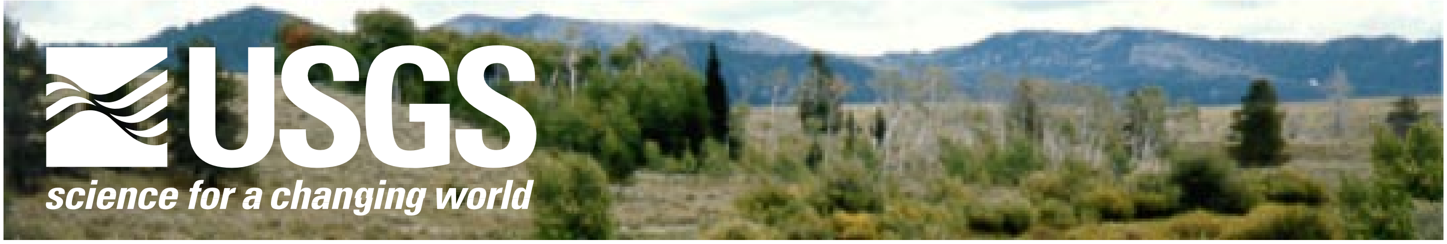


Nitrate Concentrations in Ground Water in the Henrys Fork Basin, Eastern Idaho

In 1998 and 1999, the U.S. Geological Survey (USGS) completed comprehensive studies of nitrate concentrations in ground water in the Henrys Fork Basin in eastern Idaho (fig. 1A). These studies were done in cooperation with the following agencies or groups: Idaho Division of Environmental Quality (DEQ), District 7 Health Department, Idaho Department of Water Resources (IDWR), Idaho Department of Agriculture (IDAG), Bureau of Reclamation, Henrys Fork Foundation, Fremont County, and Madison County. This Fact Sheet presents selected results of these investigations.

Description of the Area

The Henrys Fork Basin in parts of Teton, Madison, and Fremont Counties in Idaho comprises lower Henrys Fork (Menan Buttes to about Ashton, including the Fall River drainage), Teton River, and upper Henrys Fork drainages. Detailed descriptions of climate, geographic setting, land and water uses, geology, hydrology, and generalized water quality of the area are provided in reports listed in the “Selected References” section, back of this report.

Geology and hydrology of the basin are diverse and complex. Unconsolidated sediment varies in thickness from a few feet to hundreds of feet; thicknesses are greatest in areas from Menan Buttes to St. Anthony. Sediment overlies variable thicknesses of volcanic rocks, and ground-water yielding zones exist in sediment and volcanic rock units. Regionally, ground water moves generally southward to southwestward but, in localized areas, ground-water movement can be northwestward or southeastward (Crosthwaite and others, 1970; Whitehead, 1978; Spinazola, 1994). Total well depths vary from tens of feet to hundreds of feet below land surface. Some well casings may be perforated or screened at one or more intervals or wells may be constructed with uncased boreholes to increase well yields.

Most ground water in the Henrys Fork Basin is nonthermal (temperature less than 29 degrees Celsius, °C; 84 degrees Fahrenheit, °F), but geothermal water (temperature greater than 29°C) is present in many parts of the basin. On the basis of U.S. Environmental Protection Agency (EPA, 1996) standards for public water supplies, ground water in the Henrys Fork Basin is suitable for most public and private drinking-water uses. Ground water in this area is highly or very highly vulnerable to contamination (Rupert and others, 1991), and water in a few areas contains contaminants—components that can limit the water’s suitability for use or can represent degradation of water quality.

Potential pathways of contaminant movement to ground-water zones include downward flushing of contaminants by infiltration of precipitation, floodwater, or applied irrigation water; flushing from soil and unsaturated rocks by seasonal variations in ground-water levels; leakage around or into well casings or boreholes (especially important in areas with thin layers of soil and sediment overlying volcanic rock); dumping into wells; backflushing to wells through water-supply systems; and transport from upgradient ground-water zones. Contamination from land and water uses can be localized (point source) or widespread (nonpoint source).

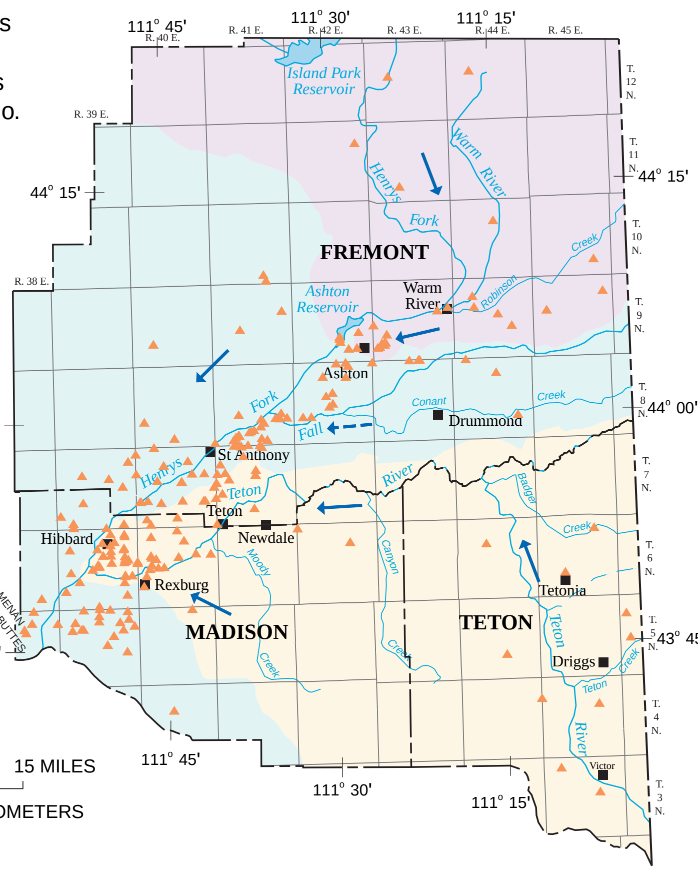
One of the most widespread contaminants in the Henrys Fork Basin is nitrate (NO_3). In this report, nitrate is reported as nitrogen (NO_3-N or nitrate-N) in milligrams per liter (mg/L, equivalent to parts per million).

Nitrate-N Concentrations in Ground Water

Concentrations of nitrate-N in Idaho prior to land and water development probably were less than 1 mg/L. From 1995 through 1999, the median concentration (50th percentile) of nitrate-N in Idaho ground water was about 1.4 mg/L, and the range of concentrations was <0.05 to 100 mg/L. During the same period, the median nitrate-N concentration in the Henrys Fork Basin was 3.2 mg/L, and the range of concentrations was <0.05 to 38 mg/L.

Large nitrate-N concentrations primarily are of concern as a drinking-water health risk, and the maximum EPA (1996) limit for nitrate-N concentration in public water supplies is 10 mg/L. Recommendations

Figure 1A. Locations of ground-water sampling sites where nitrate (as nitrogen) concentrations are less than 5 milligrams per liter, and generalized directions of ground-water movement, Henrys Fork Basin, Idaho.



EXPLANATION

Upper Henrys Fork drainage

Teton River drainage

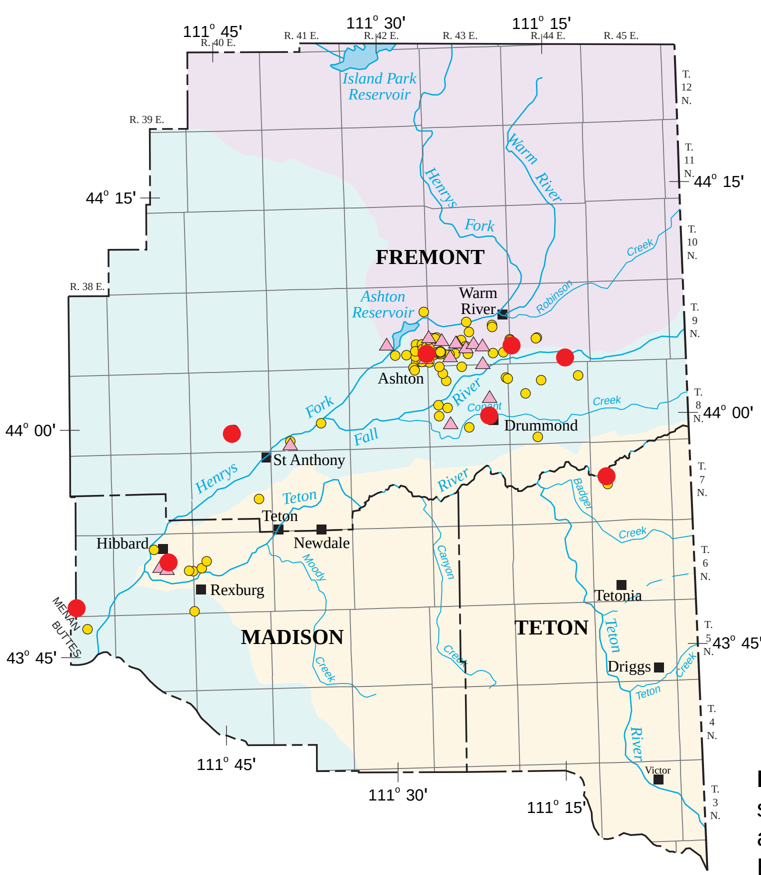
Lower Henrys Fork drainage

Generalized direction of ground-water movement (dashed where inferred)—Data from Crosthwaite and others (1970); Whitehead (1978); Spinazola (1994)

Sampling site where nitrate (as nitrogen) concentration was less than 5 milligrams per liter

Base from U.S. Geological Survey digital data, 1:500,000, 1980
Albers Equal-Area projection
Standard parallels 43° 30', 47° 30', and -114° 00', 41° 45'
No false easting or false northing

0 5 10 15 MILES
0 5 10 15 KILOMETERS



EXPLANATION

Sampling site where nitrate (as nitrogen) concentration was 5 milligrams per liter or greater

- 5 to 9.9
- 10 to 19.9
- 20 or greater

Figure 1B. Locations of ground-water sampling sites where nitrate (as nitrogen) concentrations are 5 milligrams per liter or greater, Henrys Fork Basin, Idaho.

Table 1. Drinking-water recommendations for ranges of nitrate

[Modified from Mahler and others, 1990, p. 1; mg/L, milligrams per liter]

Nitrate as nitrogen (NO_3-N, in mg/L)[1]	Nitrate as nitrate (NO_3-NO_3, in mg/L)[2]	Comments
0 to 10	0 to 44	Safe for human and livestock consumption.
11 to 20	45 to 88	Generally safe for human adult and livestock consumption. Do not use for human infants.
21 to 40	89 to 176	Short-term use acceptable for human adult and all livestock consumption unless food or feed sources are very high in nitrate. Long-term use could be risky. Do not use for human infants.
41 to 100	177 to 440	Moderate to high risk for human adult and young livestock consumption. Probably acceptable for mature livestock if feed is low in nitrate. Do not use for human infants.
Over 100	Over 440	Do not use.

[1] Laboratory nitrate analysis reported as nitrogen (N), in mg/L.
[2] Laboratory nitrate analysis reported as nitrate (NO_3), in mg/L.

for various ranges of nitrate-N in drinking water are shown in table 1.

Chronic, long-term health risks from consumption of water containing large nitrate concentrations are not fully understood. Short-term effects include the risk of methemoglobinemia (blue-baby syndrome, characterized by the reduced ability of blood to carry oxygen) to human infants, a small percentage of adults, and young livestock (Mahler and others, 1990, p. 1). Large concentrations of nitrate-N may be implicated with an increased incidence of non-Hodgkin's lymphoma (Weisenburger, 1991, p. 309). Anomalous nitrate-N concentrations also imply active exchange of water from land surface to ground-water zones and the potential for water contamination by microorganisms or other chemical compounds (Parliman, 1998, p. 4).

Ground-Water Analyses and Site Descriptions

From 1995 through 1999, water samples were collected by the USGS or DEQ from 319 wells or springs in the Henrys Fork Basin and analyzed for nitrate-N concentrations[1]. For sites with multiple analyses, only the most recent analysis per site was used in this report. Complete site descriptions and water-quality data are available from the USGS District office in Boise, Idaho. Well locations, total well depth, and selected water-quality data are available in MS-EXCEL spreadsheet format at the Idaho District Web site http://idaho.usgs.gov/ until approximately February 2001.

Locations of ground-water sites are displayed in figures 1A and 1B according to ranges of nitrate-N concentrations. Concentrations in most water samples are relatively small (less than 5 mg/L). In some parts of the study area, water contains moderately large nitrate-N concentrations (5 to 9.9 mg/L) or concentrations exceeding the EPA (1996) maximum contaminant level of 10 mg/L, a potential health risk for some drinking-water purposes.

Historical Nitrate-N Concentrations

Nitrate-N data prior to about 1990 are sparsely distributed or clustered in the Henrys Fork Basin. Most historical nitrate-N concentrations were less than 5 mg/L, but concentrations exceeding 20 mg/L were analyzed in water samples from wells east of Ashton and near Menan Buttes in the 1970's. Nitrates could have been increasing since about the 1970's in

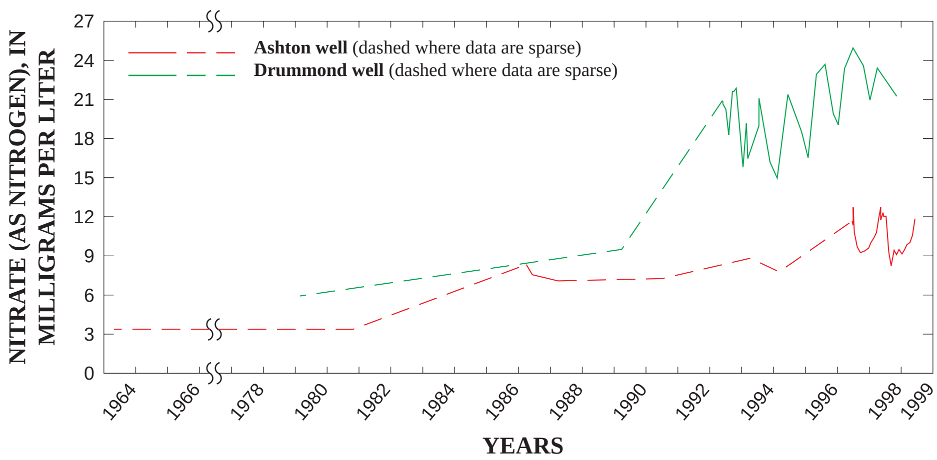


Figure 2. Changes in nitrate (as nitrogen) concentrations, 1964–99, in water samples from wells at Ashton and Drummond, Henrys Fork Basin, Idaho.

[1]USGS laboratory analyses are reported in units of nitrite plus nitrate as nitrogen (NO_2+NO_3 as N). DEQ laboratory analyses are reported in units of nitrate as nitrogen (NO_3 as N). Concentrations of nitrite in ground water generally are negligible. For purposes of this report, USGS and DEQ analyses are comparable.

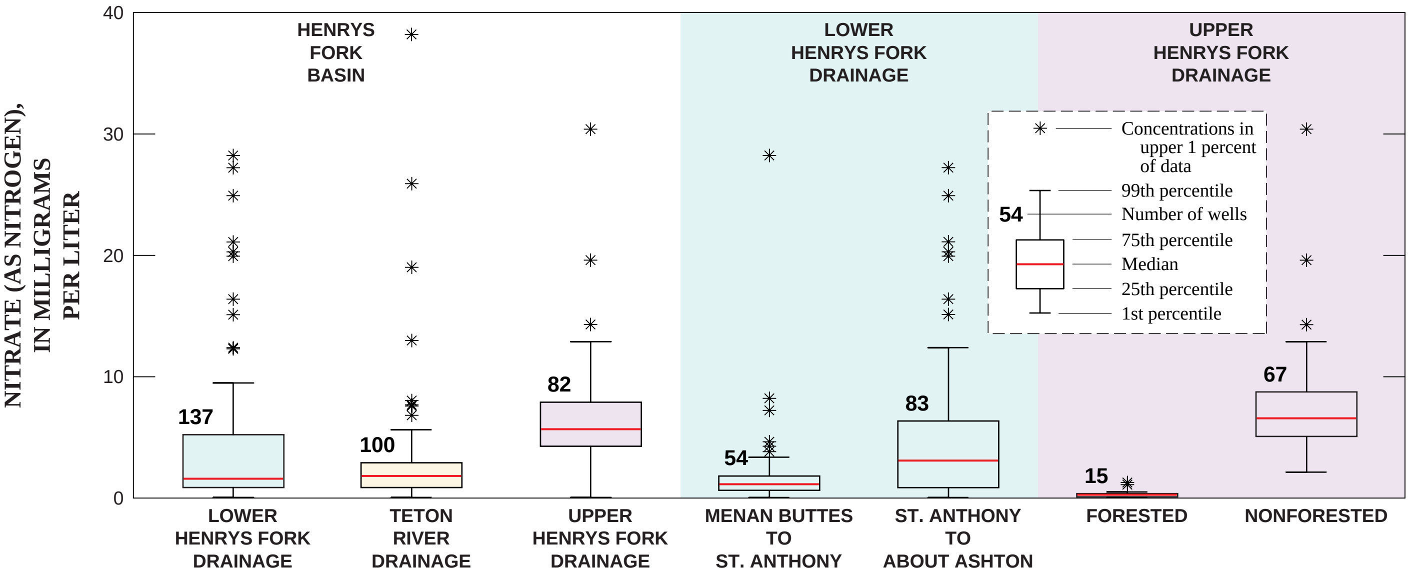


Figure 3. Nitrate (as nitrogen) data for wells in Henrys Fork Basin, Idaho.

areas where overall nitrate-N concentrations are currently large.

Changes in nitrate-N concentrations over time for water samples from wells at Drummond and Ashton are shown in figure 2. Total depth of both wells is about 300 feet, and hydrogeologic environments and nearby land-use histories are similar. Few nitrate-N data are available for either well from 1950 to about 1980, but the patterns of increasing nitrate-N concentrations are similar—relatively low nitrate-N concentrations until about 1980, then increasing concentrations to 1999 accompanied by seasonal fluctuations in concentrations each year. Causes for increasing concentrations currently are not fully understood.

Statistical Summary of Nitrate-N Data

Statistical summaries (boxplots) of nitrate-N concentrations for lower Henrys Fork, Teton River, and upper Henrys Fork drainages are compared in figure 3. Median (50th percentile) concentrations for lower Henrys Fork and Teton River drainages are similar (1.6 mg/L and 1.9 mg/L, respectively), but the median concentration for the upper Henrys Fork area is 5.7 mg/L. Substantial differences are also evident in the distribution of nitrate-N concentrations within each drainage, as shown in the comparison of summaries for segments of the lower Henrys Fork drainage—Menan Buttes to St. Anthony and St. Anthony to about Ashton. From Menan Buttes to St. Anthony, the median concentration is 1.1 mg/L, and from St. Anthony to about Ashton, the median is 3.1 mg/L. In the upper Henrys Fork drainage, large differences in concentrations are evident between areas with little or no land- and water-use development (forested) and areas with extensive and varied land- and water-use development (nonforested). The median concentration for forested areas is 0.3 mg/L, and the median concentration for nonforested areas is 6.6 mg/L.

Sources of Nitrogen

Rupert (1996) estimated the amount of total nitrogen input by cattle manure, fertilizer, legume crops (such as alfalfa and beans), precipitation, and domestic septic systems for counties in the upper Snake River Basin, eastern Idaho and western Wyoming. The estimates were used to rank the input of nitrogen by source and determine the amount of total nitrogen potentially available to ground and surface water through leaching and runoff. Results showed that about 45 percent of the input was from fertilizers, 29 percent from cattle manure, 19 percent from legume crops, 6 percent from precipitation, and less than 1 percent from domestic septic systems. Input from cattle manure, fertilizers, and legume crops varied widely among counties, reflecting differences in land-use practices such as cropping patterns and numbers of dairies and feedlots. In the Henrys Fork Basin, Rupert indicated that fertilizers were the major source of nitrogen input. Manure and crops were secondary sources, and precipitation and domestic septic systems were minor sources of nitrogen input.

Nitrogen Isotope Data

One method for estimating sources of nitrogen to ground water is analysis for stable isotopes of nitrogen. Stable isotopes are nonradioactive forms of an element. Nitrogen isotopes ^{15}N and ^{14}N constitute an isotope pair, and lab analyses determine the ratio of the abundance of the heavier isotope (^{15}N) to that of the lighter isotope (^{14}N) in water. The major potential sources of nitrogen contamination commonly have characteristic $^{15}N/^{14}N$ ratios (expressed in

Table 2. Nitrogen isotope ratios of common sources of nitrate in water

Potential contaminant ratio source	$^{15}N/^{14}N$ (permil)
Precipitation	-3
Commercial fertilizer	-4 to +4
Organic nitrogen in soil	+4 to +9
Animal waste	Greater than +10

permil units, or parts per thousand). Typical $^{15}N/^{14}N$ ratio values for nitrogen sources are presented in table 2 (Seiler, 1996, p. 12). Total well depth, nitrate-N, and nitrogen isotope ratio data for recent ground-water samples in the Henrys Fork Basin are shown in table 3.

Additional nitrogen isotope analyses are available through DEQ for areas near Ashton where intermediate nitrogen isotope ratio values in water could indicate a mixture of nitrogen sources (D. Yashan, DEQ, written commun., 1999).

Other Sources of Nitrate-N Data

The comprehensive study of nitrate-N in ground water in the Henrys Fork Basin has been completed, but there are ongoing ground-water quality programs through several agencies and organizations, including USGS, DEQ, District 7 Health Department, IDAG, and consultants. For private wellowners, nitrate-N analyses are available through local analytical laboratories. Information on water quality, health risks, laboratory analyses for private wellowners, and water-treatment options is available through DEQ and District 7 Health Department agencies.

Additional Information Needed

Effects of several hydrogeologic and environmental factors on ground-water quality are not well understood at this time. Additional information is needed in the following areas: (1) causes of increasing nitrate-N concentrations since about 1980; (2) effects of well construction on contamination of multiple water-yielding zones; (3) seasonal change in nitrate-N concentrations; (4) seasonal change in water levels and directions of ground-water movement in major water-yielding zones, particularly in the Fall River drainage; (5) comparative age dates of water in major water-yielding zones to help determine rates of contaminant movement; and (6) ground-water/surface-water relations in areas where nitrate-N concentrations are large. Large nitrate-N concentrations in ground water could contribute to increased nitrate-N concentrations in surface water, potentially resulting in deterioration of surface-water quality.

Acknowledgments

Special thanks are extended to wellowners in the study area for access to property and permission to collect water samples from their wells. Additional thanks are extended to personnel from the City of Ashton, Lockheed Martin Idaho Technologies Company, Brown and Caldwell, URS Greiner Woodward Clyde, and Ricks College for information and unpublished data for the area.

—by D.J. Parliman

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Table 3. Total well depth, dissolved nitrate (as nitrogen), and nitrogen isotope ratio data[1] for selected wells, Henrys Fork Basin, Idaho

[mg/L, milligrams per liter]

Water sample source	Sample date	Depth of well, total (feet)	Nitrate, dissolved (mg/L as N)	$^{15}N/^{14}N$ stable isotope ratio (permil)
Well near Hibbard	06-15-99	240	25.9	2.80
Well near St. Anthony	06-29-99	113	27.2	.60
Well at Drummond	06-30-99	310	21.1	8.30
Well near Ashton	10-06-98	60	18.5	9.80
	06-25-99	60	30.4	10.10
Well at Ashton	10-06-98	289	8.33	5.40

[1]Analyses from the U.S. Geological Survey National Water-Quality Laboratory, Denver, Colorado. Nitrogen isotopes, $^{15}N/^{14}N$ as nitrate and ammonia.

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Banner photo: Upper Henrys Fork Basin, Idaho.

Photo at left: Warm River Springs on Henrys Fork northeast of Ashton, Idaho (Photo by D.J. Parliman, 1998).

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