet of farmland. Infiltration of nitrate contaminated water through the vadose zone is a potential source of nitrates. The distance from the nearest cultivated land to the well was estimated for each sample site. Figure 7 shows how distance from cultivated land correlates to nitrate contamination concentrations.

Figure 7. Nitrate concentration versus well distance from farmland, 2001 data.



- For the 13 wells and springs that had nitrate concentrations above 2 mg/L, 10 were within 100 feet of cultivated land while only two were farther than 100 feet from cultivated land.
- For the nine wells and springs that fall between 2mg/L and 10 mg/L, eight are within 100 feet of cultivated land while one is farther away.
- For the four wells and springs above 10 mg/L, two were less than 50 feet from cultivated land while two others were over 1000 feet from cultivated land.
- For the 25 wells with less than 2 mg/L, six were above 100 feet from farmland; the rest were within 100 feet of farmland.

Most of the wells exhibiting nitrate concentrations greater than 2 mg/L were located within 200 feet of cultivated land. Two wells with concentrations greater than 2mg/L are over 1000 feet from cultivated land. The nitrate concentrations of these wells could be due to failed well seals or non-agricultural activities such as septic drain fields. Several of the well sites had nearby horse or cattle pastures, including one well that is 500 feet from farmland, yet shows a nitrate concentration of 8.2 mg/L. The variability of the data within 200 feet makes it difficult to derive conclusions about land use and nitrate contamination. Although a clear relationship between land use and nitrate contamination cannot be made, it should be noted that all of the springs had fairly high nitrate contamination concentrations. Only two of the five springs sampled had nitrate concentrations below 10 mg/L, and even these springs were above the background concentration of 2 mg/L. Four of the five springs sampled were located within close proximity to actively farmed land. The one spring not near cultivated land was located near land that was recently farmed but which was currently fallow. The fact that springs were high in nitrates shows that near surface water in the Cow Creek area is quite vulnerable to nitrate contamination. Since most springs were near cultivated land, it is not unreasonable to conclude that inorganic nitrogen fertilizers could be the source of contamination. More importantly, nitrogen rich surface waters undoubtedly recharge the local aquifers in the watershed. This nitrogen rich recharge water poses a risk to the drinking water aquifers.

COMMON IONS AND ISOTOPES

Of the 38 sample sites, 13 or 34% had nitrate concentrations greater than 2mg/L. This number suggests that human activity in the Cow Creek watershed has affected ground water. Most nitrate concentrations were under the MCL, but nitrate trends in the water shed have not been established. To further understand ground water conditions in the Cow Creek watershed, further tests were utilized to evaluate sources of nitrate in ground water.

Samples were collected from nine of the original sites having nitrate concentrations above 2 mg/L. These samples were analyzed for common ions (calcium, magnesium, sodium, potassium, bicarbonate, sulfate and chloride) and isotopes of nitrogen and oxygen. These data were used as additional tools to evaluate the sources of ground water nitrate contamination in the Cow Creek watershed. Two sources of nitrogen are likely to exist in the watershed: inorganic and organic nitrogen. Inorganic nitrogen originates from commercial fertilizer while organic nitrogen originates from human or animal wastes or from the decay of organic biomass.

Nitrogen from different sources can have differing isotopic compositions. The two stable isotopes of nitrogen are ^{14}N and ^{15}N. The ratio of ^{15}N to ^{14}N, reported using the delta (δ) notation and given in parts per thousand or permil (‰), can be used to distinguish between important sources of nitrogen contamination. Conditions that can obscure the nitrogen isotope signature include fractionation after the nitrogen source is deposited, or mixing from multiple nitrogen sources. Denitrification, which also can obscure the nitrate source, will produce a linear relationship for a plot if $\delta^{15}N$ versus $\delta^{18}O$ (Clark and Fritz, 1997). Typical $\delta^{15}N$ values and sources are listed in Table 3.

Table 3. Typical ^{15}N values associated with nitrogen sources (after Seiler, 1996).

Nitrogen Source	**$\delta\,^{15}$Nitrogen ($^0/_{00}$)**
Precipitation	-3
Commercial Fertilizer	-4 to +4
Organic Nitrogen in Soil	+4 to +9
Animal or Human Waste	> +9

($^0/_{00}$ = parts per thousand difference from reference standard)

Isotope analysis also included analysis of the oxygen isotopes ^{18}O and ^{16}O on nitrate. In biologically formed nitrate (NO3), one oxygen atom comes from atmospheric oxygen and the other two oxygen atoms come from locally derived water, which contains less ^{18}O. Nitrate in commercial fertilizer gets most of its oxygen from atmospheric oxygen that is enriched in ^{18}O. The ratios of $^{18}O/^{16}O$ and $^{15}N/^{14}N$ can be compared graphically to indicate whether the nitrogen is from organic or inorganic sources.

Table 4. Common ion and isotope results for selected 2001 sample locations.

Site Name	Depth (feet)	NO_3^-	NO_2^-	Na^+	Ca^{2+}	Cl^-	Mg^{2+}	K^+	SO_4^{2-}	HCO3	TDS	$^{15}N-NO_3$	$^{18}O-NO_3$
S-1	1	10.2	**0.1**	13	26	1	8	**1**	13	94	218	5.05	-1.32
W-4	463	1.8	**0.1**	9	17	**1**	6	3	12	80	126	16.52	2.36
W-7	35	3.2	**0.1**	10	27	1	9	**1**	6	127	180	3.66	-0.30
W-11	49	4.7	**0.1**	14	30	2	10	**1**	7	141	209	2.91	4.15
W-14	135	6.6	**0.1**	85	**1**	4	**1**	**1**	3	165	250	5.36	-0.30
W-20	85	6	**0.1**	11	17	1	5	**1**	2	67	148	9.22	2.84
W-22	70	5.1	**0.1**	17	23	2	8	**1**	3	126	185	2.12	0.62
W-23	97	6.2	**0.1**	20	37	11	11	**1**	14	155	260	12.34	-0.76
W-26	160	11	**0.1**	27	54	6	16	3	34	215	330	4.28	2.13
		All concentrations in mg/L (ppm) except isotope values which are ratios. Concentrations in **bold** were below laboratory detection levels, either 0.1 or 1.0 mg/L.											

The chemical composition of ground water is a function of the water that recharges the aquifer, the mineralogy of the aquifer, length of time water has been in the aquifer (residence time), and the concentration of individual dissolved constituents. The chemical composition of ground water is dependent on the residence time because the longer the water is in the aquifer, the more likely that the water has dissolved soluble minerals in the aquifer framework. Some common ions are suggestive of specific pollutant sources. For instance, elevated chloride in a water sample may indicate water from a septic tank/drain field origin. Common ion concentrations for 9 samples from the Cow Creek watershed are listed in Table 4.

In order to evaluate the common ion data for the 8 wells and one spring, plots called Stiff diagrams were prepared for each sample. The concentrations of the various cations and anions were converted to milliequivalents per liter and the results were plotted as shown on Figure 8. The resulting shapes of the individual Stiff diagrams show chemical similarities or differences between water samples collected from the various sample points.

Seven of the 9 samples have nearly identical chemical compositions, as shown on Figure 8. These similarities indicate that the general ground water quality across the watershed is relatively uniform. Of the remaining two samples, S-1 was collected from a spring in the northern part of the watershed and sample W-14 was collected from a well with a total depth of 135 feet, in the northeastern part of the watershed. Calcium and magnesium concentrations in sample W-14 are anomalously low. The reason for these sample results is unknown.

Nitrogen isotope data (Table 4) suggest that animal or human waste are likely sources of nitrate for samples W-4, W-20 and W-23. For samples W-7, W-11, W-22 and W-26, commercial fertilizer may be the nitrogen source in ground water. For samples with nitrogen isotope values in the +4 to +9 range (S-1 and W-14), nitrogen could originate from organic sources in the soil or from a mixture of inorganic and organic sources.

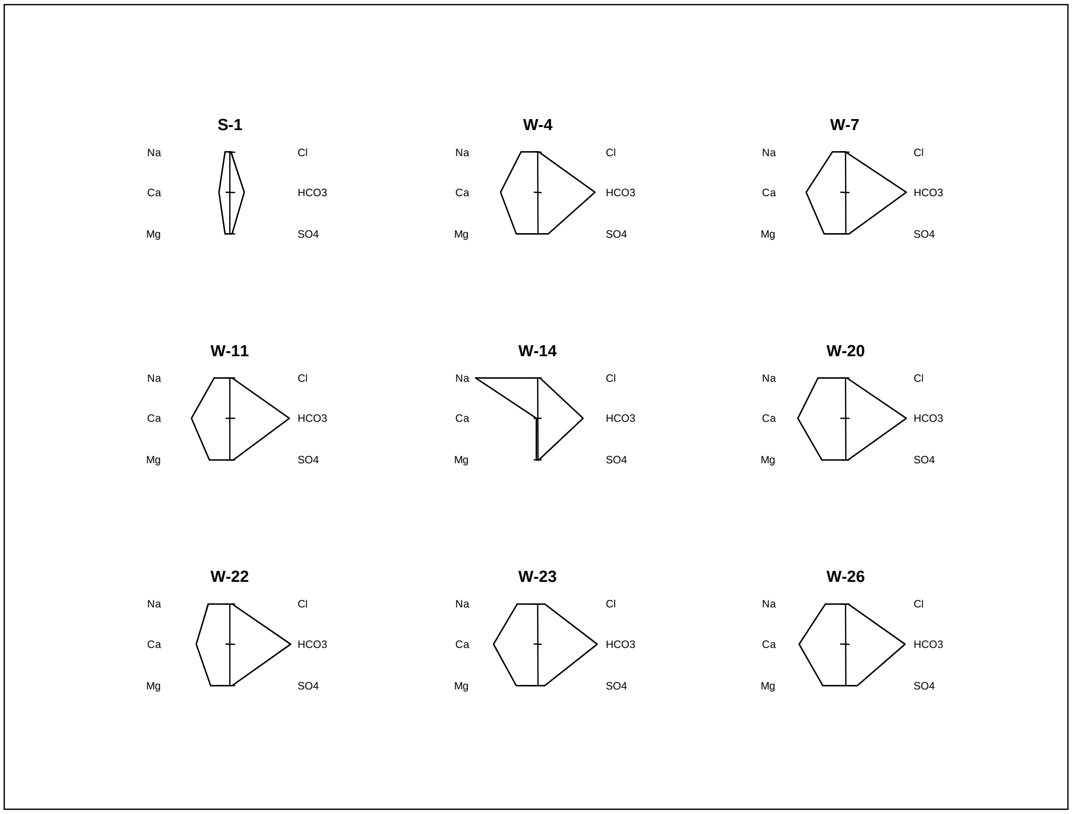


Figure 8. Stiff diagrams showing cation and anion concentrations, in millequivalents per liter, for 9 selected spring and well samples in the Cow Creek drainage.

CONCLUSIONS

The primary goal of this study was to assess ground water nitrate concentrations in the Cow Creek watershed. The scope of the project was that of a reconnaissance level survey. The results give an improved understanding of nitrate concentrations in Cow Creek ground water. Additional testing is needed to provide a definitive picture of the ground water quality in the watershed. However, reliable assumptions can be made based on the data collected in this project.

Elevated nitrate concentrations exist in the Cow Creek watershed in both domestic and municipal drinking water supplies. The concern is based on previous testing done by the City of Genesee on its municipal wells and by the IDWR. The Genesee city wells have had several nitrate spikes within the past 10 years. Concentrations have ranged from 3mg/L to 9 mg/L for one of the city wells in Genesee. The Ambient Monitoring Network data also showed elevated nitrate concentrations at a few sites. A further survey of the watershed was warranted to assess the general quality of ground water and specifically nitrate contamination. The data collected showed that nitrate concentrations are indeed elevated in some wells, but are generally low for the majority of wells. The data ranges are shown in Table 5.

Table 5. Range in nitrate concentration for samples collected during this study.

Percentage of samples per nitrate concentration category				
	< 2 mg/L	**2-5 mg/L**	**5-10 mg/L**	**> 10 mg/L**
Cow Creek Data	66	5	18	11

The majority (89%) of the 38 sample sites were below the nitrate MCL for drinking water. Only 11% of the wells and springs tested exceeded the MCL. Of the four sites over the MCL, one was from a well, and the other three were from springs. In addition, 18% of the wells and springs had nitrate concentrations between 5 mg/L and 10 mg/L. This is a cause for concern as these sites are at risk due to elevated nitrate concentrations. Much of the area seems to be unaffected by nitrate sources; 66% of the wells were below the 2 mg/L background concentration. These results are similar to those of the IDWR Ambient Monitoring Network (AMN). The AMN results show 71% of the wells tested had nitrate concentrations less than 2 mg/L.

Comparing nitrate concentrations to well depth did not lead to any obvious conclusions. Nitrate concentrations were expected to be higher in shallower wells, and this is evident in looking at Figure 6. Most of the wells with higher concentrations of nitrate were less than 200 feet in depth. A few exceptions did occur which could be the result of local anomalies for those wells such as poor or failed construction. Even though most of the higher concentration wells were less than 200 feet deep, so were most of the wells with low nitrate concentrations. This study included springs which indicate the quality of near surface water in the area. This is important because springs can recharge deeper aquifers that are used for drinking water. Most of the high nitrate concentrations were found in springs. The only well exceeding the MCL was the City of Genesee's Well #1, which is not used for human consumption. If the springs are not considered, then 71% of the wells tested were below 2 mg/L. This is encouraging and shows that ground water quality in the Cow Creek watershed is better than previously thought.

Most wells and springs tested were close to cultivated farmland. This is a cause for concern because agricultural fertilizers can be a source of nitrate contamination. The plot in Figure 7 shows the relationship between the proximity of farmland and nitrate contamination. Since most of the wells were quite close to farmland, trends were hard to discern. Most of the high nitrate wells are very close to farmland (within 100ft). In fact, 77% of wells with nitrate concentrations greater than 2 mg/L were 100 feet or less from a currently farmed area. Many wells with very low nitrate concentrations were also located quite closely to cultivated farmland contradicting any real trend that might suggest a relationship between proximity to farmland and nitrate concentrations. More ground water testing is needed to determine if proximity to farmland results in higher nitrate concentrations.

In this study, 24% of the wells exhibited nitrate concentrations higher than 2 mg/L. Since 2 mg/L is considered the background concentration of nitrates in ground water, it can be assumed that 24% of the wells are being affected by human activities. Isotope nitrate analysis found three sources of nitrate contribution to ground water. About a third each of nitrate contribution to ground water came from inorganic fertilizer, organic nitrogen in soil, and human or animal waste. Three wells (W-4, W-20 and W-23) are believed to be impacted by nitrate from human or animal waste sources. Four wells (W-7, W-11, W-22 and W-26) are believed to be impacted by nitrate from commercial fertilizer sources. Two samples (S-1 and W-14) appear to have mixed nitrate sources based on nitrogen isotopes.

A larger nitrate isotope sample size is probably necessary to more clearly describe nitrate source contribution. The nitrate impact in the Cow Creek area is not as great as was found in other areas of Idaho. A study conducted on the Camas Prairie showed that 75% of the wells there exhibited some form of human influence with respect to nitrate concentrations (Bentz, 1998). Further sampling to monitor nitrate trends in the Cow Creek watershed will be highly beneficial.

RECOMMENDATIONS

The following recommendations are based on the results of this study:

- Discourage the use of springs as a source of drinking water.
- Closely monitor wells and springs with nitrate concentrations greater than 5 mg/L if used as a source of drinking water.
- Provide a buffer strip around well heads (100 ft) where possible.
- Continue to collect nitrate and nitrate isotope ground water data from new and existing sites throughout the Cow Creek watershed.
- Provide guidance to well owners concerned with the quality of their ground water.

The limited scope of this study does not allow for quantitative nitrate analysis of ground water in the Cow Creek watershed; it was intended as a reconnaissance of nitrates in the watershed. Continued sampling for nitrates should provide a more detailed picture of the nitrate conditions in the Cow Creek watershed. Re-sampling of the higher concentration wells and springs in the area for nitrate isotopes and common ions indicates the source of nitrates in the watershed.

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APPENDIX A. SAMPLE LETTER AND FORMS

June 22, 2001

Dear Well Owner:

The Idaho Department of Environmental Quality (DEQ) is currently working on a ground water study of the Cow Creek watershed. Data from a statewide monitoring network has revealed some elevated concentrations of nitrates in the ground water. Existing data is inadequate for making any clear conclusions about the state of the ground water in the Cow Creek area. The purpose of this project is to gather data that can help to determine the quality of the ground water in the Cow Creek watershed. In order to do this, water samples need to be taken from wells in the area and tested for concentration of nitrates.

The completion of this study requires that many wells be sampled. The more wells that are sampled, the better idea we can get for nitrate concentrations in the ground water of the watershed. We would like to include your well in this study. **There is no associated cost** with the sampling of your well, but before we can sample it, we need your permission to do so. The sampling process is quite simple and unobtrusive. It involves taking a water sample from an inside or outside faucet. The entire procedure takes less than half an hour. **Please return the enclosed permission sheet as soon as possible.** I would appreciate it if you returned the permission sheet even if you don't want your well to be sampled. That way, I can cross you off the list for potential wells to be sampled. A postage-paid envelope has been provided for your convenience.

If you received more than one permission sheet, this means that you probably have more than one well on the properties that you own. If you could fill out a sheet for each well and send them back in the provided envelope that would be great. Also, if you do not own a well and believe you have received this letter in error, then please state this on the permission sheet and send it back to me. This will allow me to keep better records for the study. If you have any questions regarding the details of this project, please call me at (208) 799-4370.

Thank you for your help with this study.

Sincerely,

David Strausz
DEQ Ground water Intern

Permission Form for DEQ Ground water Study

Date: ________________

Well Location (TRS): ______________________ Total Depth: ___________________

Water used for: ______________________ (irrigation, stock, domestic, business, etc.)

Well owner: Please check one or more of the following options and return the form in the attached envelope.

_____ I grant permission for a sample to be taken from my well even if I am not home.

_____ I grant permission for a sample to be taken from my well, but only if I am contacted first.

_____ The well information given is incorrect because ___________________
(well abandoned, well deepened, not my well, etc.)

Comments: ____

____

____

____

____

Name: ____

Address: ____

City: ____ Zip Code: _________________________________

Daytime Phone Number (and best time to call): ___________________________

Please fill out the above information to the best of your knowledge. It is OK if you do not know all of the information. If your home address and the address of the location of the well are different, please indicate this and include the address of the well location. Thank you for your time.

WELL INVENTORY

T-R-S________________________ GWSI ID. NO.____________________

WELL INFORMATION: DATE INVENTORIED__________ BY_________________

INVENTORY BY: WELL LOG PHONE BOOK TELEPHONE SITE VISIT

SOURCE OF DATA: DRILLER OWNER OTHER:_____________

WATER USE_____________________

DEPTH________ DIAMETER OF CASING_______ DATE DRILLED_________

OWNER'S NAME________________________ PHONE______________________

ADDRESS____________________________

____________________________ ZIP CODE______________

ATTACH DRILLER'S LOG AND COPY OF 7.5 MINUTE MAP

Change in well construction or ownership:

Original Depth and Date_________________ Deepened Depth and Date_________________

Original Owner's Name____

SKETCH OF WELL AND SAMPLE POINT LOCATION

DESCRIBE SAMPLING POINT____

LOCAL LAND USE—WITHIN ABOUT ½ MILE OF THE WELL **(CIRCLE CHOICES)**

PASTURE……….FEEDLOT………DRY CROP (NO IRR)………..IRRIGATED CROP…………..

RURAL-SUBURBAN (SEPTIC TANK, NO FARMING)……….RURAL FARM OR LIVESTOCK

URBAN RESIDENTIAL (SEWER)……….URBAN COMMERCIAL………FOREST………………

SUMMER HOME…………UNDEVELOPED………….OTHER________________________________

If agriculture, what crops?____

How far is nearest cultivated land from well?__________________________________

How is nearby cultivated land irrigated? - - Center Pivot……..Wheel Line………Gravity……….Other____________

Source of irrigation water:____

Nearby ditch or canal?____________________ Lined or Unlined?____

Irrigation drain-well(s) nearby?__________________

COMMENTS:

____

____

____

____

SKETCH OF LAND USE WITHIN ½-MILE OF WELL (1 MILE x 1MILE SECTION)

APPENDIX B. COW CREEK DATA

Well #	County	TRS	UTM Northing (m)	UTM Easting (m)	Elevation (ft)	Depth (ft)	Farmland (ft)	N Results (mg/L)
S-1	Latah	38/5-4cc	5167101	501601	3000	5	20	13.7
S-2	Latah	37/5-3ca	5157719	503823		5	5	12.9
S-3	Nez Perce	37/4-19cb	5153235	508188		5	5	9.9
S-4	Nez Perce	37/4-20bc	5153580	509612		5	1000	11.8
S-5	Nez Perce	37/5-29ab	5152358	500914		5	20	4.3
W-1	Latah	39/5-34cd	5168762	503872	2900	125	100	0.146
W-2	Latah	38/5-4cc	5167386	501555	3150	135	200	0
W-3	Latah	38/5-4cc	5167386	501555		90	200	1.6
W-4	Latah	38/5-8aa	5166523	501044	3000	463	500	8.22
W-5	Latah	38/5-3cb	5167421	503522	2850	80	10	0
W-6	Latah	38/5-3dd	5167119	504483	2800	143	10	0
W-7	Latah	38/5-2ca	5167411	505367	2800	35	20	3.5
W-8	Latah	38/5-23bb	5163379	505162	2750	45	300	0.5
W-9	Latah	38/5-23cb	5162930	504905	2700	65	75	0
W-10	Latah	38/5-23ca	5162747	505402	2800	100	300	0
W-11	Latah	38/5-23cd	5162392	505374	2730	49	100	4.9
W-12	Latah	38/5-26ba	5161792	505599		100	50	0
W-13	Latah	38/5-24dd	5162352	507845	2770	50	20	0.9
W-14	Latah	38/4-30bb	5162093	508104	2760	135	50	6.8
W-15	Latah	38/4-19dc	5162234	508957	2800	484	20	0.034
W-16	Latah	38/4-30dd	5160835	509243	2780	110	100	0.5
W-17	Latah	38/4-31aa	5160432	509283	2750	180	50	0.7
W-18	Latah	38/4-29cc	5160680	509821	2760	55	200	0.8
W-19	Latah	38/4-32dd	5159198	510918	2750	110	100	0.6
W-20	Latah	37/5-5ad	5158416	501312	2800	8.5	75	7.21
W-21	Latah	37/5-3ca	5158096	504204	2730	100	5	1.7
W-22	Latah	37/5-1dd	5157409	507649	2680	70	100	6.5
W-23	Latah	37/5-10ac	5156534	504290	2690	97	50	5.9
W-24	Latah	37/5-12bd	5156551	507041	2700		70	0
W-25	Latah	37/5-12cc	5153979	509370	2700	100	20	0.475
W-26	Latah	37/5-14ac	5154924	505918	2700	160	1000	14.2
W-27	Nez Perce	37/4-19aa	5153979	509370	2720	290	10	0.403
W-29	Nez Perce	37/5-24cb	5153275	506793	2750	90	50	0
W-29	Nez Perce	37/5-24da	5153293	507908	2800	130	30	0.38
W-30	Nez Perce	37/5-24da	5153233	507969	2800	180	20	0.362
W-31	Nez Perce	37/4-19bc	5153394	508140		174	20	0
W32	Nez Perce	37/4-30ab	5152436	508868	2800	230	160	0.579
W-33	Nez Perce	37/6-36bb	5151089	497320	2760	160	5	0

VOLUME 2. RAW COW CREEK DATA (Found in a separate report)