GROUND WATER QUALITY IN THE TWIN FALLS HYDROGEOLOGIC SUBAREA, 1991-2000

Prepared by:

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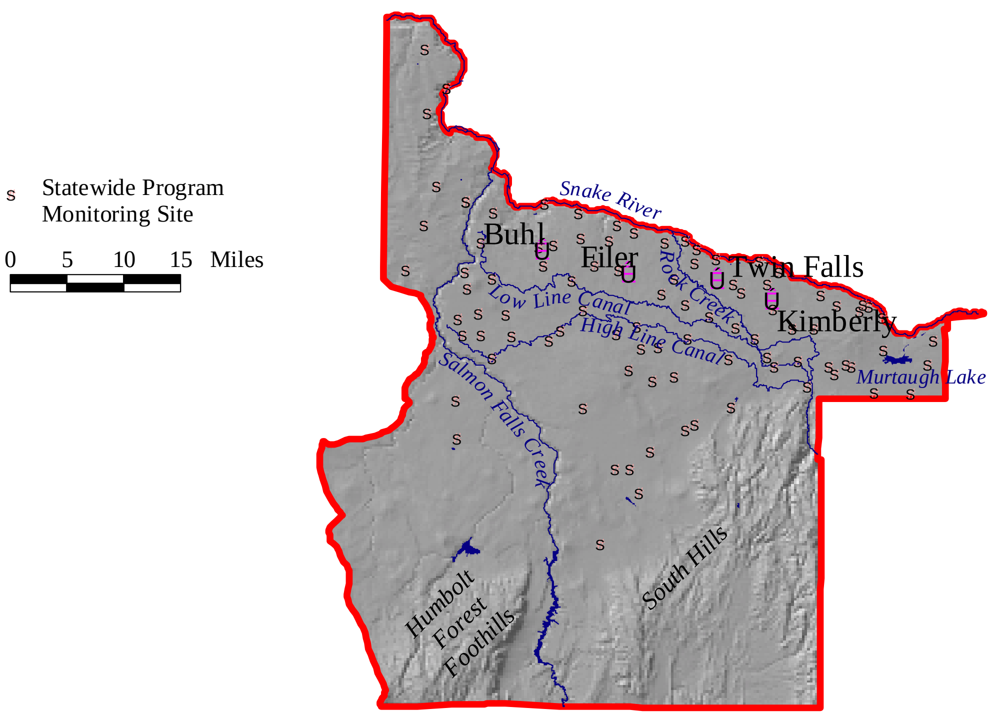

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1. ABSTRACT

This report describes the ground water quality in the Twin Falls hydrogeologic subarea as determined from data collected through the Statewide Ambient Ground Water Quality Monitoring Program (Statewide Program). The Statewide Program is administered by the Idaho Department of Water Resources in cooperation with the U.S. Geologic Survey, Water Resources Division. The Statewide Program monitoring network currently consists of over 1,300 sites (wells and springs) in 20 hydrogeologic subareas.

The Twin Falls hydrogeologic subarea is located in Twin Falls County of south-central Idaho. The results from 93 Statewide Program monitoring sites in the Twin Falls subarea are included in this report. Data collected during from 1991 through 1994 are referred to as First Round data. Second Round data sampling took place from 1995 through 1999; during this time period, most of the First Round sites were re-sampled. Third Round data collection began in 1999. Most sites are presently scheduled for sampling once every five years. However, six sites are being sampled annually.

Ground water in the Twin Falls subarea occurs in aquifers within the Idavada Volcanics, the Banbury Basalt, the Glenns Ferry Formation, and the Snake River Group, with the latter three being the major drinking water aquifers in this area. The Idavada Volcanics Formation is a minor drinking water aquifer in the Twin Falls subarea because it often contains geothermal water (equal to or greater than 29.4° Celsius) and because it is usually quite deep. The Banbury Basalt overlies the Idavada Volcanics; the Glenns Ferry overlies the Banbury Basalt. The Snake River Group includes undifferentiated basalt units in the northeastern part of the subarea.

Characterization of the water quality data collected from First Round sampling indicates that calcium and magnesium are the dominant cations, and that bicarbonate is the dominant anion. Ground water from the Twin Falls subarea sites is high in dissolved minerals; the median values for total dissolved solids and hardness from the First Round were 575 and 308 milligrams per Liter (mg/L), respectively.

The ground water at 15 of the 93 Statewide Program monitoring sites in the Twin Falls subarea (16 percent) had one or more constituents that exceeded a primary Maximum Contaminant Level (MCL) as established by the Environmental Protection Agency (EPA) for public water supplies. Constituents that exceeded their respective primary MCL were adjusted gross alpha, fecal coliform bacteria, and nitrate (dissolved nitrite + nitrate as nitrogen).

Nitrate has impacted ground water quality in the Twin Falls subarea. From 1991 through 2000, 7 of the 93 sites had one or more samples with a nitrate concentration greater than the

MCL of 10 mg/L. During this time period, 84 percent of the sites had a least one nitrate sample result equal to or greater than 2 mg/L, which is the concentration used to indicate that nitrate impacts to the ground water from land uses have occurred. The Twin Falls subarea had the highest median nitrate value for the First Round of the 20 subareas (3.6 mg/L).

Nitrogen isotopes were analyzed from 26 sites in 2000. Nitrogen isotopes can be useful for determining the source of nitrogen in the ground water. Nitrogen isotope data indicated three possible nitrogen sources in the sites sampled: nitrogen in commercial fertilizers, organic nitrogen in soil, and nitrogen from human or animal wastes. More data are needed to understand the relationships between nitrate, nitrogen isotopes, nitrogen sources, and other ground water quality variables of the Twin Falls subarea.

One or more pesticides were detected in ground water at 32 of the 93 sites (34 percent) analyzed by immunoassay methods from 1992 through 2000. Sixty-one of the 93 sites were tested for pesticides using gas chromatography methods. Thirty-seven of these 61 sites had detections of one or more pesticides. Atrazine and alachlor were the most commonly detected pesticides. All pesticide concentrations were below any primary MCLs, Health Advisories or Reference Doses.

Initial trend monitoring data showed that nitrate concentrations increased at 48 of the 77 Twin Falls subarea sites (62 percent) sampled in both the First and Second Round. Individual nitrate increases ranged from 0.03 mg/L to 10.8 mg/L. Fifteen of the 77 sites (19 percent) had increases greater than 1 mg/L. Although median nitrate values (paired sites only) increased from 3.6 mg/L in the First Round to 4.0 mg/L in the Second Round, statistical test results indicated that this increase was not significant at the 95 percent confidence level.

2. INTRODUCTION

2.1. Statewide Ambient Ground Water Quality Monitoring Program

The Ground Water Quality Protection Act (Senate Bill #1269), passed by the Idaho State Legislature in 1989, authorized a comprehensive approach for maintaining and improving Idaho's ground water quality. The Act resulted in the formation of the Ground Water Quality Council which developed the Idaho Ground Water Quality Plan in 1992 (Figure 1). The monitoring component of the plan outlined the need for statewide, regional, and local ground water quality monitoring. The Idaho Department of Water Resources (IDWR) was tasked with designing and maintaining a statewide ambient ground water quality monitoring network. Responsibilities for regional and local monitoring were designated to the Idaho Department of Environmental Quality (IDEQ) and the Idaho State Department of Agriculture (ISDA). The three parts of the plan are designed to complement each other by allowing different degrees of data resolution (Ground Water Quality Council, 1992).

Figure 1. The Ground Water Quality Council developed the Ground water Quality Plan in 1992.

The Statewide Ambient Ground Water Quality Monitoring Program (Statewide Program) began in 1990 with a limited prototype network of 97 monitoring sites (IDWR, 1991). The Idaho Legislature increased funding for the Statewide Program in 1991 from $187,300 to $539,000 per year. The IDWR developed a joint funding agreement with the U.S. Geological Survey (USGS) in 1990, and since 1991, the USGS has contributed at least $200,000 annually through federal cooperative funding. The combined State and Federal funds enabled the addition of about 400 sites to the network each year from 1991 through

1994. By the fall of 1994, the Statewide Program network included over 1,500 monitoring sites. The ISDA contributed funding to the Statewide Program for pesticide analyses from 1993 through 1999.

The IDWR, with assistance from the USGS and the Monitoring Subcommittee of the Ground Water Quality Council, developed the network design and selected the monitoring sites. The IDWR has the following areas of responsibility:

1. Provides overall management of the program (plans for each field season, notifies owners of ground water quality concerns, administers contracts, etc.),
2. Stores and manages the water quality and other data,
3. Analyses the data and writes interpretive reports, and
4. Provides vision for future program developments.

As the principal cooperator in the Statewide Program, the USGS:

1. Conducts field work for pre-sampling and sampling activities,
2. Provides logistical support (ordering of supplies, contacting site owners, etc.),
3. Manages the data received from the USGS National Water Quality Laboratory (NWQL), and
4. Transfers the data received from the NWQL to the IDWR.

USGS staff at the District and National levels provided consultation during the development of the network. Both the USGS and the IDWR have responsibilities for ensuring that appropriate Quality Assurance and Quality Control practices are followed.

Currently, samples are analyzed according to the constituent types at either the USGS National Water Quality Laboratory in Arvada, Colorado, the Idaho State Health Laboratory in Boise, Idaho, Alpha Analytical Laboratory in Sparks, Nevada, or the University of Illinois in Urbana-Champaign, Illinois.

2.2. Program Objectives, Purpose of Report, and Data Availability

The objectives of the Statewide Program are to:

1. Characterize the ground water quality of the state's major aquifers,
2. Identify trends and changes in ground water quality within the state's major aquifers, and
3. Identify potential ground water quality problem areas.

Initial data collected for the Statewide Program from 1991 to 1994 (First Round) are being used to address the first objective (characterization) and, to some extent, the third objective (potential problem areas). Data collected in 1995 through 1998 (Second Round) are being used for trend analyses and additional characterization. Third Round data (1999-2003) will be used primarily for trend monitoring. More detailed information regarding the “rounds” of data collection is presented later in this report.

The purpose of this report is to:

1. Characterize the ground water quality data collected for the Twin Falls hydrogeologic subarea,
2. Provide initial results for trend monitoring,
3. Discuss the ground water quality concerns identified through Statewide Program monitoring, and
4. Provide recommendations for future efforts related to understanding and protecting the ground water quality in the Twin Falls subarea.

This report is the second in a series of technical reports for the Statewide Program . The first report described the ground water quality for the Treasure Valley Shallow and Deep subareas (Neely and Crockett, 1998). In addition to technical reports, Statewide Program data are presented in a technical summary for nitrate by Neely and Crockett (1999) and in a series of maps for the Snake River basin.

The data presented in this report can be obtained by contacting the author (kneely@idwr.state.id.us) (208.327.5455). Online data searches can be accomplished through the Snake River basin website at IDWR. Some of the data can be obtained through the USGS either by contacting Ivalou O'Dell (ioodell@usgs.gov) (208.387.1325), or by accessing the USGS National Water Quality Assessment Data warehouse.

2.3. Site Numbering System

The numbering system used in this report for monitoring sites (wells and springs) is identical to the system used by the USGS in Idaho (Figure 2). The system indicates the location of wells within the official rectangular subdivision of the Public Land Survey System (PLSS) with reference to the Idaho baseline and meridian which originates at Initial Point in Ada County. The first two segments of the number designate the township and range. The third segment gives the section number followed by three or four letters and a number. The letters indicate the ¼ section (160 acre tract), ¼-¼ section (40 acre tract), ¼-¼-¼ section (10 acre tract), ¼-¼-¼-¼ section (2.5 acre tract), and the serial number of the well within the tract. Quarter sections are lettered A, B, C, and D in counterclockwise order beginning in the northeast quarter of the section. Successively smaller tracts are lettered in the same manner. For example, well 05N 01W 34ACD1 corresponds to the PLSS location: SE¼, SW¼, NE¼, Section 34, Township 5 North, Range 1 West, and the "1" indicates that it was the first well inventoried by the USGS in that tract.

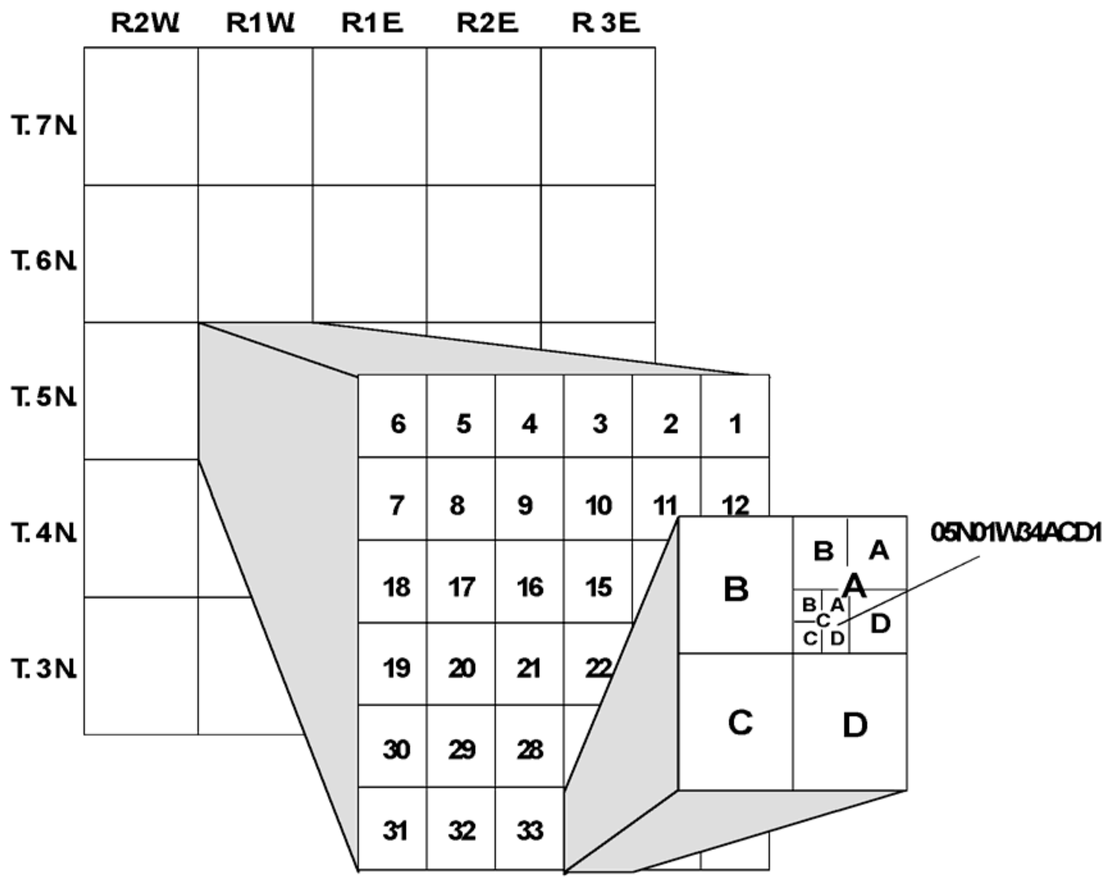

Figure 2. Site numbering system

2.4. Acknowledgements

The author would like to thank the following persons for their assistance with the Statewide Program: 1) the U.S. Geological Survey (USGS) - Water Resources Division in Boise, Idaho, for their dedication to the Statewide Program since its inception in 1990, 2) the Idaho State Department of Agriculture (ISDA) for their financial assistance with pesticide testing, 3) the Trend Monitoring Technical Committee for their input regarding characterization and trend monitoring: Gary Bahr (ISDA); Charlie Bidondo, Rob Howarth, and Gerry Winter (IDEQ); Dean Yashan (formerly with IDEQ); Paul Castelin (IDWR); Flint Hall (Idaho Department of Health and Welfare-Idaho National Environmental and Engineering Laboratory Oversight Program); and Mark Hardy, Ivalou O'Dell, Mike Rupert, and Annette Campbell (USGS), 4) technical reviewers of this report: Hal Anderson, Lin Campbell, Paul

Castelin, Ed Hagan, and Bob Sutter (IDWR); Joe Baldwin and Rob Howarth (IDEQ), Deb Parliman (USGS), and Rick Carlson (ISDA), 5) Brian Abbott (formerly of the Idaho Department of Health and Welfare, Office of Environmental Health), and Jim Baker (ISDA) for their reviews of health consequences listed in Appendix A, and 6) the Idaho State Department of Agriculture, particularly Gary Bahr and Rick Carlson, for follow-up investigations in the Twin Falls subarea.

Special thanks to Janet Crockett who worked as a Senior Ground Water Quality Analyst with IWDR from 1991 through June, 2000. Many of the ideas and data presentations in this report are the result of Janet's professional input. Additionally, Janet provided a technical review of this report.

3. Twin Falls Hydrogeologic Subarea

3.1. Location

The Twin Falls hydrogeologic subarea is located in Twin Falls County in south-central Idaho (Figure 3). The subarea's northern boundary is the county line which follows the Snake River. The eastern boundary is the county line with Cassia County. The western boundary is made up in part by the county line with Owyhee County and in part by a Hydrologic Unit boundary (USGS, 1974). The subarea's southern boundary is the state line with Nevada.

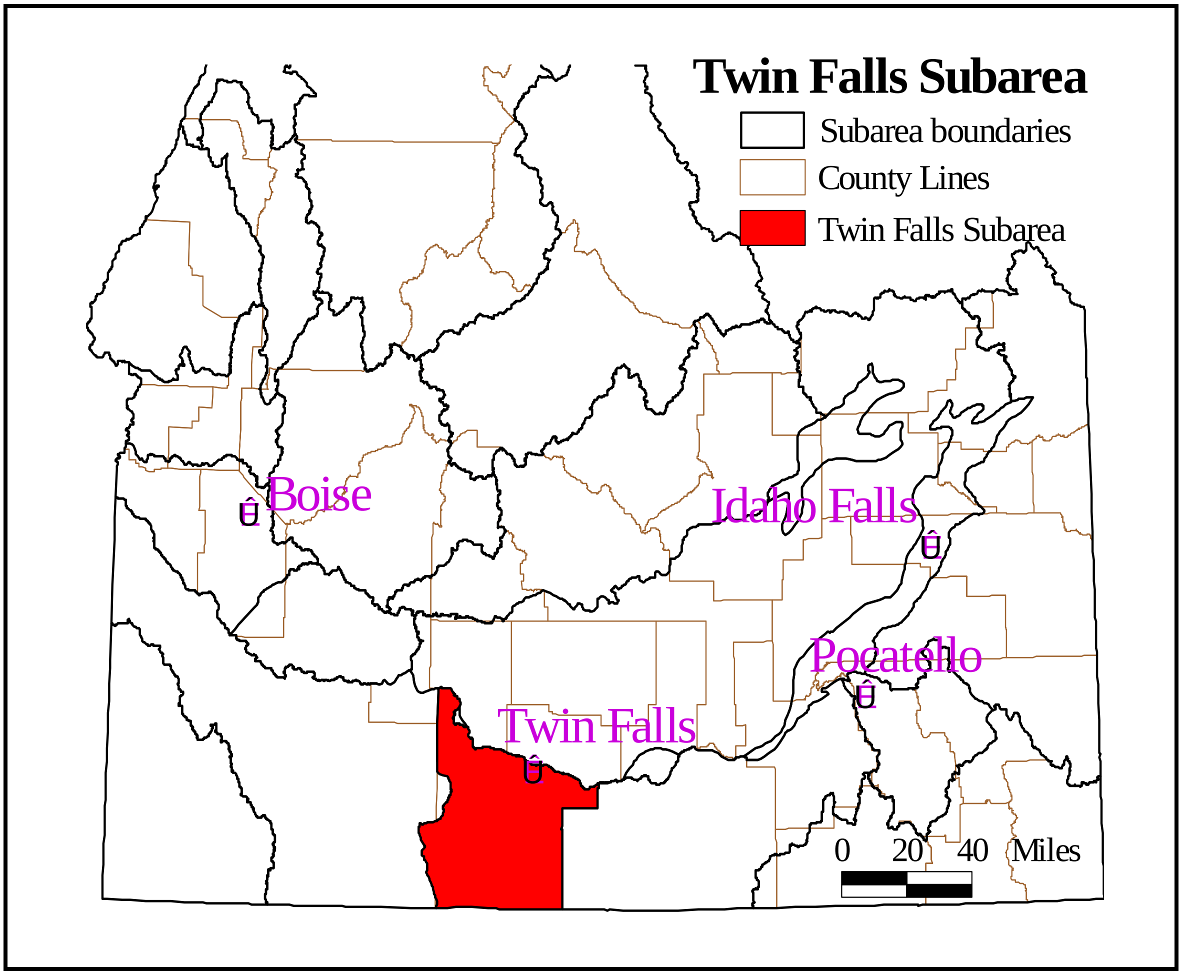

Figure 3. The Twin Falls hydrogeologic subarea.

3.2. Geography

The Twin Falls subarea is along the southern flank of a large structural trough called the Snake River downwarp (Chapman and Ralston, 1970). The arcuate trough extends from eastern Idaho to eastern Oregon (Figure 4) and is bordered on the north and south by

mountains. Northwest trending faults are present in the Twin Falls subarea with the downthrown blocks being on the northeast (Crosthwaite, 1968; Lewis and Young, 1989).

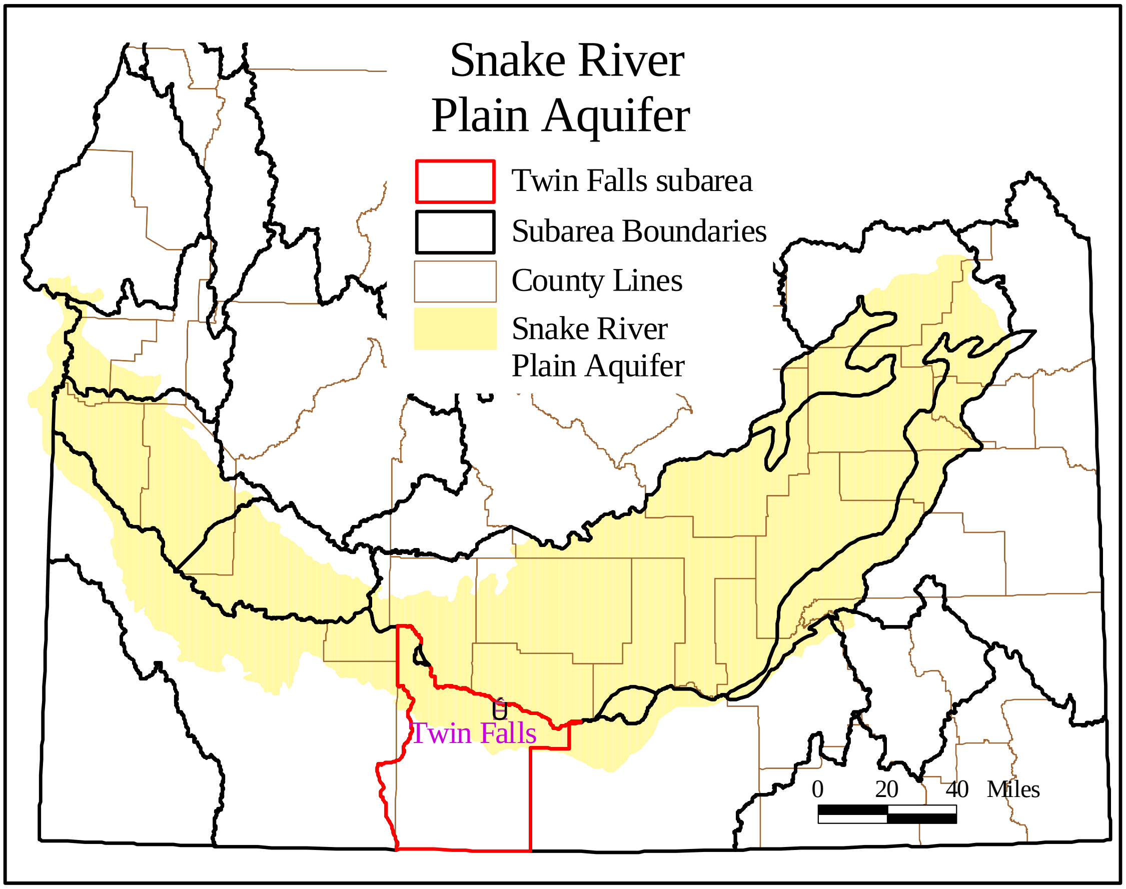

Figure 4. The Twin Falls subarea in relation to the Snake River Plain.

The subarea's geomorphology changes from hills with moderate relief in the south (Humboldt Forest Foothills and South Hills), to a gently north-dipping plateau in the center, to the steep Snake River Canyon in the north (Figures 5 and 6). The elevation between the southern and northern edges of the subarea decreases from about 7,450 feet to about 2,800 feet. Major drainages are the Snake River and Salmon Falls Creek. Salmon Falls Creek, located in the western part of the subarea, has cut a deep (up to 400 feet) but narrow canyon into the plateau at some locations. Other drainages include Cedar Draw, Rock Creek, Deep Creek, and Mud Creek which flow northward and discharge into the Snake River. These streams flow through canyons as they near the Snake River.

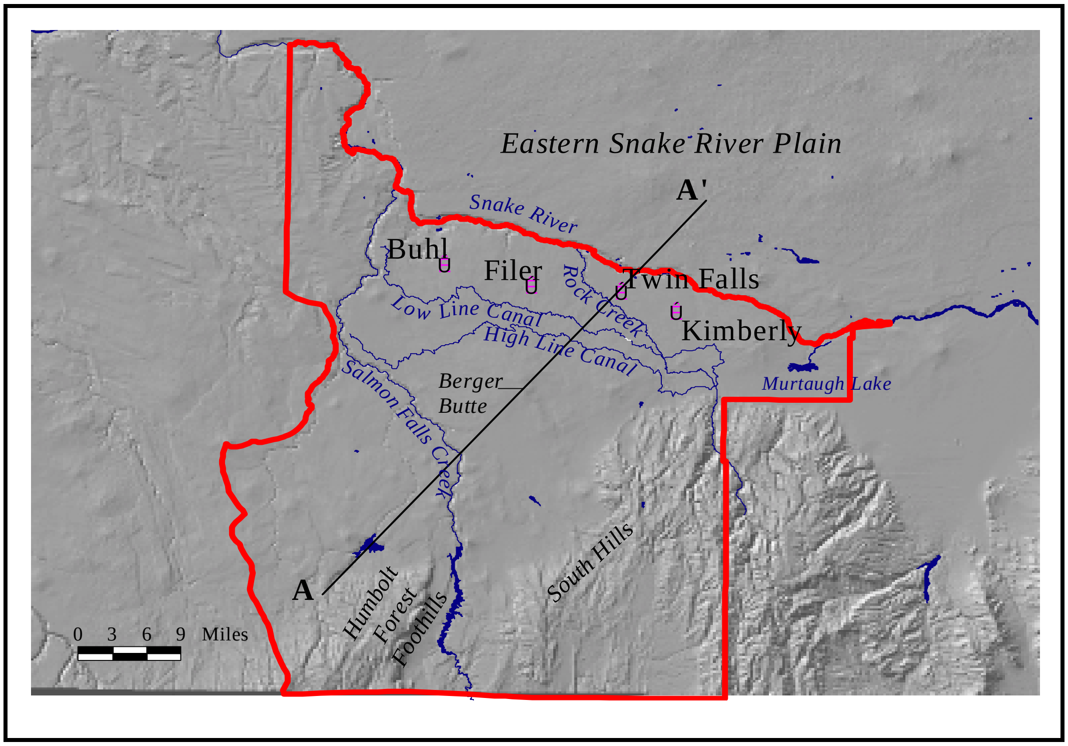

Figure 5. Geomorphological features in the Twin Falls subarea, and A-A' Line of Section.

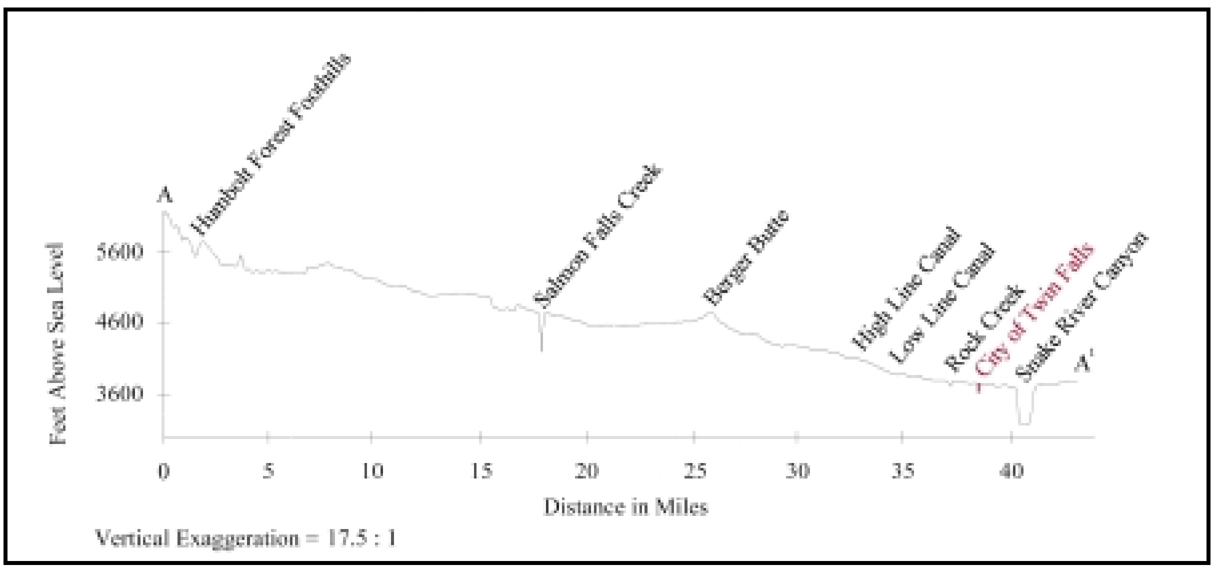

Figure 6. Profile showing the general geomorphic features in the Twin Falls subarea. Location of the Line of Section is shown in Figure 5.

3.3. Climate

The climate in the Twin Falls subarea is arid to semi-arid with hot dry summers and moderately cold winters (Ralston and Young, 1971). Average annual precipitation is higher in the eastern part of the subarea than in the western part. The 30-year average annual precipitation (1961-1990) for the Holister and Twin Falls gauging stations was 10.53 and 10.40 inches, respectively. From 1991 through 2000, precipitation at the Twin Falls and Hollister gauging sites was about 8 percent higher than the 30 year averages with the wetter years occurring roughly in the middle of this time period (Figure 7).

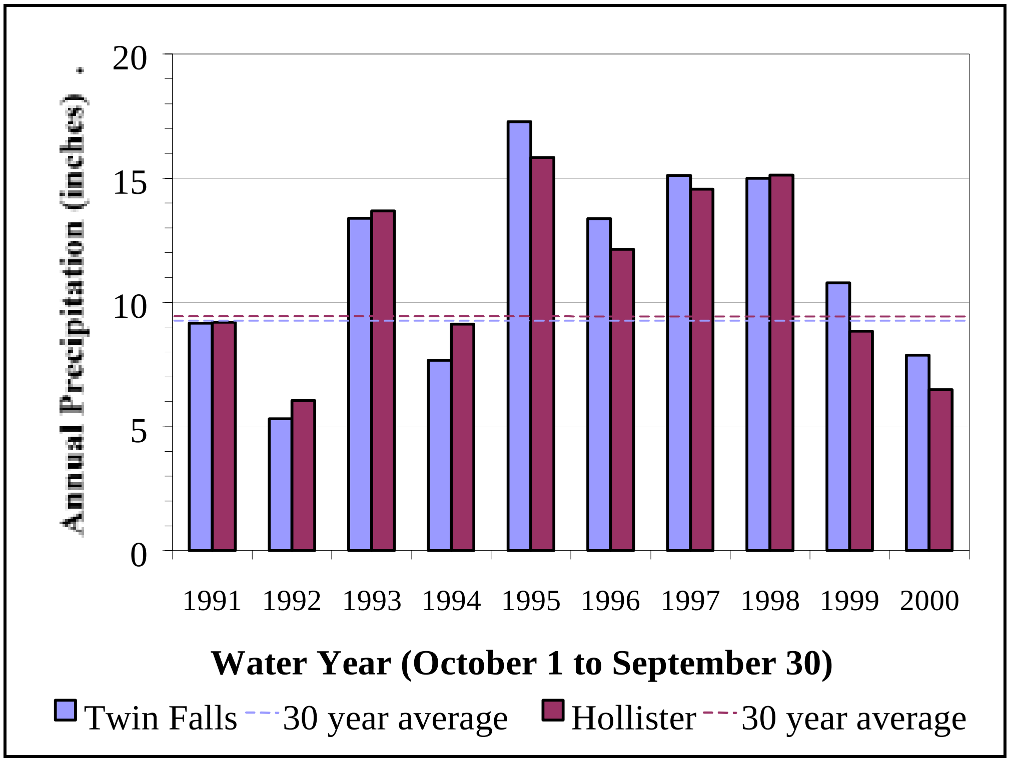

Figure 7. Precipitation records for the Twin Falls and Hollister rain gauges, 1991-2000.

3.4. Demographics

Using Census 2000, the population for Twin Falls County was estimated to be 64,284 with approximately 64 percent of the people residing in urban areas and 36 percent living in rural settings (Alan Porter, Idaho Department of Commerce, personal communication). The four largest cities/towns are Twin Falls, Buhl, Kimberly, and Filer.

3.5. Land Use, Ground Water Vulnerability and Nitrate Probability Mapping

Major land uses in the Twin Falls subarea are irrigated agriculture, residential, and rangeland (Figure 8). Agriculture is extensive in northern parts of the subarea; rangeland occurs in the southern areas. In the early 1990's, there were over 100,000 head of cattle throughout Twin

Falls County in dairies, feeding operations, and rangeland (Idaho Department of Commerce, 1994). Residential land use includes the cities and towns of Twin Falls, Buhl, Kimberly, Filer, Hanson and several other smaller communities. The relationship between land use and ground water quality for the Twin Fall subarea has yet to be anaylzed.

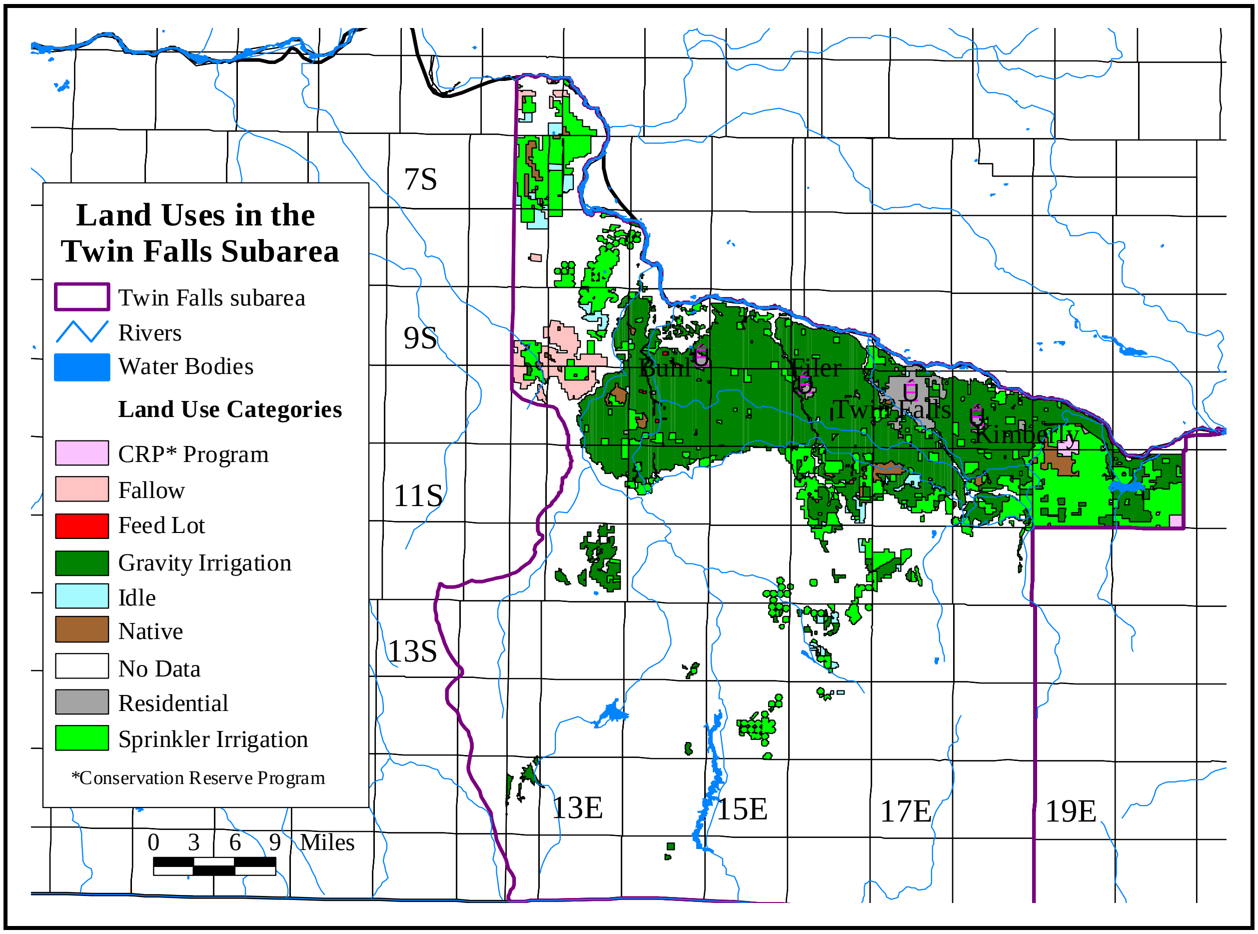

Figure 8. Land uses in the Twin Falls subarea.

Ground water vulnerability (GWV) mapping is a method that has been developed and used to rate areas within Idaho for their relative ground water pollution potential (Rupert et al., 1991). GWV ratings range from moderate to very high for the northern part of the Twin Falls subarea where this type of mapping has been completed (Figure 9). Residential areas comprise a significant portion of the ground water vulnerability rating in and around Twin Falls, Buhl, Kimberly and Filer.

Rupert (1997) showed that the GWV maps for the Eastern Snake River Plain Aquifer can be improved considerably by calibrating the vulnerability point ratings with actual ground water quality data. Rupert (1997) made statistical comparisons of nitrate data collected by the Statewide Program to soils, land uses, and depth to ground water. Rupert developed a vulnerability point rating scheme based upon those statistical comparisons. The resulting maps, called nitrate probability maps, show where differences in nitrate concentrations

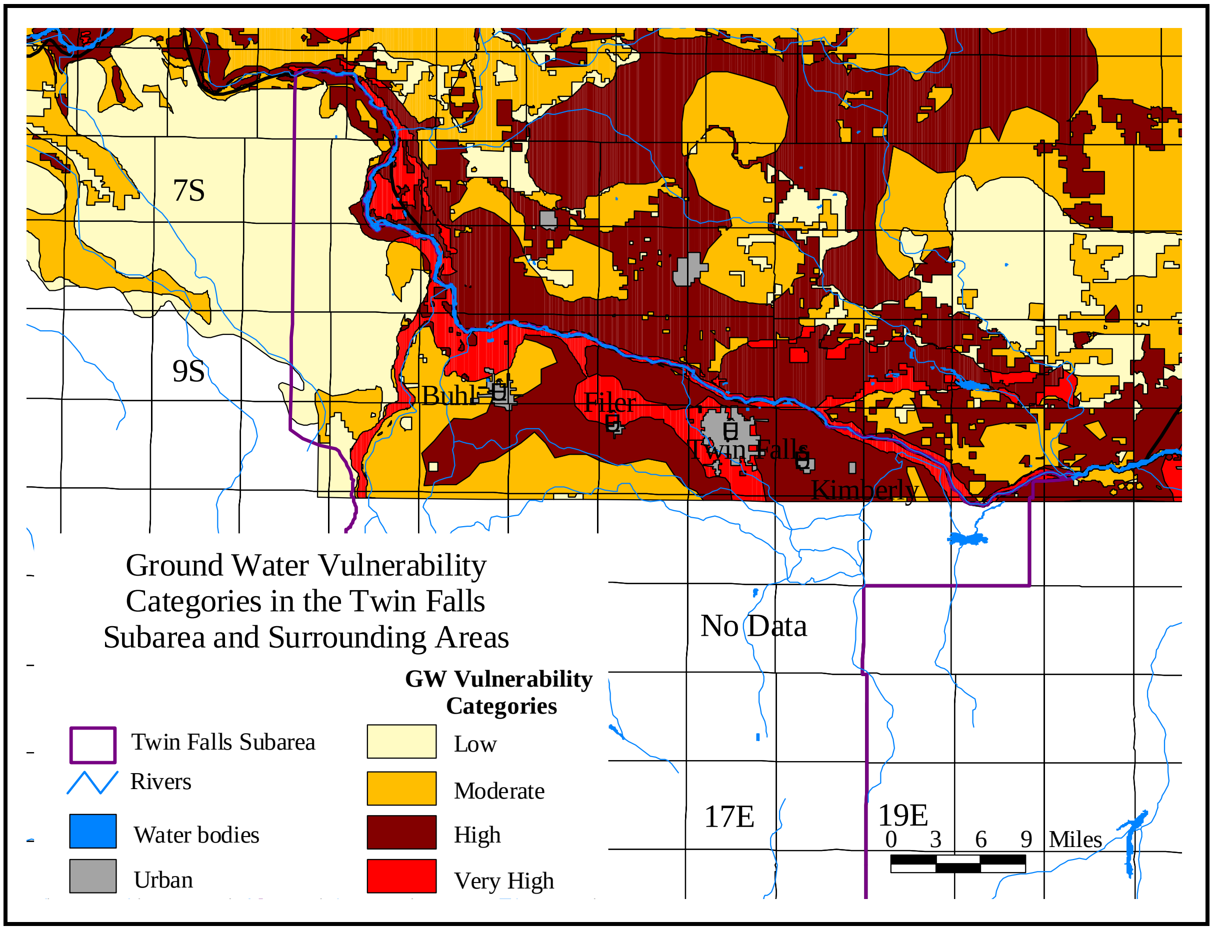

Figure 9. Ground water vulnerability in the Twin Falls subarea.

between probability categories are statistically different at the greater than 99 percent confidence level. Nitrate probability mapping is completed for northern Twin Falls County (Rupert, 1997).

GWV and nitrate probability maps can be used to help determine target areas for Best Management Practices and for other ground water protection applications.

3.6. Hydrogeolgic Investigations in and near the Twin Falls Subarea

A number of reports described the geologic and hydrologic conditions in the Twin Falls subarea. Stearns et al. (1938, as referenced in Ralston and Young, 1971) discussed the Twin Falls area as part of their paper on the southeastern portion of the Snake River Plain. Malde and Powers (1962) and Malde et al. (1963) described the rock types and geology of the western and west central Snake River Plain, which included Twin Falls County. Ralston and Young (1971) detailed the water resources of the Twin Falls Tract which is the northern part of Twin Falls County. Fowler (1960) and Crosthwaite (1968) described the water resources in the Salmon Falls Creek area (located southwest of Twin Falls). Moffatt and Jones (1984)

described ground water availability and ground water chemistry in Twin Falls County and adjacent Owyhee County.

A few other papers have documented discharge and water level data in the county (Jones, 1970; Thomas, 1968; 1969). Published ground water quality data for non-thermal water (water temperatures equal to or less than 29.4 ° C) are found in Ralston and Young (1971) and in USGS annual reports.

Donna Cosgrove and others (1997) developed a steady state ground water flow model for Twin Falls based on 20 years of recharge and discharge data. The model was developed in response to the stresses on the aquifer due to development in the Twin Falls area.

Geothermal water is used for space heating, aquaculture, and recreation in some areas of the Twin Falls subarea. Technical reports that describe the occurrence of geothermal water in the Twin Falls subarea include: Lewis and Young, 1982; Lewis and Young, 1989; Mariner and Young, 1995; Mariner et al., 1997; Mariner et al., 1991; and Young and Lewis, 1982.

3.7. Hydrogeology

Depth-to-water varies throughout the subarea. Overall, water levels tend to be deeper in the central part of the subarea than in other parts of the subarea. Depth-to-water is generally less than 150 feet in a radial distance of about six miles around Buhl, and in the area northwest of Twin Falls. East of Twin Falls, the depth-to-water is typically over 150 feet but less than 300 feet. The variability in depth-to-water may be due to wells being completed in different water-bearing zones or to recharge from surface water.

Ground water flow direction is from the south to the north and northwest (Moffatt and Jones, 1984) (Figure 10). Recharge to the ground water systems occurs through precipitation in the uplands to the south and by infiltration from surface water and canal leakage throughout the north.

The four primary water-bearing units in the Twin Falls subarea are the Idavada Volcanics Formation, Banbury Basalt Formation, Glenns Ferry Formation and Snake River Group.

The rhyolites and ash flows of Idavada Volcanics Formation are exposed at the land surface in the southern part of the subarea; the layers dip to the north and are overlain by the younger deposits of the Banbury Basalt Formation and the Glenns Ferry Formation in the northern part of the subarea (Figure 11). Permeability in the Idavada Volcanics Formation is highly variable and dependent on fracturing, faulting and the presence of sand, tuff and ash beds (Ralston and Young, 1971). In some wells and springs, the water is classified as low-temperature geothermal by the IDWR because the temperature exceeds 29.4° C. The Idavada Volcanics is not a major non-thermal aquifer.

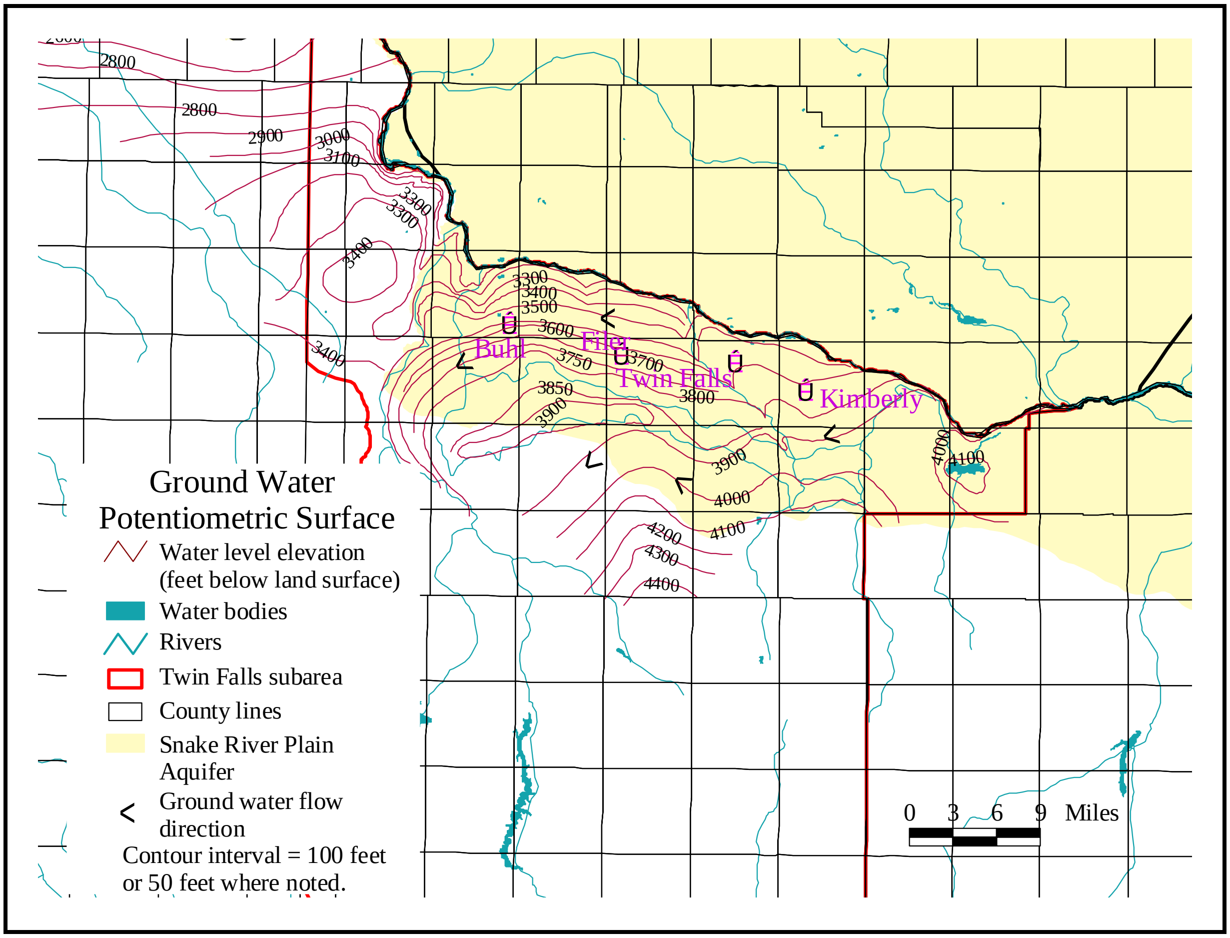

Figure 10. Ground water contours and ground water flow directions for the Twin Falls subarea and surrounding areas (from Moffatt and Jones, 1984).

The Banbury Basalt Formation overlies the Idavada Volcanics Formation in the northern part of the subarea (Figure 11). The Banbury is not exposed at the land surface because it is overlain by the Glenns Ferry Formation. The Banbury Basalt Formation has been divided into three members designated as the lower basalt, the middle sedimentary unit, and the upper basalt (Ralston and Young, 1971). The lower and upper basalts are major non-thermal (water temperature less than 29.4 C) aquifers in this subarea (Ralston and Young, 1971). In most cases, the upper basalt member cannot be distinguished from the overlying Glenns Ferry basalt because of similarities in lithologies.

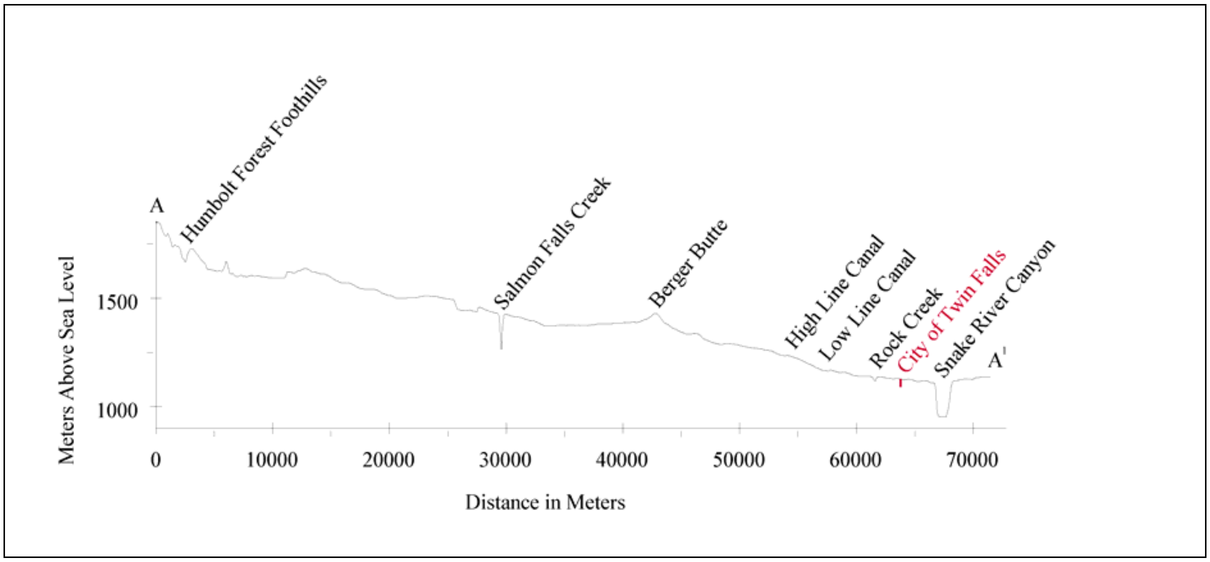

Figure 11. Stratigraphic relationships based on well driller's reports for the Twin Falls subarea. Location of the Line of Section is shown in Figure 5.

The Glenns Ferry Formation is another major non-thermal water aquifer in the Twin Falls subarea. This formation is exposed in the northern part of the subarea where it overlies the Banbury Basalt Formation (Figure 11). The permeability of this basalt is highly variable and dependent on jointing and flow contacts (Ralston and Young, 1971).

Basalts designated as the Snake River Group occur in the northern part of the subarea. These basalt units may overlay the Glenns Ferry Formation in places, and they may be the southern extensions of the basalts of the Eastern Snake River Plain Aquifer. However, the non-thermal waters in Snake River Group aquifers north and south of the Snake River are probably not hydrologically connected due to the boundary effect of the Snake River Canyon. The Snake River Group units are major water-bearing aquifers in the Twin Falls subarea.

3.8. Network Development

The number and location of monitoring sites for the Statewide Program were determined using a stratified random selection technique (Neely, 1994). The following steps describe the site selection process:

1) the state was subdivided into 22 hydrogeologic subareas based primarily on aquifer descriptions by Graham and Campbell (1981),
2) the number of sites for 20 of the 22 subareas was estimated using the Neyman Maximum Allocation Method which incorporated weighting factors for population, aquifer area and water quality variability (Nelson and Ward, 1981; Spruill, 1990); two subareas were not sampled because they do not have major aquifers and have very small populations,
3) potential monitoring areas were selected using the Public Land Survey System as the grid,

4) monitoring sites were picked for each selected grid using existing well and spring databases maintained by the USGS and the IDWR. Potential sites were required to have well construction and lithologic information, water temperatures equal to or less than 29.4° C, and to be representative of the aquifer system in the area (which was determined by inspecting the lithologic records on the well driller's reports), and
5) owners were contacted for permission to sample their sites.

Originally, 96 Statewide Program monitoring sites (all wells) were sampled in the Twin Falls subarea from 1991 through 1994. However, four wells were dropped from the network after one sampling event because they either had geothermal water temperatures or they were missing critical well construction information; the data from these sites were not included in the analyses. Another nine wells were dropped for various reasons; one of these wells was replaced with a nearby well. Six sites are currently on hold because the wells have not been in operation.

Although clustering of monitoring sites has occurred in some areas due to the nature of the selection process, the original spatial distribution provided fairly uniform coverage (Figure 12). A few data gaps (no sites in some areas) do exist in some areas because there were no viable monitoring sites or because the selection process did not pick those areas.

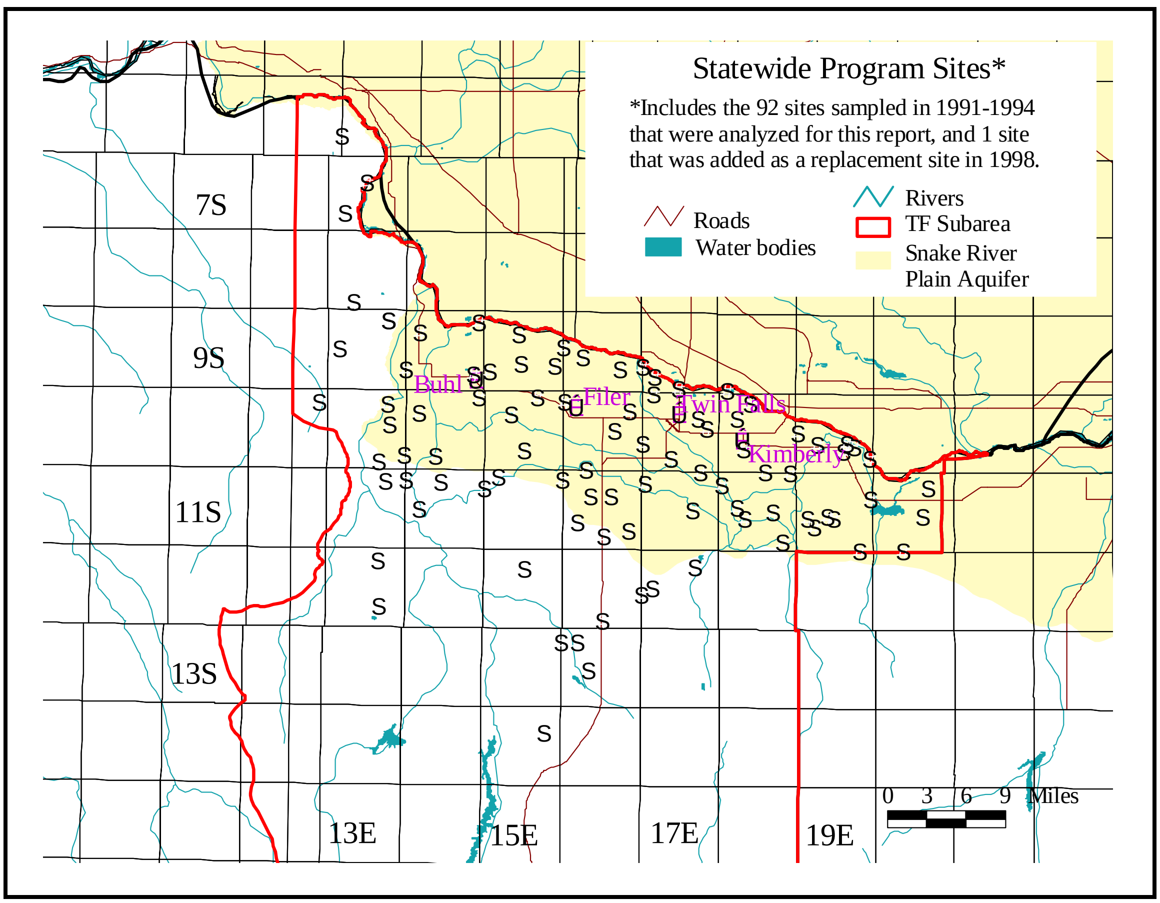

Figure 12. Statewide Program monitoring sites for the Twin Falls subarea.

4. GROUND WATER QUALITY CHARACTERIZATION

Characterization of ground water quality in the Twin Falls subarea was accomplished using Statewide Program data collected from 1991 through 2000. This report includes general statements about constituent concentration distributions as well as basic descriptive and non-parametric statistical test results. Detailed characterization relating ground water quality to stratigraphy, land uses, etc., is not within the scope of the Statewide Program but may be addressed through regional and/or local monitoring. Primary and secondary Maximum Contaminant Levels (MCLs) as established by the U.S. Environmental Protection Agency were used as yardsticks to assess the ground water quality. Primary MCLs apply to constituents with potential human health concerns; secondary MCLs are used for aesthetic properties of the water. Primary and secondary MCLs were adopted in the Idaho Ground Water Quality Rule of 1996 (IDAPA 58.01.11).

Characterization results are discussed in the following sections: 1) Network Design Verification, 2) Well Construction Parameters and On-Site Measurements, 3) Major Ions, 4) Nutrients, 5) Trace Elements, 6) Radioactivity, 7) Volatile Organic Compounds, 8) Pesticides, and 9) Bacteria. Two additional sections are incldued: 1) Selected Constituents with Secondary MCLs, and 2) Characterization Summary.

4.1. Network Design Verification

Ideally, it would have been desirable to select and sample all network sites in one year. However, this approach was not economically or logistically possible. Therefore, the network development occurred over a four-year time period from 1991 through 1994; this time period is referred to as the First Round. Since the baseline sampling was spread out over four years, there was a concern that different populations were sampled in one or more of these four years. Statistical tests were conducted to determine if the data collected during each of the four years in the First Round could be combined and treated as a single dataset for the Twin Falls subarea (i.e., even though the data were collected in separate years, did they come from the same overall ground water quality population?).

The Kruskal-Wallis and the Mann-Whitney rank-sum non-parametric statistical tests were selected because most of the data had non-normal (generally right skewed) distributions as indicated by distribution curves and by skewness coefficients greater than 2.0. Skewed distributions are common for ground water quality parameters (Montgomery et al., 1987). The Kruskal-Wallis test can determine if k groups ($k > 2$) have identical distributions or if at least one group differs in its distribution (Helsel and Hirsch, 1992). If a Kruskal-Wallis test indicates that at least one group has a different distribution than the other groups, the Mann-Whitney rank-sum test can be used to determine which group(s) has the different distribution. The Mann-Whitney rank-sum test is used to test two groups at a time to determine if one group is producing larger observations than the second group (Helsel and Hirsch, 1992). Each test produces a test statistic and an associated probability (p) value. There is a significant difference at the 95 percent confidence level between the groups tested if the p value is less than 0.05.

Statistical tests were conducted on 26 constituents and parameters which were selected because few or no concentration values were below the laboratory method detection limits. Individual tests were run according to each constituent and parameter.

Kruskal-Wallis test results indicated that there were no significant differences in median concentrations at the 95 percent confidence level for 23 of the 26 constituents and parameters (88 percent). Significant differences that existed for ammonia, pH, and potassium indicated that at least one subset (year) was significantly different than the other subsets. Mann-Whitney rank-sum tests were conducted on two subsets at a time (1991 versus 1992, 1991 versus 1993, etc.) for ammonia, potassium, and pH. Results from the Mann-Whitney rank-sum tests indicated that ammonia data had the highest number of paired years with significant differences (four). Potassium had three paired years with significant differences; pH had two. The reasons for the significant differences for ammonia, pH, and potassium are unknown.

The test results for the Twin Falls subarea indicated that the building of the network over the First Round (1991 through 1994) did not appear to mix populations of different water qualities. This conclusion permitted the water quality results for the First Round to be combined by constituent type and treated as one sampling event for statistical analyses. This also facillitates the comparision of Rounds of data (First Round to Second Round, etc.) for trend analysis.

4.2. Well Construction Parameters and On-Site Measurements

Well construction parameters discussed in this section include well depth, casing and openings. On-site measurements recorded as part of the Statewide Program include alkalinity, dissolved oxygen, pH, specific conductance, and temperature (all of the parameters are discussed below except dissolved oxygen).

4.2.1. Well Construction Parameters

Total well depths in the Twin Falls subarea ranged from 62 to 1,285 feet with the median value being 260 feet. Well depths for Statewide Program sites vary throughout the subarea but, in general, wells are deeper in the central and eastern areas (Figure 13). Shallower Statewide Program wells (less than the median depth) occur commonly in a band from south of Kimberly to northeast of Buhl and in an area southwest of Buhl. Wells in the Twin Falls subarea often have very little casing because most of them were completed in consolidated volcanic rocks. Casing lengths for 81 wells ranged from 7 to 1017 feet with the median value being 22 feet. There were no casing records for 11 wells. Most casing strings were open-ended at the bottom with long sections of open hole beneath the casing shoe.

4.2.2. Ground Water Temperatures

Ground water temperatures for the First Round sites ranged from 11.8° to 29.0° C with the median value being 15.0° C. The higher temperatures reflect the geothermal influences in some parts of the subarea. The distribution of temperatures was skewed due to high values at some sites (Figure 14). Higher ground water temperatures occurred generally in the northwestern, central, and eastern parts of the subarea (Figure 15). Cooler ground water

temperatures occurred in several distinct areas including the band of shallower wells from south of Kimberly to northwest of Filer, an area southeast of Buhl and in the south-central part of the subarea. In general, cooler ground water temperatures are associated with the shallower wells. However, deeper well depth does not necessarily result in higher temperatures.

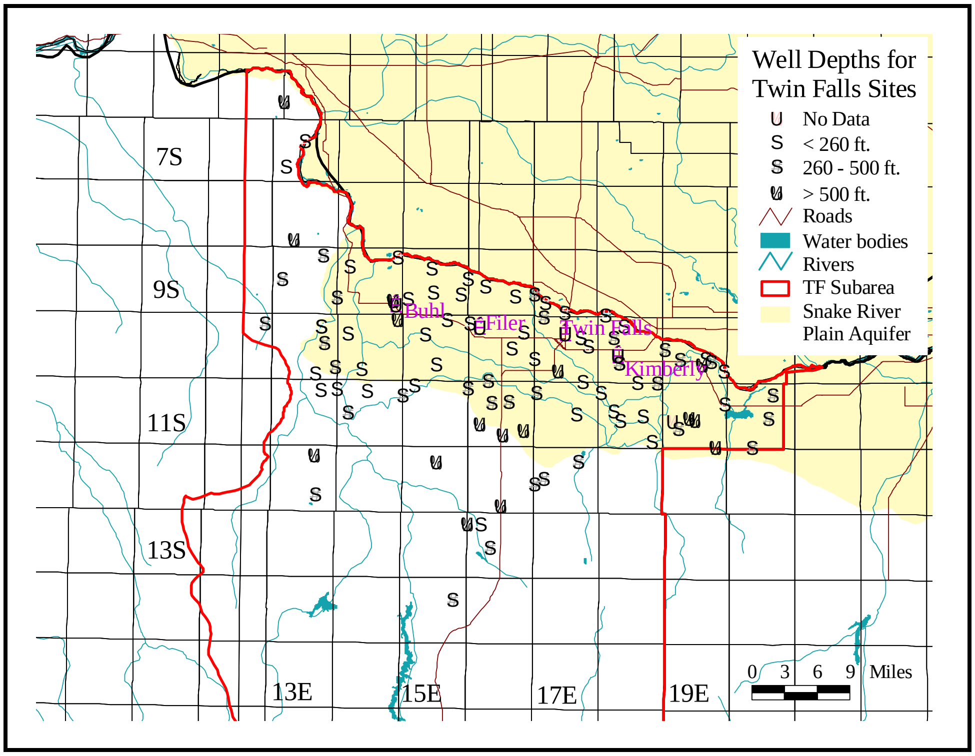

Figure 13. Wells depths for the Twin Falls subarea monitoring sites.

4.2.3. Specific Conductance

Specific Conductance (SC) is "a measure of the electrical conductance of a substance normalized to unit length and unit cross section at a specified temperature" (USGS National Field Manual). Specific conductance is an indication of the mineral content of the water; higher mineral content results in higher specific conductance.

SC for the Twin Falls subarea ranged from 208 to 2,350 microsiemans per centimeter (µS/cm) with the median value being 872 µS/cm. SC values were skewed because some values were higher than would be expected for a normal distribution shape (Figure14). SC concentrations occur in clusters throughout the subarea (Figure 16). For example, clusters of sites with SC concentrations greater than 1000 µS/cm occurred north of Filer and in the south central part of the subarea.

4.2.4. PH

PH is the measure of acidity or alkalinity in a water sample. PH values less than 7 indicate that the water is acidic; pH values greater than 7 indicate that the water is alkaline. The Secondary Maximum Contaminant Level (SMCL) for pH applies to for waters with pH values less than 6.5 or greater than 8.5. Acidic pH waters can cause corrosion of plumbing, and may cause a bitter taste and discoloration of water.

PH in the Twin Falls wells ranged from 7.0 to 10.4 with the median value being 7.72. The data had a normal distribution shape with the exception of a few high values (Figure 14).

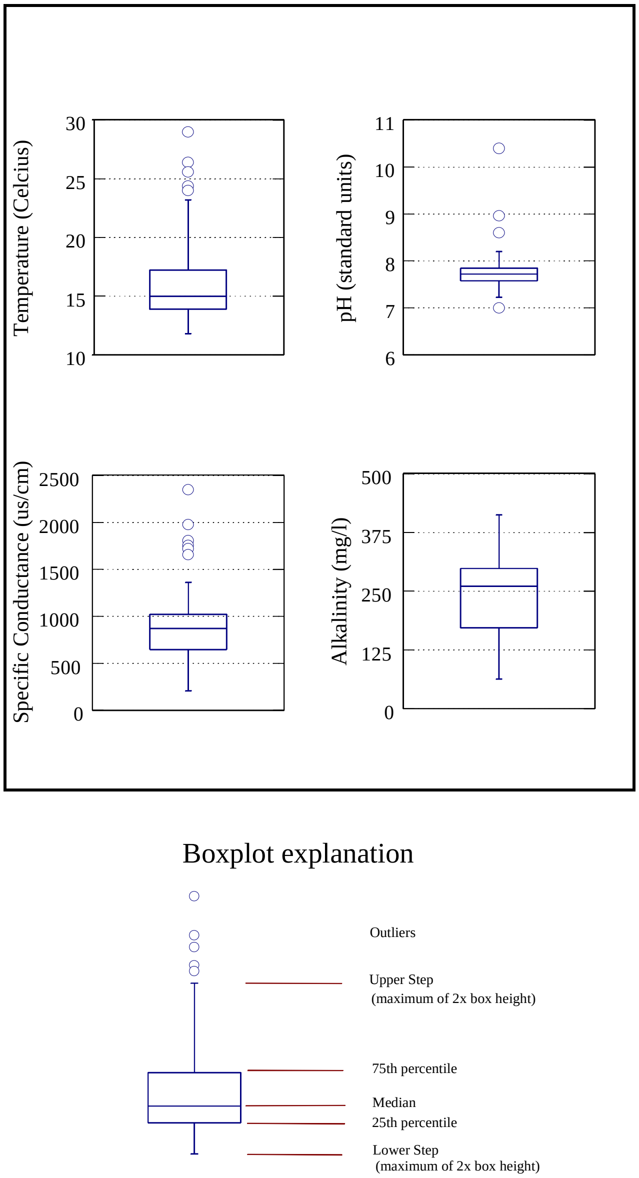

Figure 14. Boxplots for field parameters for the Twin Falls subarea monitoring sites, 1991-1994.

In general, pH values below the median were found in the shallower and cooler temperature wells, especially throughout the band of wells from south of Kimberly to northwest of Filer (Figure 17). The higher pH values in the central part of the subarea were associated with deeper wells. Three sites had pH values greater than 8.5, which is the upper limit of the secondary MCL for pH.

4.2.5. Alkalinity

Alkalinity is the "the capacity of solutes in an aqueous system to neutralize acid" (USGS National Field Manual). Alkalinity ranged from 63 to 413 milligrams per Liter[1] (mg/L) with the median value being 261 mg/L. Distinct patterns of alkalinity concentrations occurred in the Twin Falls subarea. Higher concentrations were more common in the northern and western parts of the subarea (Figure 18). Lower concentrations were common in the northwest, central and eastern parts of the subarea. In general, the lower alkalinity concentrations were associated with the deeper well depths.

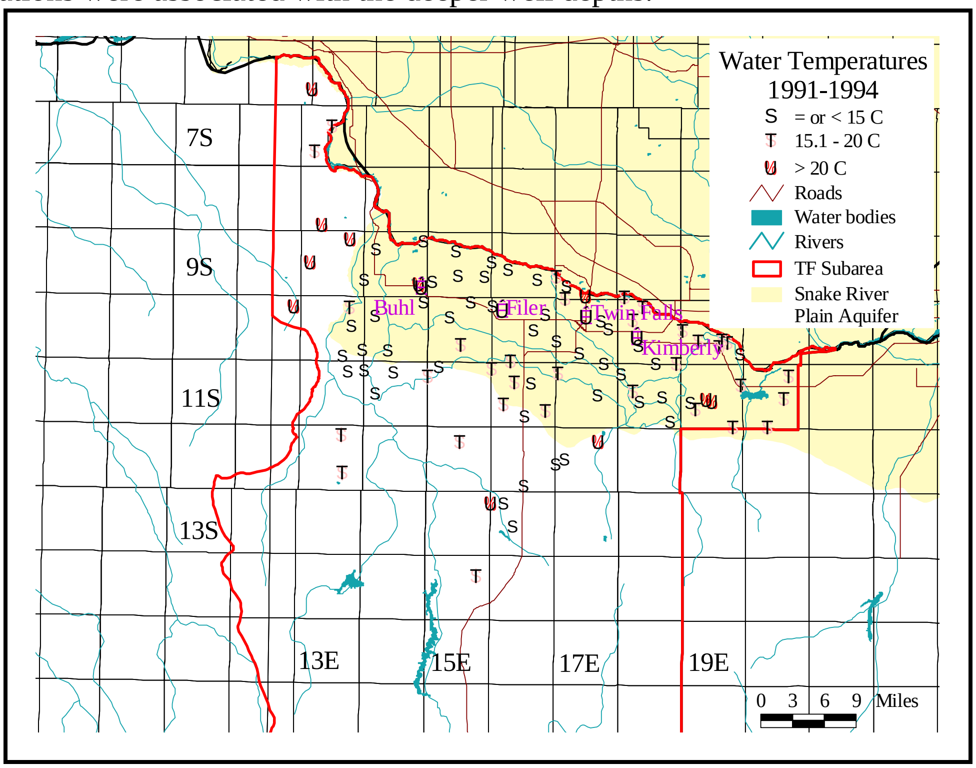

Figure 15. Ground water temperatures for the Twin Falls subarea monitoring sites, 1991-1994.

[1]milligrams per Liter is equivalent to parts per million.

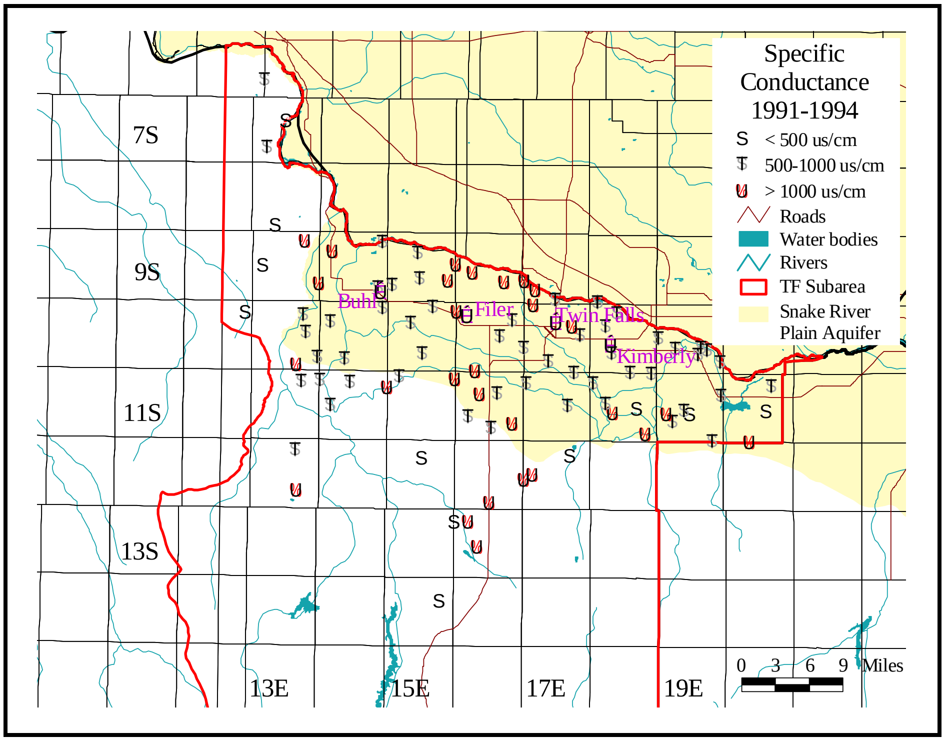

Figure 16. Specific conductance values for the Twin Falls subarea monitoring sites, 1991-1994.

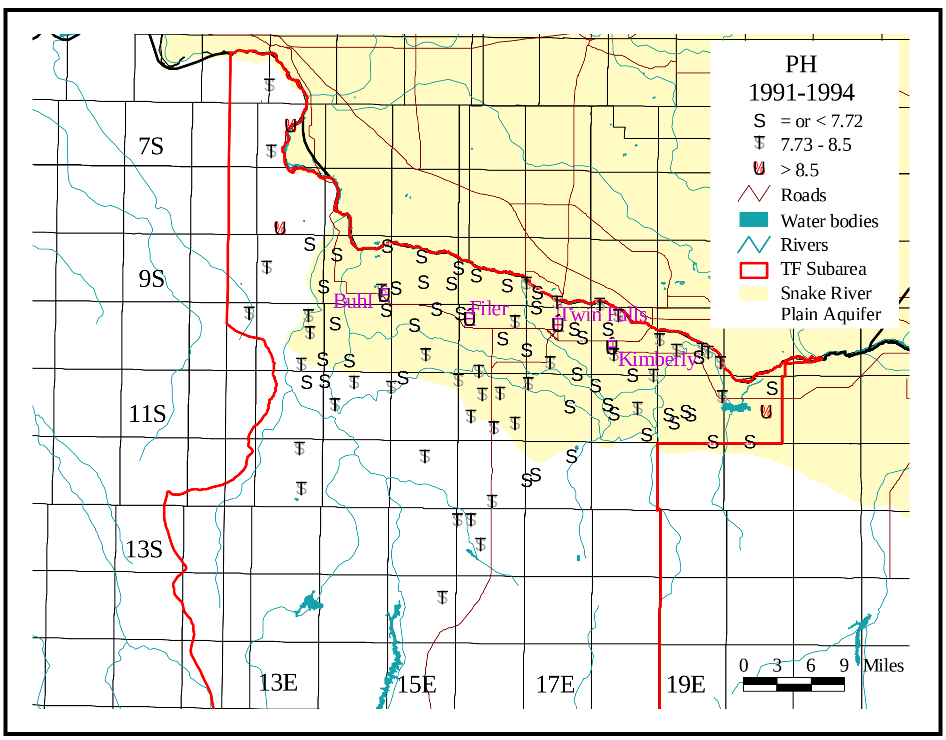

Figure 17. PH values for the Twin Falls subarea monitoring sites, 1991-1994.

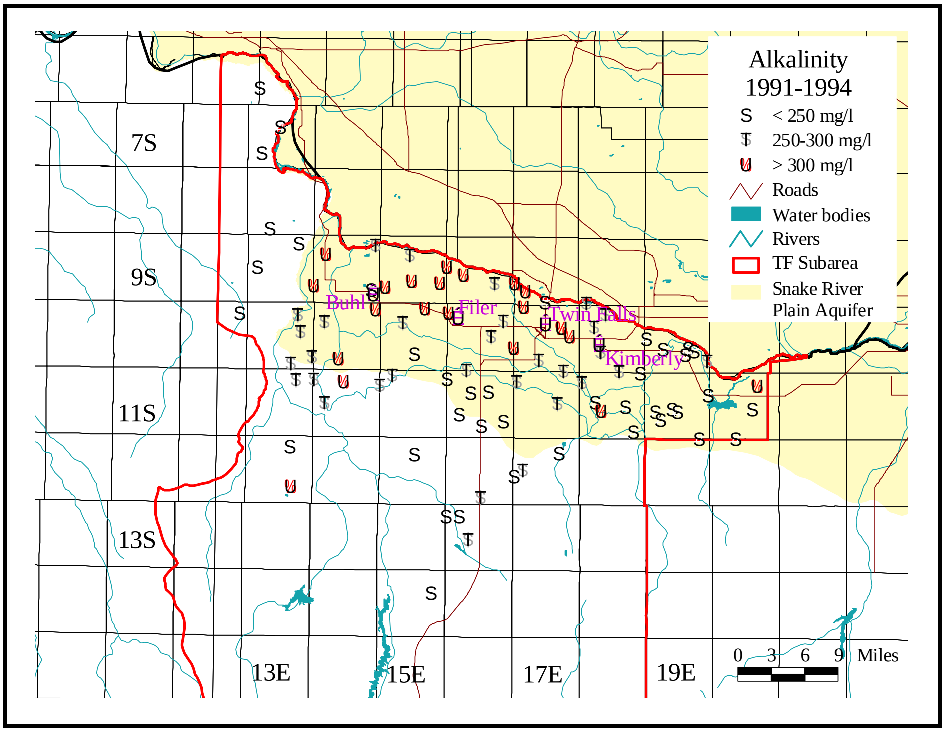

Figure 18. Alkalinity values for the Twin Falls subarea monitoring sites, 1991-1994.

4.2.6. Correlations Between On-Site Measurements and Well Depth

On-site measurements and well depths were examined using scatterplots for any apparent correlations. Linear regression was used to evaluate possible correlations (linear regression reference 2; linear regression reference 3). The Spearman's rho rank-order nonparametric test was performed on two water quality variables at a time to measure the correlation coefficient (i.e., the strength of the association) between the variables (Helsel and Hirsch, 1992). Correlation coefficients can range from -1 to 1 using the Spearman's rho test. Correlation coefficients near zero indicate no correlation between the two variables tested. Positive correlation coefficients indicate that as one variable increases, the other variable increases too. Negative correlation coefficients indicate that as one variable increases, the other variable decreases. A probability (p) can be calculated for each correlation coefficient. When p is less than 0.05, the relationship between the two variables is significant at the 95 percent confidence level.

Correlations between between well depth and the four field parameters (temperature, pH, specific conductance and alkalinity) were signficant at the 95 percent confidence level. Temperature and pH increased as well depth increased; specific conductance and alkalinity decreased with increasing well depth. Temperature and alkalinity had the strongest correlations with well depth (Figures 19 and 20). Significant correlations also existed between the four field parameters. The strongest correlation existed between alkalinity and specific conductance (Figure 21), and between alkalinity and temperature (Figure 22).

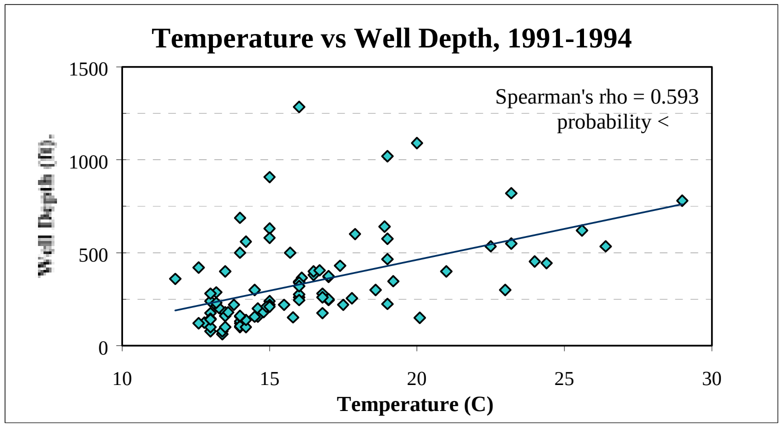

Figure 19. Scatterplot and Spearman's rho test results for well depth versus well temperature for the Twin Falls subarea monitoring sites for 1991-1994.

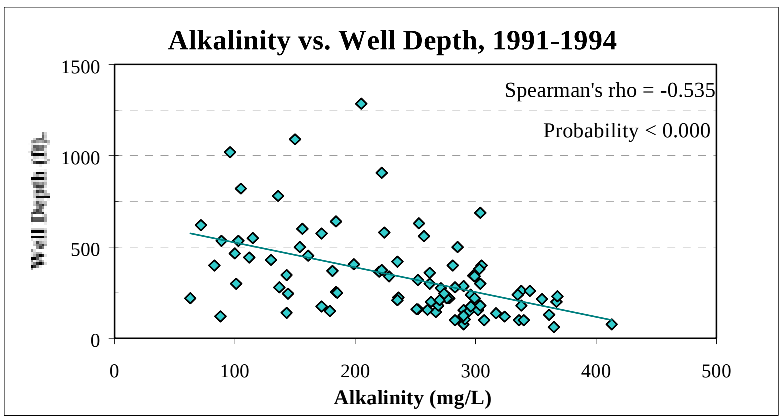

Figure 20. Scatterplot and Spearman's rho test results for well depth versus alkalinity for the Twin Falls subarea monitoring sites for 1991-1994.

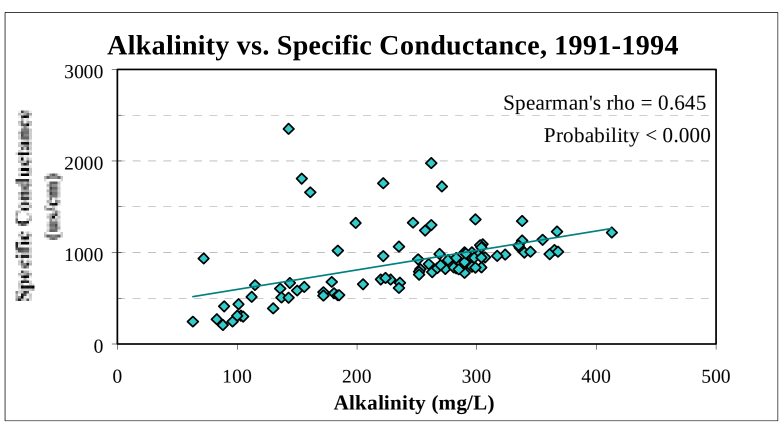

Figure 21. Scatterplot and Spearman's rho test results for alkalinity versus specific conductance for the Twin Falls monitoring sites for 1991-1994.

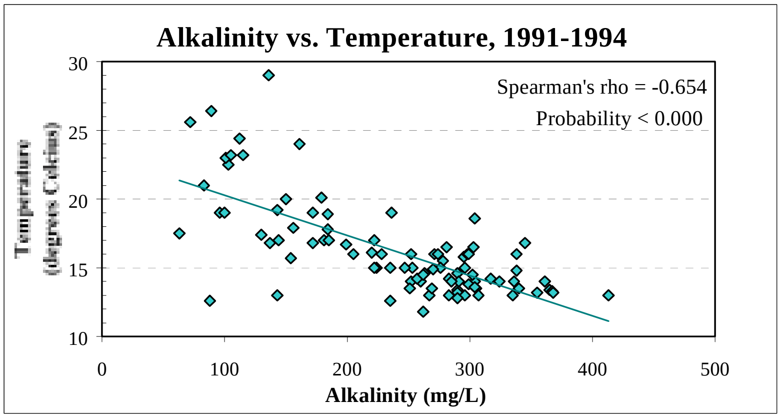

Figure 22. Scatterplot and Spearman's rho test results for temperature versus alkalinity for the Twin Falls subarea monitoring sites for 1991-1994.

4.3. Cations and Anions, Water Types, TDS, and Hardness

4.3.1. Cations and Anions

Cations and anions analyzed were calcium, magnesium, sodium, potassium, bicarbonate, sulfate, chloride, and fluoride. Boxplots showed that most ions had distributions that were non-normal and right-skewed (Figure 23).

4.3.2. Water Types

Trilinear plotting of the First Round data indicated that there is a significant clustering of points in the left-central portion of the quadrilateral (i.e., diamond-shaped) plot (Figure 24). Characterization of the water quality data collected from First Round sampling indicated that calcium and magnesium were the dominant cations, and that bicarbonate was the dominant anion. A cluster of sites fell into the upper part of the quadrilateral plot. These sites appear to have calcium+magnesium as the dominant cations and chloride+sulfate as the dominant anions. The majority of the sites in the upper-central portion of the quadrilateral diagram had TDS concentrations greater that the median TDS value of 575 mg/L. All of these sites with the exception of one had well depths greater than the median depth of 260 feet. The sites with this water type occurred mainly in an area southwest of Twin Falls in Townships 11, 12 and 13 South, Range 16 East.

Three sites had unusual results. These sites plot along the 100 percent sodium+potassium line on the quadrilateral plot. Two of the sites are located in the northwest part of the subarea (07S 13E 16ADB1 and 08S 13E 32ADD1) and one site is located just north of Twin Falls (09S 17E 33DAC1). Reasons for soft water at these sites (they have very little calcium and magnesium) are unknown. Two of the sites have elevated fluoride and pH values which may indicate geothermal influences; however, the ground water temperatures were still in the non-thermal temperature category (16.7° C and 22.5° C).

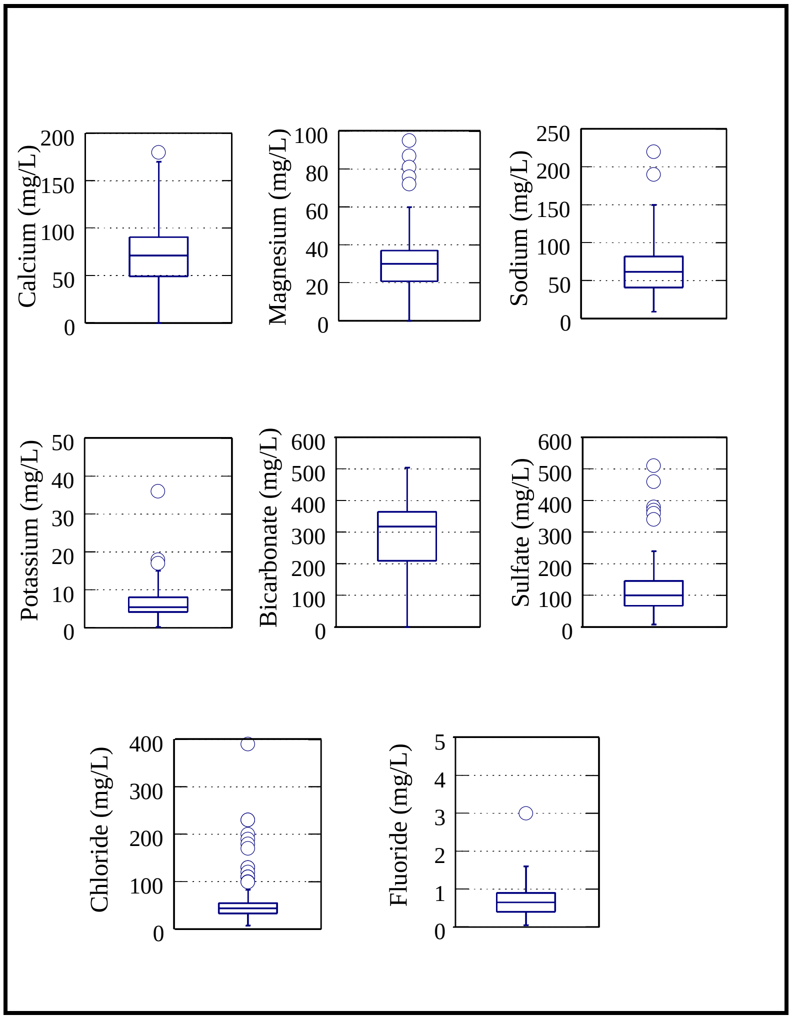

Figure 23. Boxplots for cations and anions for the Twin Falls subarea monitoring sites, 1991-1994.

4.3.3. Total Dissolved Solids

Total dissolved solids (TDS) is the amount of solids left when a filtered ground water sample is evaporated to dryness (Drever, 1988). TDS can also be calculated from major ion concentrations. The secondary MCL for TDS is 500 mg/L.

TDS concentrations (calculated from major ion concentrations) for the Twin Falls subarea ranged from 140 to 1,545 mg/L with the median being 575 mg/L. TDS exceeded the secondary MCL of 500 mg/L at 60 of the 93 sites (65 percent). TDS concentrations greater than 500 mg/L occurred throughout the subarea with distinct clustering (Figure 25). Sites with TDS concentrations less than 500 mg/L were most common in the northwest, central, and eastern parts of the subarea. At the six sites where TDS exceeded 1,000 mg/L, sulfate and chloride were elevated and, to a lesser extent, calcium, magnesium, and sodium were higher sites with lower TDS values.

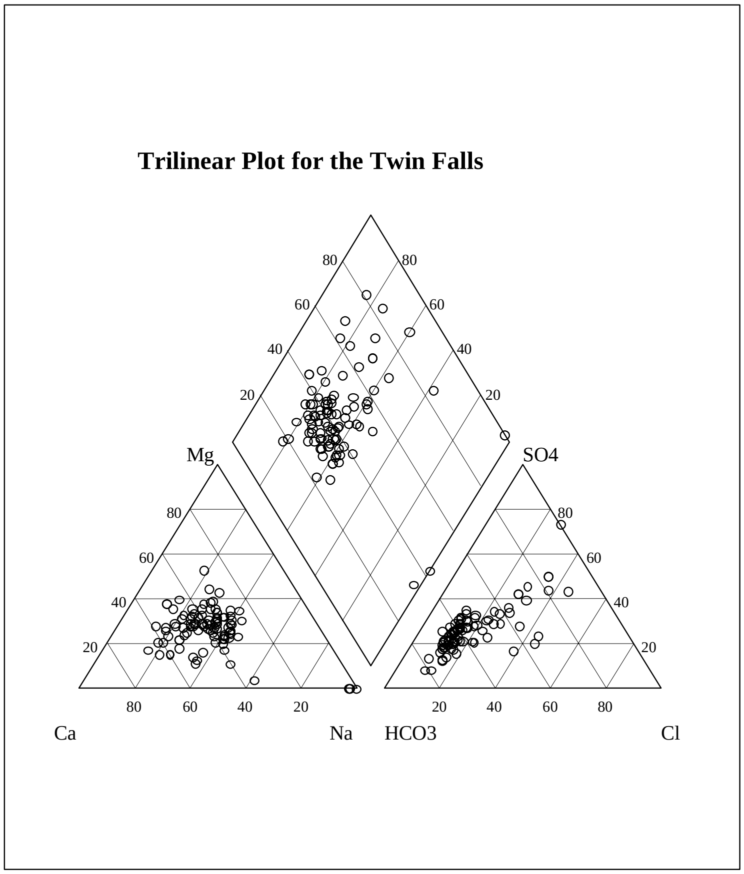

Figure 24. Trilinear diagram plot for the Twin Falls subarea monitoring sites, 1991-1994.

4.3.4. Hardness

Hardness is calculated from the calcium and magnesium concentrations of a water sample. Hardness values for the Twin Falls subarea ranged from 0.4 to 738 mg/L (as CaC03) with the median value being 309 mg/L. Seventy-nine of the 93 Twin Falls subarea sites (86 percent) had hardness concentrations greater than 150 mg/L (hard or very hard water) (Figure 27). Hardness concentrations greater than 150 mg/L occurred throughout the subarea with very hard water (>300 mg/L) being ubiquitous in the ground water near Buhl and Filer (Figure 26). The few sites with soft and moderately hard values were found in the western, southern and eastern areas.

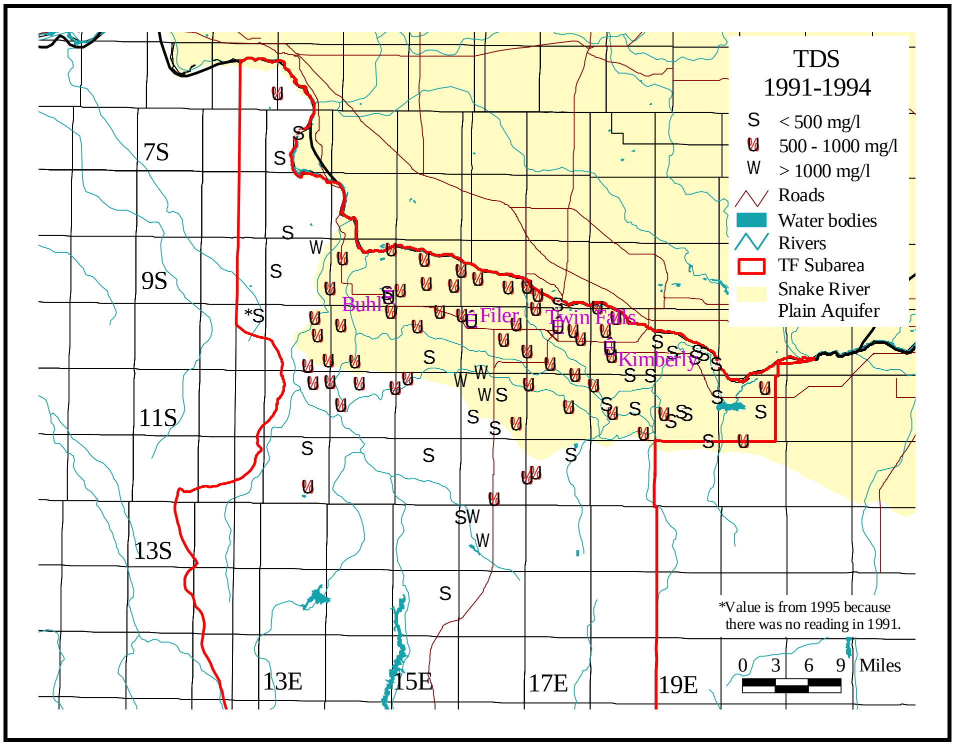

Figure 25. TDS results for the Twin Falls subarea monitoring sites, 1991-1994.

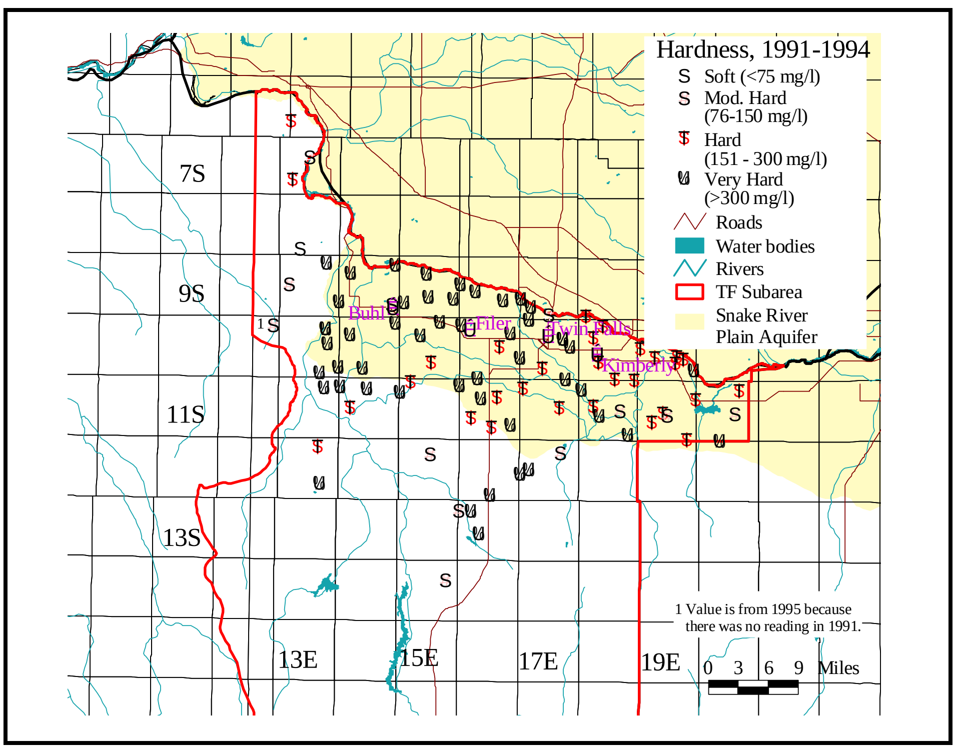

Figure 26. Hardness results for the Twin Falls subarea monitoring sites, 1991-1994.

4.4. Nutrients

4.4.1. Nitrate

Nitrate is an oxidized form of nitrogen that typically comes from inorganic fertilizers, decaying organic matter, waste water from commercial operations, animal manure, and human sewage (nitrate reference 2). Nitrate can cause a potentially-fatal blood condition known as methemoglobinemia in infants age six months and younger. Nitrate may: 1) cause miscarriages (Mortality and Morbidity Weekly Report, 1996), 2) be passed on to infants through the milk of nursing mothers, and 3) contribute to the risk of non-Hodgkin's lymphoma (Ward et al., 1996). The elderly who are infirmed also may be affected by high levels of nitrate.

In the First Round, dissolved[1] nitrate concentrations ($N0_2$+$N0_3$ as nitrogen) for the Twin Falls subarea ranged from less than the minimum laboratory reporting limit of 0.05 mg/L at three sites to 19.0 mg/L with the median value being 3.6 mg/L. The median nitrate value for the Twin Falls subarea was higher than the median values for the other 19 hydrogeologic subareas in the Statewide Program for the years 1991 through 1994.

From 1991 through 2000, seven of the 93 Twin Falls sites[2] (seven percent) had at least one sampling result with a nitrate concentration greater than 10 mg/L (Table 1). During this time period, 84 percent of the Twin Falls sites had at least one sampling event with a nitrate concentration equal to or greater than 2 mg/L, which is the concentration that is considered to be an indication that the ground water quality has been impacted by land-use activities (Crockett, 1995). Nitrate concentrations greater than 5 mg/L show where impacts have been more severe. In the Twin Falls subarea, clustering of sites with nitrate values greater that 5 mg/L occurred in some areas (Figure 27). The significance of elevated nitrate in ground water is not only related to health concerns, but also as an indicator that other potential contaminants from land surface activities may be getting into the ground water.

Table 1. Maximum nitrate results for 93 sites in the Twin Falls subarea for sampling events from 1991 through 2000.

Nitrate concentration ranges	# of sites with a maximum nitrate result in the concentration range	% of sites in the concentration range
< 2 mg/L	15	16
2-5 mg/L	39	42
5.01-10 mg/L	32	34
> 10 mg/L	7	8

[1]Nutrient and trace element samples are filtered through a 0.45 micron filter prior to analysis to remove solids.
[2]In 1998, site 09S 13E 02DBD1 replaced 09S 13E 02DBD2; both results are included in Table 1 and Figure 27.

A scatterplot of nitrate versus well depth for the Twin Falls monitoring sites shows a correlation between the two variables that is significant at the 95 percent confidence level (Figure 28). These results indicate that nitrate concentrations decrease with increasing well depths.

A positive correlation between nitrate and TDS was significant at the 95 percent confidence level (Figure 29). Rupert (1997) reported a similar relationship between nitrate and bicarbonate, specific conductance, alkalinity, calcium, magnesium, chloride, and sulfate in a study of ground water quality in the Upper Snake River Basin in Idaho and western Wyoming. Rupert (1997) suggested that these relationships indicate leaching of nitrate and salts from soils by excessive irrigation. The cause and nature of the TDS/nitrate relationship in the Twin Falls subarea are unknown.

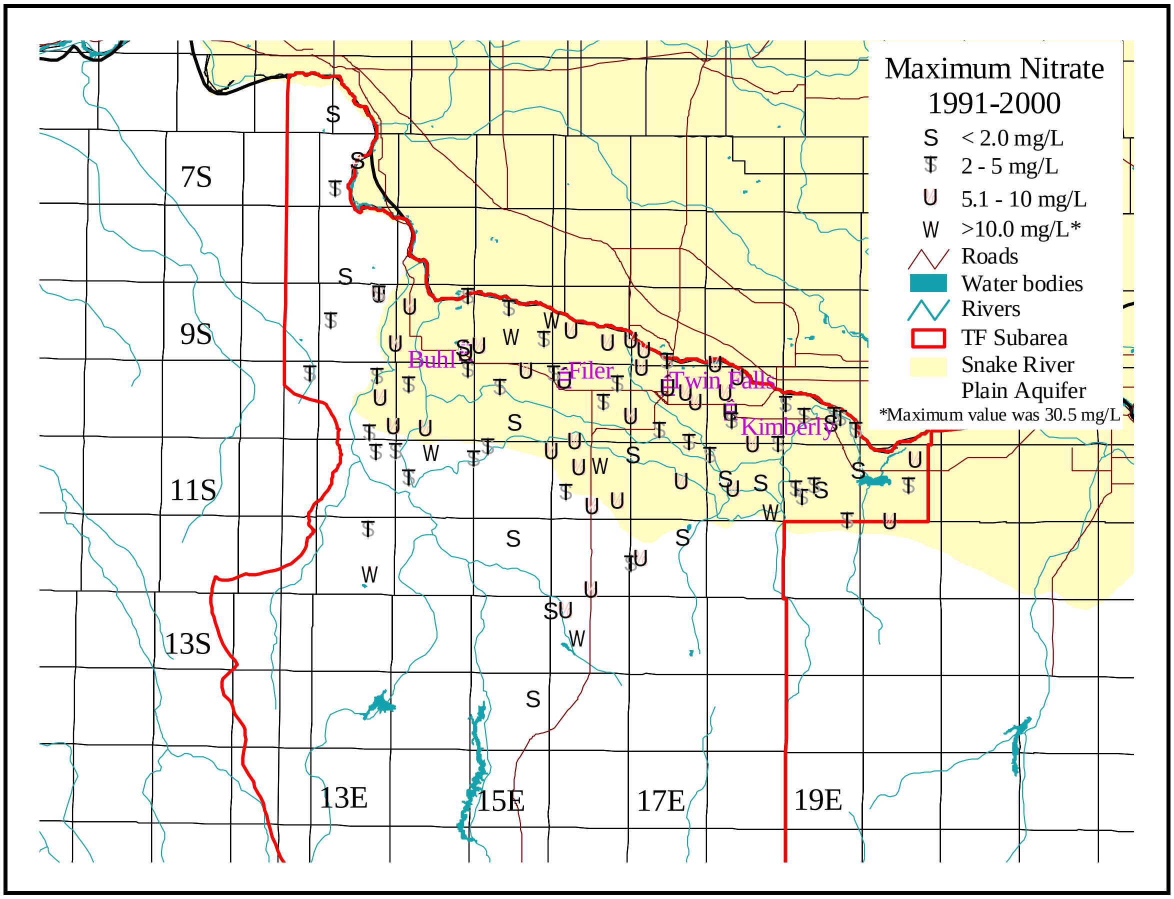

Figure 27. Maximum nitrate results for the Twin Falls subarea monitoring sites, 1991-2000.

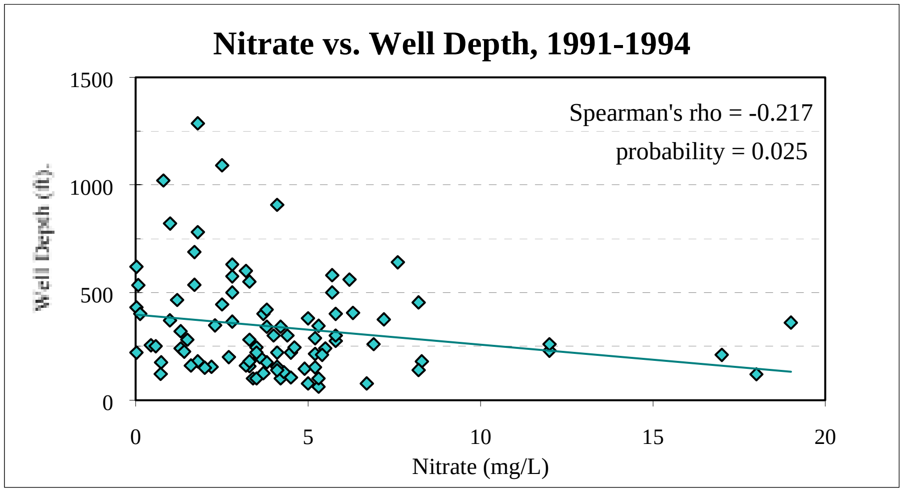

Figure 28. Scatterplot and Spearman's rho test results for nitrate versus well depth for Twin Falls subarea monitoring sites for 1991-1994.

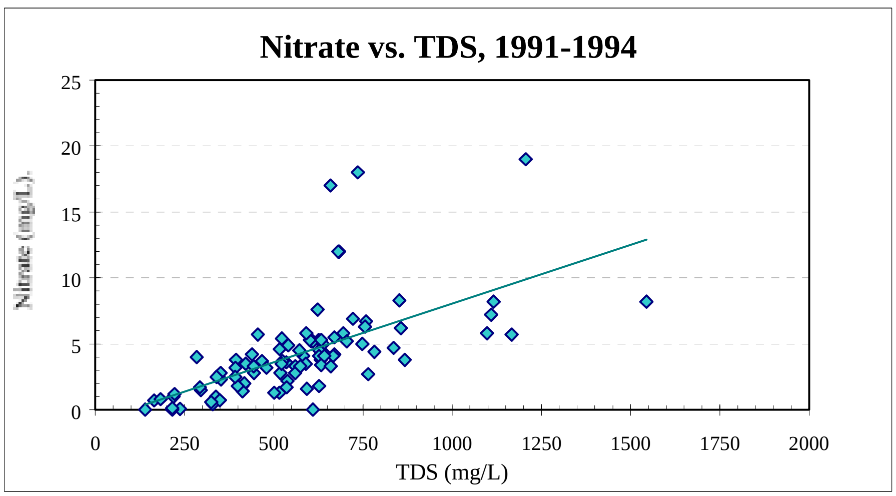

Figure 29. Scatterplot and Spearman's rho test results for nitrate versus TDS for the Twin Falls subarea monitoring sites for 1991-1994.

4.4.2. Nitrogen Isotopes

In 2000, some Statewide Program sites were sampled for the stable isotopes of nitrogen (^{14}N and ^{15}N) in nitrate. Sites with previous nitrate concentrations greater than 1 mg/L were selected for nitrogen isotope analyses. The nitrogen isotope value provided by the laboratory (reported as $\delta^{15}N$ with units of parts per thousands or permil ($^{0}/_{00}$)) is the difference between the ratio of ^{15}N to ^{14}N in a measured sample and the same ratio in a referenced standard.

In the Twin Falls subarea, 26 Statewide Program sites were analyzed for nitrogen isotopes in 2000. $\delta^{15}N$ ranged from –6.22 to 24.6 $^{0}/_{00}$.

Nitrogen isotope data can be useful for identifying the source of nitrogen in the water (Table 2) (Seiler, 1996). In some cases, a $\delta^{15}N$ value can be distinct with respect to the source (Rob Howarth, IDEQ, personal communication (rhowarth@deq.state.id.us)). For example, a low $\delta^{15}N$ value (0 or lower) is a strong indication of a commercial fertilizer source. Also, a very high

Table 2. Nitrogen sources with associated $\delta^{15}N$ values (Seiler, 1996).

Nitrogen Source	$\delta^{14}N$ Values ($^0/_{00}$)[1]
Precipitation[2]	-3
Commercial fertilizer	-4 to +4
Organic nitrogen in soil	+4 to +9
Human[2] or animal waste	+10

[1] $^0/_{00}$ = permil = parts per thousands.
[2]Precipitation and domestic septic systems were determined to be minor sources of total nitrogen input in the upper Snake River Basin (Rupert, 1996).

$\delta^{15}N$ value (>+10) is likely to be indicative of a human or animal waste source. However, interpreting the data can be complicated for at least two reasons. First, mixing of waters with nitrogen isotopes from different sources can occur. Second, $\delta^{15}N$ can be enriched (higher than the original values) if water conditions are anerobic and denitrification takes place (Rob Howarth, IDEQ, personal communication).

The nitrogen sources based on the nitrogen isotope data for the Twin Falls subarea for 2000 can be summarized as follows: commercial fertelizer - 8 sites; organic nitrogen in soil or a mixture of sources - 10 sites; and human or animal waste - 8 sites (Figure 30). However, mixing and/or denitrification may be impacting the $\delta^{15}N$ values in the mid (1-9) or upper (+10) ranges (Kendall, 1998). Additional nitrogen isotope data are needed to determine the relationships between $\delta^{15}N$ values, nitrate, land uses, nitrogen sources, and other variables.

4.4.3. Ammonia and Orthophosphorus

Dissolved ammonia concentrations for the Twin Falls subarea for 1991 through 1994 ranged from less than the detection limit of 0.01 mg/L at 32 sites to 0.49 mg/L with the median value being 0.01 mg/L.

Dissolved orthophosphorus concentrations for 1991 through 1994 ranged from less than the detection limit of 0.01 mg/L at 28 sites to 0.14 mg/L with the median value being 0.02 mg/L. The higher values could be indicative of fertilizer sources.

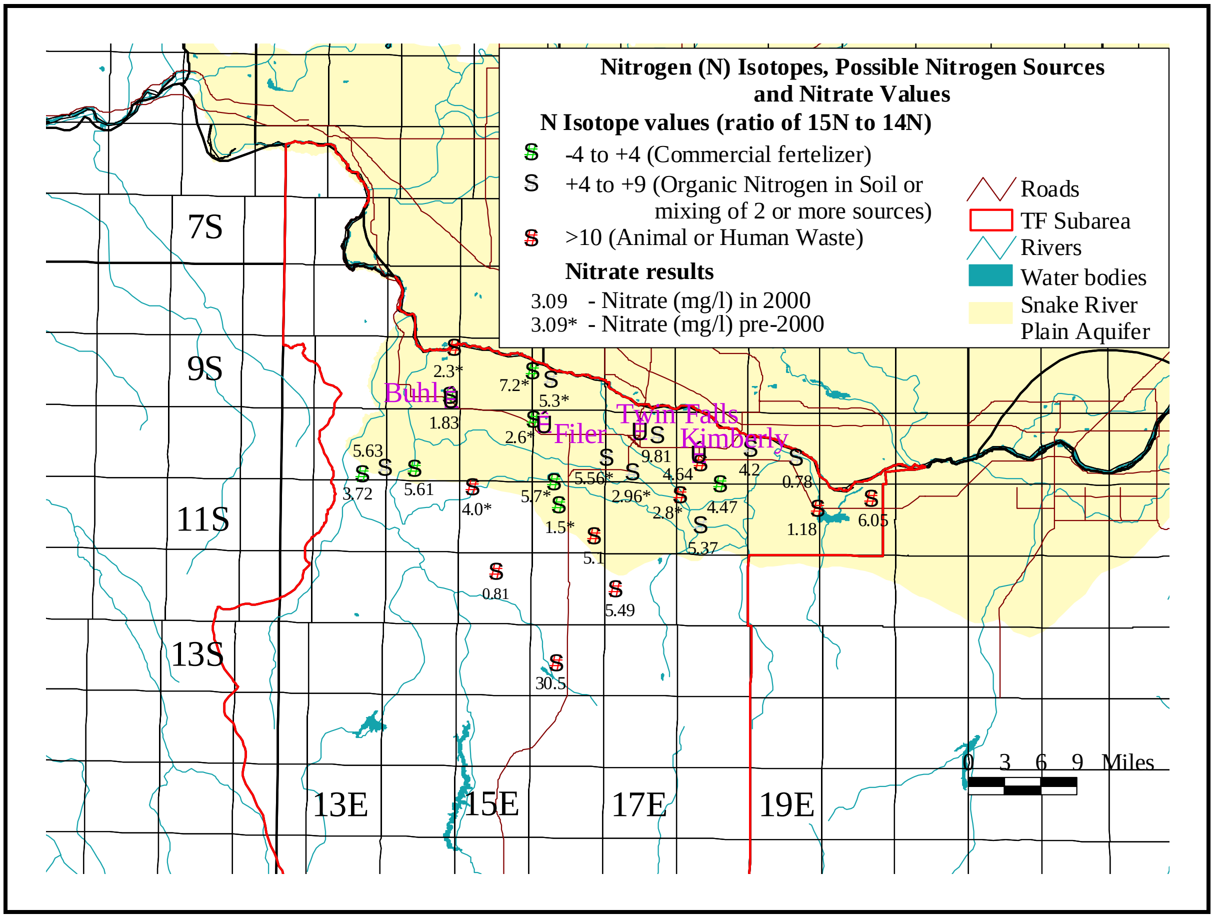

Figure 30. Nitrogen isotope results (reported as $\delta^{15}N$) for the Twin Falls subarea monitoring sites tested in 2000. Possible nitrogen sources, and nitrate data from 2000 or from an earlier sampling event are also presented.

4.5. Trace Elements

Arsenic, iron, selenium, and zinc are the trace elements discussed for the Twin Falls subarea. Cadmium, chromium, copper, cyanide, lead, and manganese are other trace elements that were analyzed but are not discussed in this report because the results contained high percentages of non-detections. Uranium, although a heavy metal, is included in the Radioactivity section (4.6.3) because it is an alpha particle emitter.

4.5.1. Arsenic

Arsenic is a trace element that occurs commonly in Idaho's ground water probably as the result of natural conditions. Dissolved arsenic concentrations for the Twin Falls subarea ranged from 1 to 33 micrograms per Liter[1] (µg/L) with the median being 9.5 µg/L. The primary MCL for arsenic in water is 50 µg/L.

[1]one microgram per Liter is equivalent to one part per billion.

In January, 2001, the EPA proposed to lower the MCL for arsenic to 10 µg/L. However, in March, 2001, the EPA recommended that the new proposal be withdrawn until further studies were completed. Arsenic concentrations greater that 10 µg/L occurred throughout the subarea with the exception of eastern area (Figure 31).

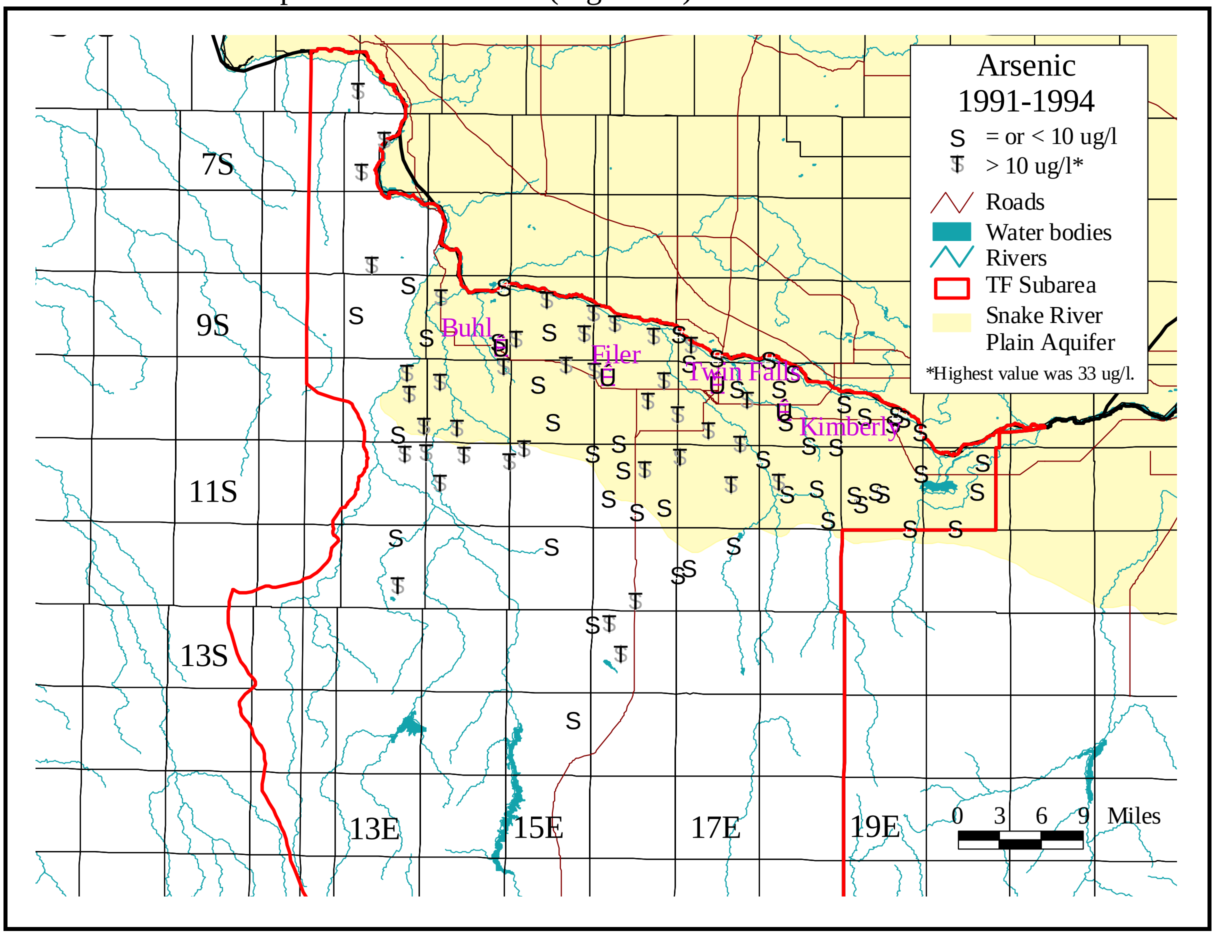

Figure 31. Arsenic results for the Twin Falls subarea monitoring sites, 1991-1994.

4.5.2. Iron

Dissolved iron in ground water is typically the result of natural sources. All of the Twin Falls subarea sites had dissolved iron concentrations less than 70 µg/L, which is well below the secondary MCL of 300 µg/L. Fifty-five of the 93 sites (60 percent) had iron concentrations below the minimum laboratory reporting limit of 3.0 µg/L.

4.5.3. Selenium

Selenium can occur in ground water naturally and usually in low concentrations. The maximum dissolved selenium concentration for the Twin Falls subarea was 7µg/L. The primary MCL for selenium is 50 µg/L.

4.5.4. Zinc

Dissolved zinc can occur in water naturally, can leach from pipes, or can originate from paints and dyes. The secondary MCL for zinc is 5,000 µg/L. A majority of Twin Falls sites had dissolved zinc concentrations greater than the minimum laboratory reporting limit of 3 µg/L. The maximum zinc concentration was 730 µg/L with the median being 52 µg/L. Areas of lower zinc concentrations occurred near Twin Falls and to the west and southwest of Buhl.

4.6. Radioactivity

Radioactivity testing included total gross alpha, total gross beta, radon, uranium, and radium-226. Total gross alpha and total gross beta samples were collected at all 93 sites. Radon samples were collected at only 59 of the 93 sites (63 percent) because the radon samples had to be processed within 24 hours of collection and overnight shipping was not feasible for some of the sites. Uranium and radium-226 activities were analyzed at 16 of the Twin Falls sites.

In this report, radioactivity results for total gross alpha, total gross beta, and radon are present in terms of activity levels (i.e., picoCuries per Liter[1] (pCi/L)) since human health risks for these constituents are based on activity levels. Uranium results are presented in micrograms per liter since the proposed MCL is in this form. Radium-226 results are not included in this report, but are available on request.

4.6.1. Adjusted Gross Alpha

The primary MCL for alpha radiation is complicated. An MCL violation occurs when 1) the *adjusted gross alpha* activity (total gross alpha activity minus the alpha activities in the sample from uranium and radon) exceeds 15 pCi/L, or 2) the combined radium-226 and radium-228 activities exceed 5 pCi/L. Public water suppliers must test for radium-226 if the total gross alpha activity exceeds 5 pCi/L. If the radium-226 activity is greater than 3 pCi/L, they must test for radium-228 to see if the combined activities exceed 5 pCi/L. Adjusted gross alpha activities can be determined either by 1) speciating each sample for uranium and substracting the uranium result from the total gross alpha activity, or 2) multiplying the total gross alpha activity by 0.67 (Jerri Henry, IDEQ, personal communication). In the Twin Falls subarea, 16 sites were speciated for uranium-238 and radium-226. An adjusted gross alpha activity for each of these 16 sites was calculated by subtracting the uranium result from the total gross alpha activity. Using the uranium data from the 16 sites, an average adjustment factor of 0.69 was calculated. An estimated adjusted gross alpha activity for each of the 76 sites that did not have uranium speciation data was calculated by multiplying the total gross alpha activity by 0.69.

Adjusted gross alpha concentrations ranged from –3.9 to 33.4 pCi/L with the median being 2.7 pCi/l. Five of the 93 sites (five percent) had adjusted gross alpha values that exceeded the MCL of 15 pCi/L. Clustering of sites with gross alpha concentrations greater than 7.5 pCi/L (½ of the primary MCL) occurred in some parts of the subarea (Figure 32). It is

[1]Picocurie (pCi) is the quantity of radioactive material producing 2.22 nuclear transformations per minute.

assumed that gross alpha activities in the ground water in the Twin Falls subarea are related to natural conditions.

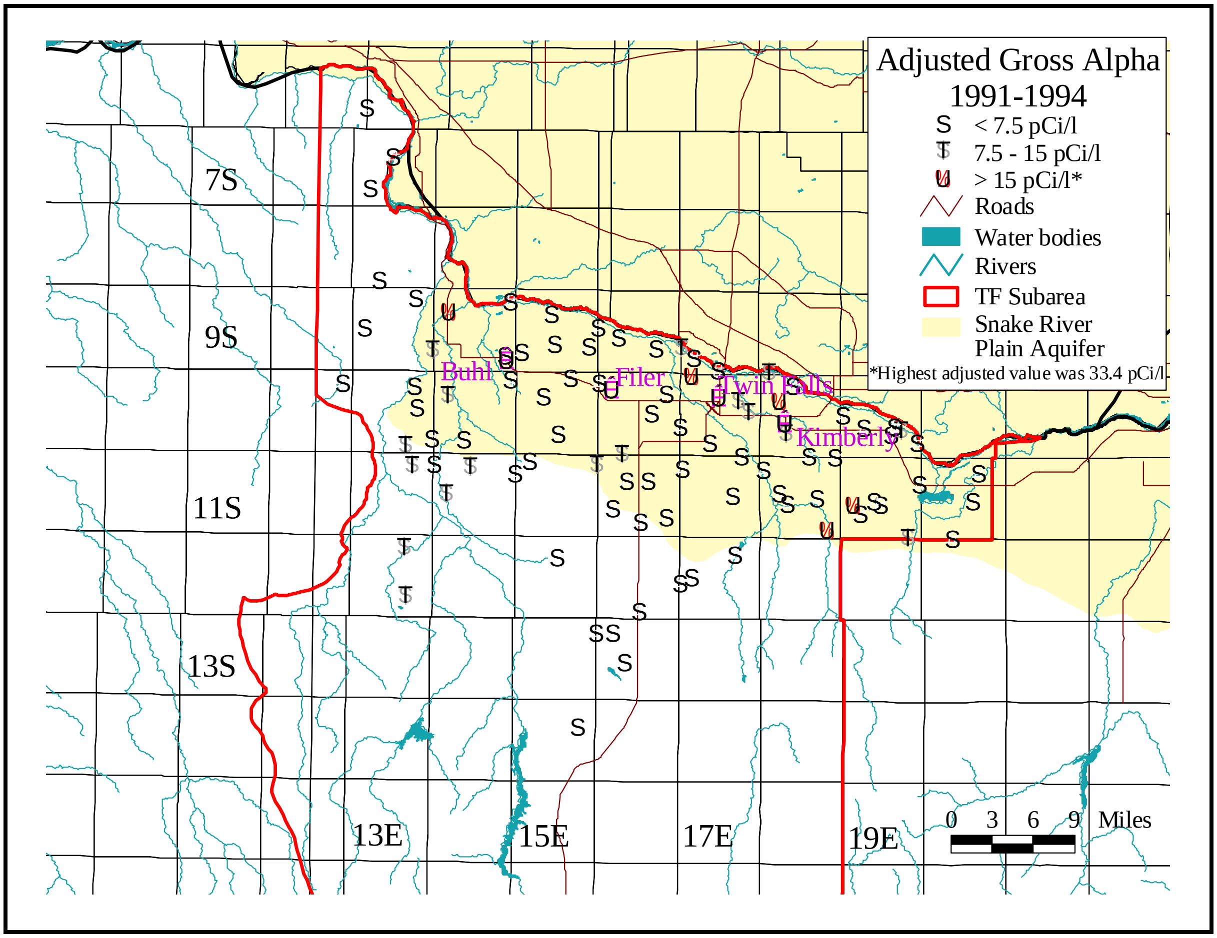

Figure 32. Adjusted gross alpha radioactivity results for the Twin Falls subarea monitoring sites, 1991-1994.

4.6.2. Total Gross Beta

The primary MCL for gross beta activities is described as follows: "The average annual concentration of beta particle and photon radioactivity from man-made radionuclides in drinking water shall not produce an annual dose equivalent to the total body or any internal organ greater than 4 millirem/year.". A public water system is considered to be in compliance if gross beta activity does not exceed 50 pCi/L, and if the concentrations of tritium or strontium-90 do not exceed 20,000 pCi/L and 8 pCi/L, respectively.

Gross beta concentrations ranged from –0.1 to 25.4 pCi/L. The median gross beta concentration for the Twin Falls subarea was 8.3 pCi/L. Concentrations greater than 12.5 pCi/L (¼ of the primary MCL) occurred in clusters in some parts of the subarea (Figure 33). It is assumed that the gross beta activities in the ground water in the Twin Falls subarea are related to natural conditions.

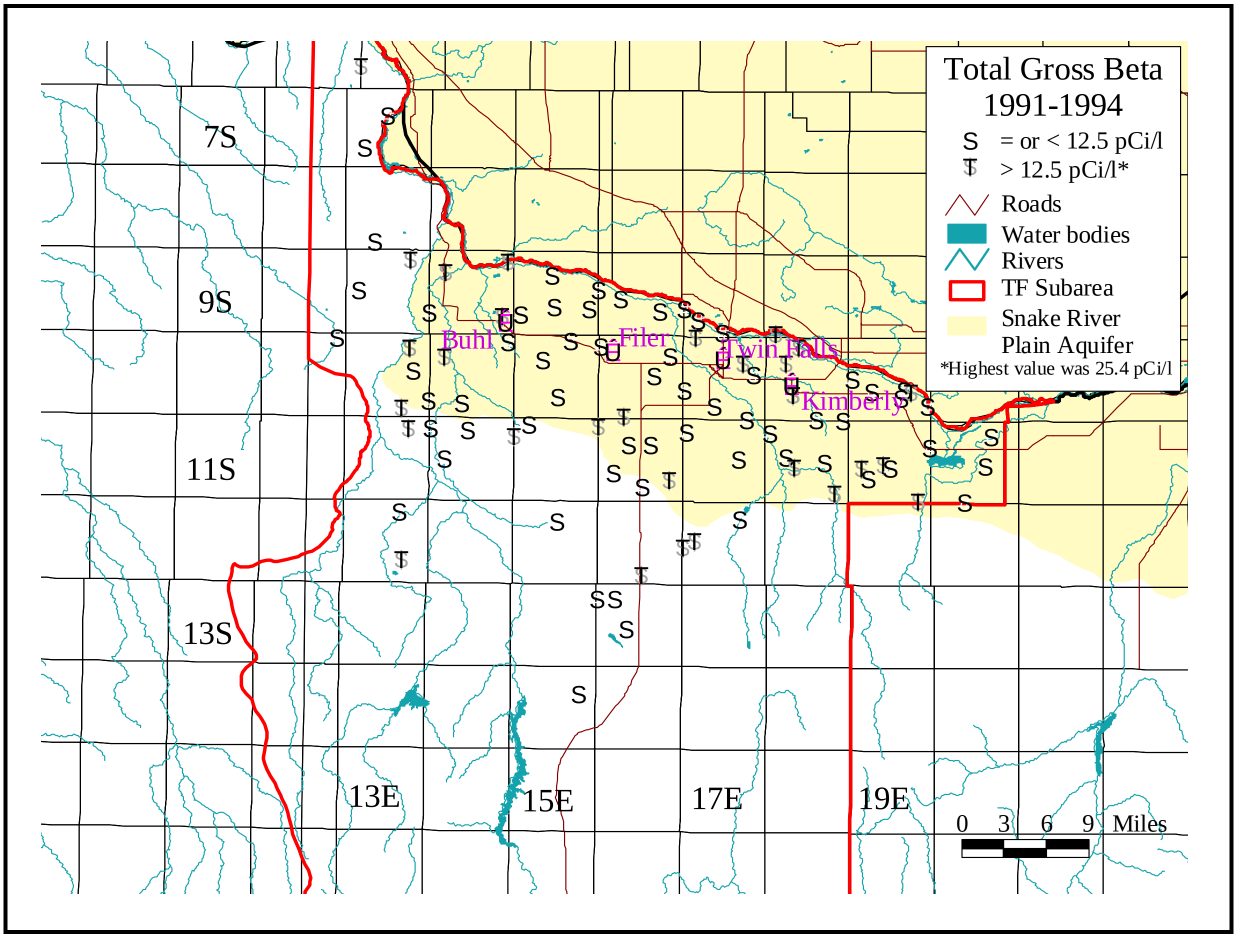

Figure 33. Gross beta results for the Twin Falls subarea monitoring sites, 1991-1994.

4.6.3. Uranium

Total uranium (uranium-238) was the primary alpha emitter in the 16 samples that were selected for speciation because they had the higher gross alpha concentrations in the subarea.the proposed primary MCL of 30 ug/L (Figure 34). The proposed primary MCL for uranium is currently under review by the EPA.

4.6.4. Radon

Radon is a tasteless, odorless, and colorless gas that originates from the radioactive breakdown of uranium in rock, soil, or water. Breathing radon can cause lung cancer. Drinking water with radon may cause stomach and other internal cancers; however, the risk of health problems is lower for drinking water with radon than for breathing radon.

Radon concentrations for the 59 sites tested for radon ranged from less than the minimum laboratory reporting limit of 80 pCi/L to 2,200 pCi/L with the median being 302 pCi/L. Thirty of the 59 sites tested for radon (51 percent) had concentrations greater than 300 pCi/L,

which is the primary MCL for Option 2 under the proposed radon standard[1]. Clustering of sites with radon concentrations greater than 300 pCi/L occurred in the some places (Figure 35).

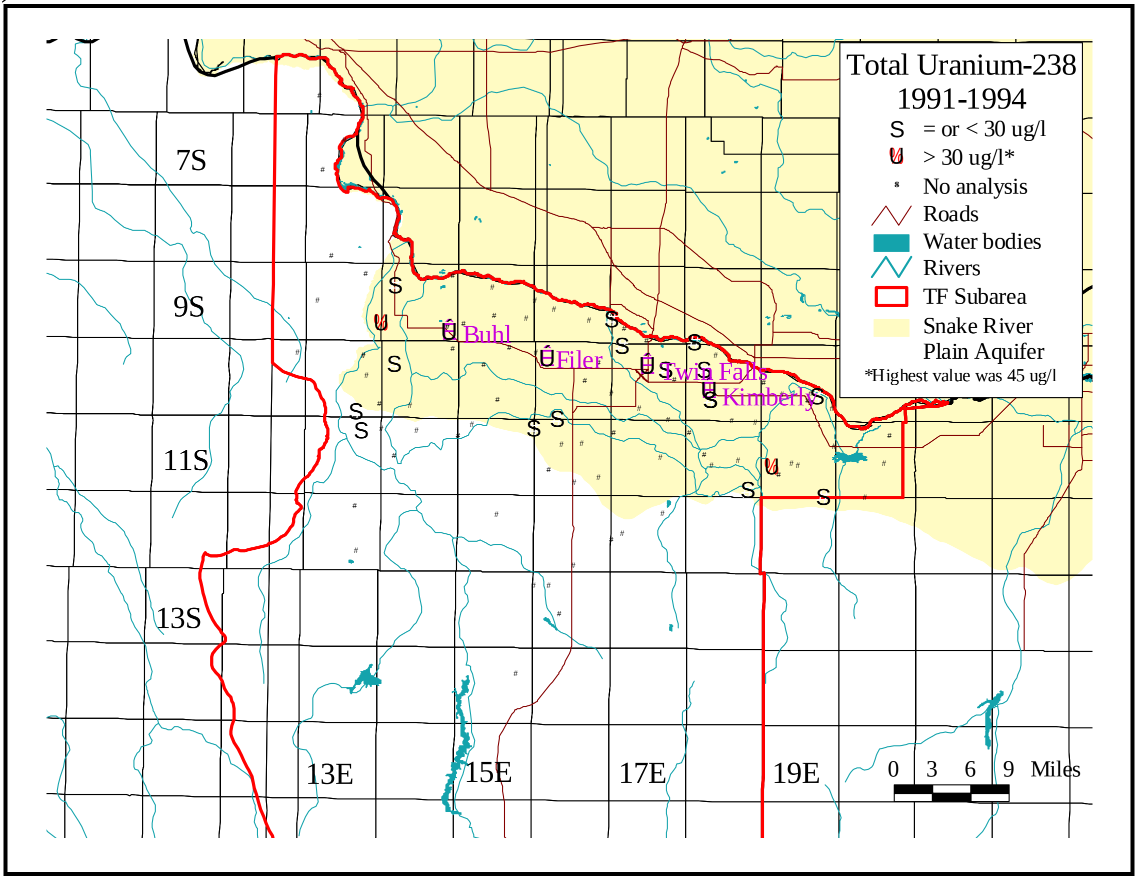

Figure 34. Total uranium results for the Twin Falls subarea monitoring sites, 1991-1994.

[1] The proposed EPA standard for radon in public drinking water supplies allows for two options with different MCLs for ground water. Option 1 is focused on multimedia mitigation which allows public water suppliers to develop programs that will reduce airborne radon. For public water suppliers who select this option, the primary MCL for radon is proposed to be 4,000 pCi/L. Option 2 is for systems that do not choose to develop a multimedia mitigation approach. The primary MCL for option 2 is proposed to be 300 pCi/L.

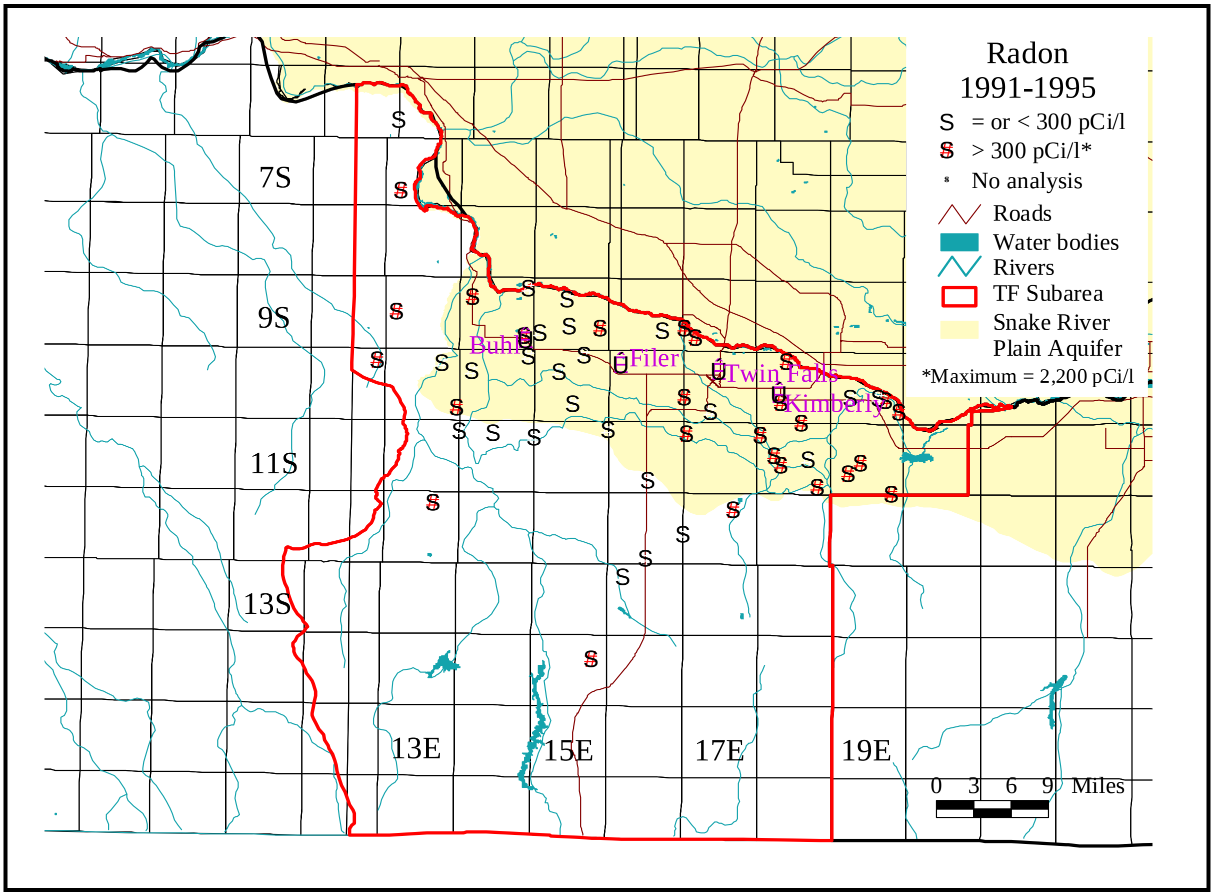

Figure 35. Radon results for the Twin Falls subarea monitoring sites, 1991-1995.

4.7. Volatile Organic Compounds

Volatile organic compounds (VOCs) are synthetic chemicals that can be toxic to humans, animals, and plants. The presence of VOCs in ground water indicates that human activities have impacted the water quality since VOCs do not occur naturally.

Ground water samples were analyzed for a wide spectrum of VOCs using EPA methods 502.2 and 524.2. Ground water at six of the 93 sites (six percent) had one or more detections of VOCs. One site had a detection of 1,1,1,-Trichloroethane (Figure 36). Three sites had detections of trihalomethanes (THMs) which are often byproducts of chlorination. Two sites had freon detections. None of the VOC detections exceeded established MCLs.

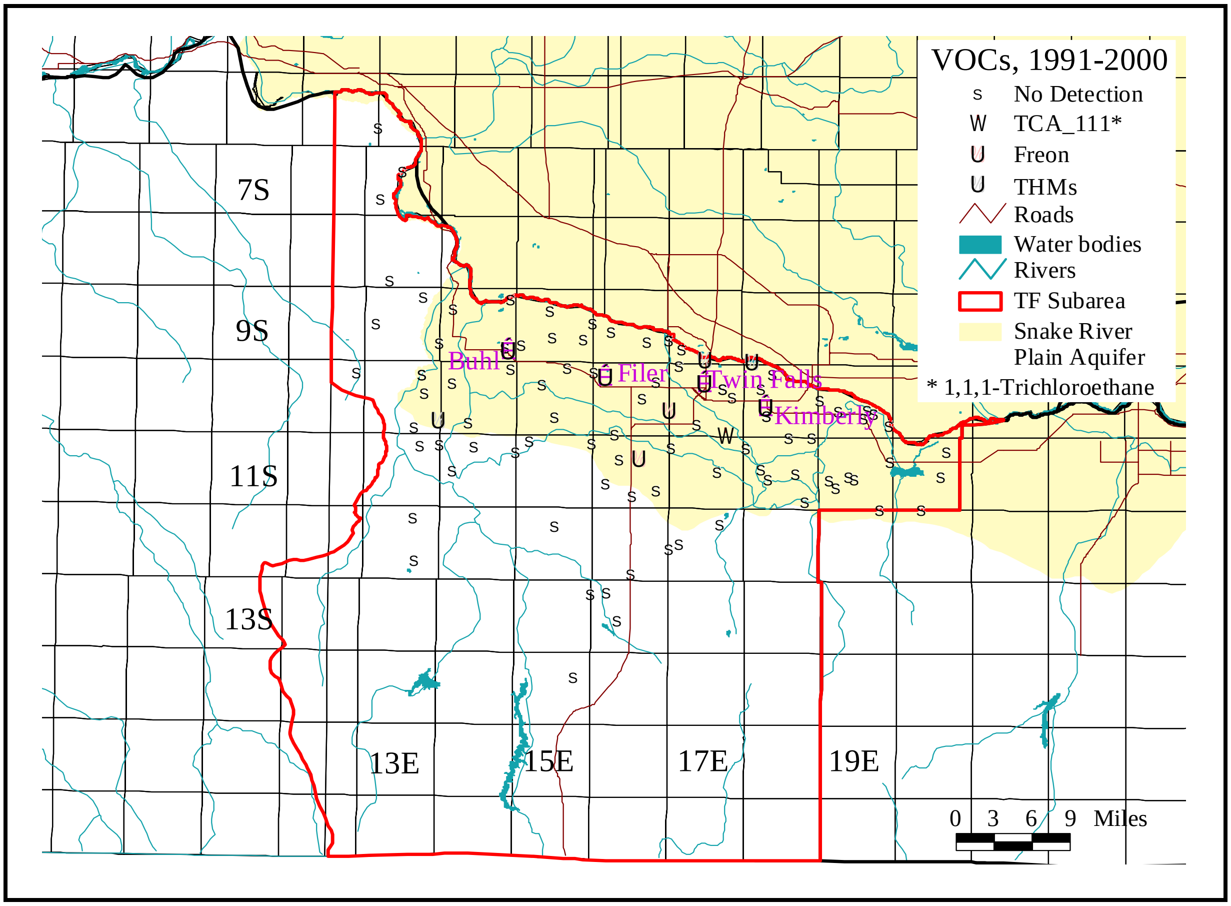

Figure 36. VOC results for the Twin Falls subarea monitoring sites, 1991-2000.

4.8. Pesticides

A pesticide is any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating pests. Pesticide is a general term which includes such things as insecticides, herbicides, fungicides, rodenticides, fumigants, disinfectants, and plant growth regulators.

Three methods were used to test for pesticides in ground water samples: VOC analyses, immunoassay technology, and gas chromatography (GC). There were no pesticides detected through VOC analyses. Immunoassay tests were performed on all 93 Twin Falls subarea sites. GC pesticide analyses were done on 60 of the 93 sites (65 percent).

Immunassays (enzyme-linked immunosorbent assays or ELISA) are enzyme-specific tests developed originally for the medical field and also now being used for environmental monitoring (Vanderlaan et al., 1988). Immunoassay tests were selected for use in the Statewide Program because they are inexpensive, relatively easy to perform, unlikely to produce false negatives and have minimum laboratory reporting limits as low as, or lower than, some GC analyses. Each test is designed for a specific pesticide family. For example,

the atrazine test will detect atrazine as well as some other members in the triazine family. This results in a limitation of immunoassay analyses in that results are not analyte-specific for individual compounds within each family tested because of the cross-reactivity attributes of the method.

Immunoassay tests have been used in the Statewide Program since its inception. Data from 1992 through 2000 are presented in this report (data from 1991 were not used because of laboratory quality control problems). The number of individual tests performed on each ground water sample ranged from four to ten from 1992 through 2000 depending on available funding and on recommendations from the Idaho State Department of Agriculture.

Immunoassay results for the Twin Falls subarea indicated that 32 of the 93 sites (34 percent) had at least one confirmed detection of a pesticide compound. Atrazine and alachlor were the two most commonly detected pesticides (Table 3); the USGS has reported the detections of these and other pesticides in other ground waters (pesticide reference 1)(pesticide reference 2)(pesticide reference 3). None of the detections exceeded any existing or proposed MCLs, or any Health Advisory levels. Immunoassay detections were more common in areas west and southwest of Buhl than in other parts of the subarea (Figure 37).

Table 3. Pesticide detections from immunoassay testing for the Twin Falls subarea, 1992-2000.

Type of pesticide detected	# and % of sites with pesticide detected	Concentration range of detections	Primary Drinking Water Standard
Atrazine	12 (13%)	0.05 – 0.25 µg/L	3 µg/L
Alachlor	12 (13%)	0.05 – 0.63 µg/L	2 µg/L
Carbofuran	10 (11%)	0.07 – 0.27 µg/L	40 µg/L
Metolachlor	6 (6%)	0.06 – 0.38 µg/L	
Aldicarb	2 (2%)	0.50 – 0.73 µg/L	3 µg/L
Chlorpyrifos	2 (2%)	0.12 – 0.23 µg/L	
Simazine	2 (2%)	0.03 – 0.10 µg/L	4 ug/L
Acetochlor	1 (1%)	0.16 µg/L	

[1]The sum of the # of sites with detections in this column exceeds the # of sites with detections (32) because six sites had more than one pesticide detection.

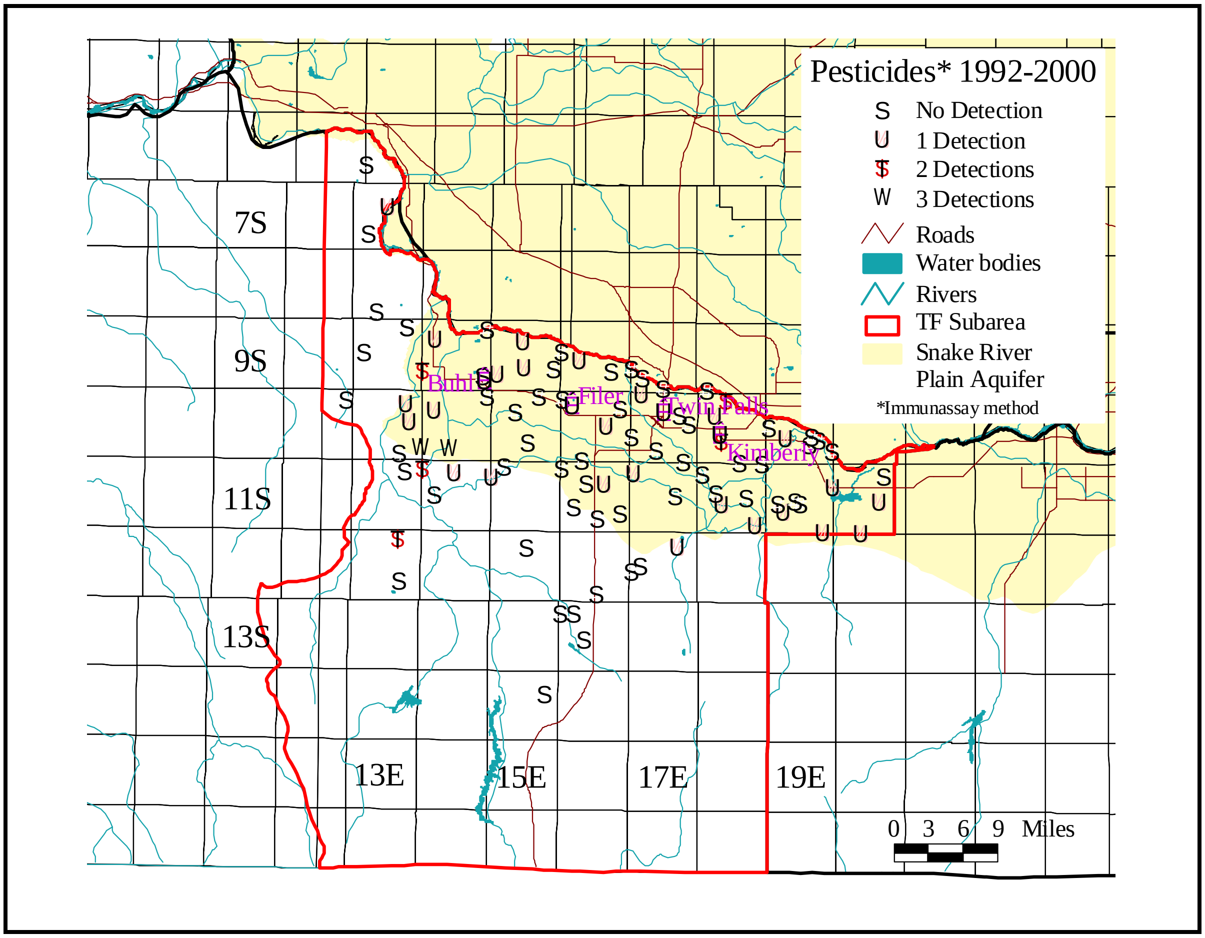

Figure 37. Pesticide results from immunoassay testing for the Twin Falls subarea monitoring sites, 1992-2000.

Gas chromatography (GC) analyses were conducted on shallow wells (generally less than 300 feet deep) in the Twin Falls subarea in 1993 through 1996, and in 1999 (the number of samples was limited by the high laboratory costs associated with GC tests). Sixty-one of the 93 Twin Falls subarea sites were tested for pesticides using GC methods. Thirty-seven of the 61 sites had at least one detection of a pesticide above the minimun laboratory reporting limit[1]. Atrazine and deethylatrazine (a degradation product of atrazine) were the most common pesticides detected by GC; eight other pesticides were detected in the samples (Table 4). None of the GC pesticide results exceeded any established MCLs, Health Advisories or Reference Doses.

In 1993, 18 sites were tested for 25 compounds using EPA Methods 507, 508, 515.1, 531.1 and 8141; the minimum laboratory reporting limits for these methods is in the parts per billion range. Dacthal (DCPA) was found in one sample (Table 5).

[1]The laboratory method used in 1993 had higher minimum reporting limits than the method used in 1994, 1995, 1996, and 1999. See discussion in following paragraphs.

Table 4. Types of pesticides detected using gas chromatography methods for the Twin Falls subarea, 1993-1996 and 1999.

Type of pesticide detected	# and % of sites with pesticide detected[1]	Concentration range of detections	Primary Drinking Water Standard[a], Health Advisory[b], of Reference Dose[c]
Deethyl Atrazine	34 (56%)	0.001 – 0.096 µg/L	
Atrazine	30 (49%)	0.002 – 0.18 µg/L	3 µg/L[a]
Simazine	10 (16%)	0.002 – 0.013 µg/L	4 µg/L[a]
Dacthal	2 (3%)	0.001 – 0.32 µg/L	100 µg/L[c]
Diazanon	2 (3%)	0.004 – 0.007 µg/L	0.6 µg/L[b]
Alachlor	1 (2%)	0.002 µg/L	2 µg/L[a]
Carbaryl	1 (2%)	0.003 µg/L	700 µg/L[b]
EPTC	1 (2%)	0.009 µg/L	
Metribuzin	1 (2%)	0.005 µg/L	200 µg/L[b]
P,P'DDE	1 (2%)	0.001 µg/L	

[1]The sum of the # of sites with detections in this column exceeds the # of sites with detections (38) because some sites had more than one pesticide detection.

Samples collected at 47 Twin Falls subarea sites[2] in 1994, 1995, 1996, and 1999 were analyzed for 46 compounds using USGS method 2001 which is a solid-phase extraction method that has minimum laboratory reporting limits in the one or more parts per trillion range, depending on the analyte. One or more pesticides were detected at 36 of the 47 sites (77 percent) (Table 5). A high percentage of sites with GC detections occurred in the western and north-central parts of the subarea (Figure 38).

4.9. Bacteria

Ground water samples were tested for fecal coliform bacteria primarily as a courtesy to the site owner. Samples were filtered, incubated, and analyzed in the field. Fecal coliform bacteria originate from the waste products of humans and warm-blooded animals. The presence of one or more fecal coliform bacteria colonies in the ground water indicates that the MCL has been exceeded and that the ground water quality has been impacted by surface or near-surface activities. From 1991 through 2000, four of the 93 Twin Falls sites (four percent) had a detection of fecal coliform bacteria (Figure 39).

[2]Three sites that were sampled in 1993 where re-sampled. One site was sampled in both 1996 and 1999.

Table 5. Types of pesticide detections using gas chromatograpy methods by year for the Twin Falls subarea.

Year	# of GC analyses	# of detections (% of detections)	Compound(s) detected
1993[1]	18	1 (6%)	Dacthal
1994[2]	7	4 (57%)	Atrazine Alachlor Deethylatrazine
1995[2]	23	17 (74%)	Atrazine Deethylatrazine Diazinon EPTC Simazine
1996[2]	15	13 (87%)	Atrazine Carbaryl Deethylatrazine Metribuzin Simazine
1999[3]	3	3 (100%)	Atrazine Dacthal Deethylatrazine P,P'DDE Simazine

[1]EPA Methods 507, 508, 515.1, 531.1 and 8141 (parts per billion laboratory detection range)
[2]USGS Method 2001 (parts per trillion laboratory detection range)
[3]USGS Method 2001 (parts per trillion laboratory detection range); two of the three sites sampled in 1999 had been sampled for GC pesticides in previous years.

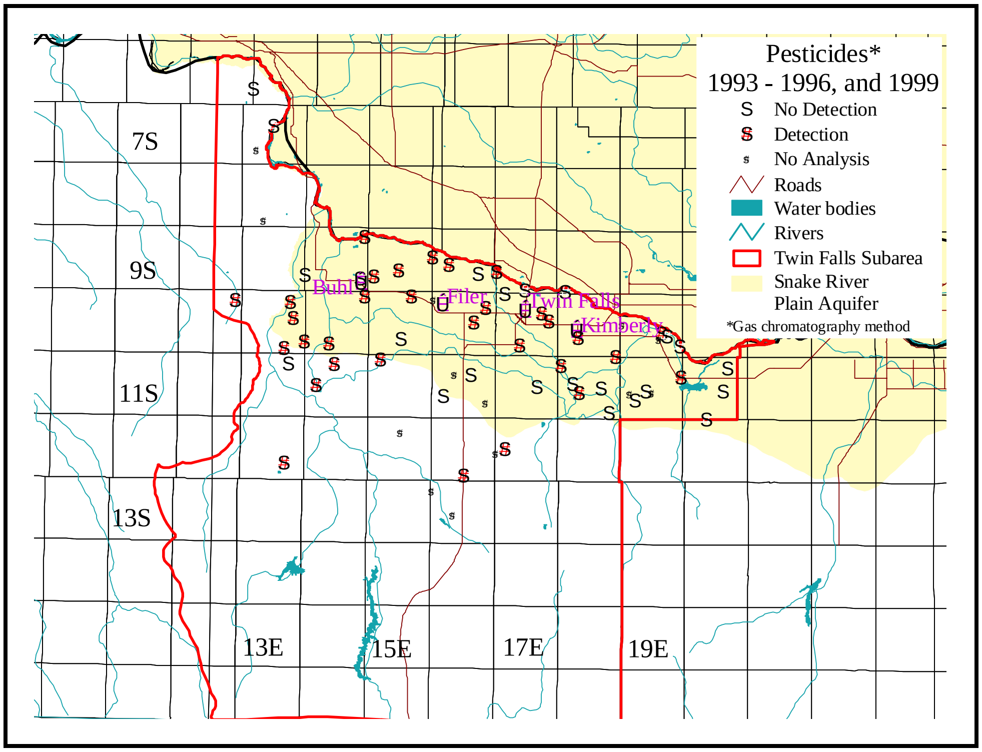

Figure 38. Pesticide results from gas chromatography testing for the Twin Falls subarea monitoring sites, 1993-1996.

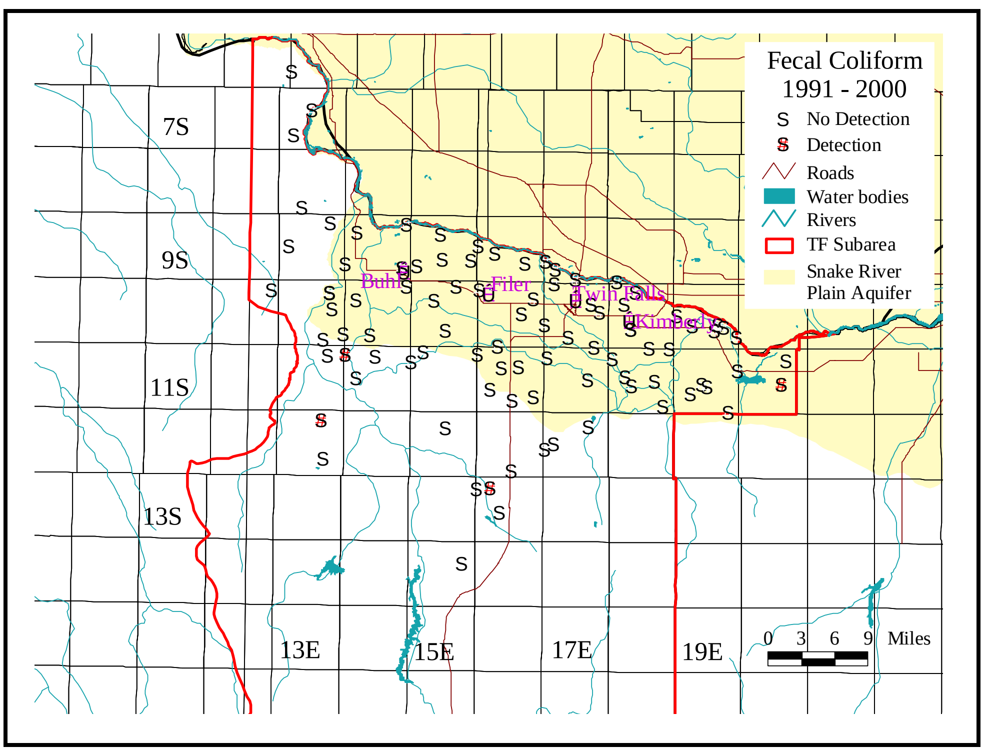

Figure 39. Fecal coliform bacteria results for the Twin Falls subarea monitoring sites, 1991-2000.

4.10. Selected Constituents with Secondary MCLs

The following constituents that were analyzed through the Statewide Program have secondary MCLs as established by the EPA: chloride, copper, fluoride[1], iron, manganese, pH, sulfate, total dissolved solids (TDS), and zinc. Secondary MCLs may affect the color, odor, or taste of the water, or may cause skin or teeth discoloration. Chloride, copper, fluoride, manganese, and sulfate are discussed in this section; iron, pH, TDS, and zinc were discussed in previous sections..

Excluding TDS, nine of the 93 sites (10 percent) had one or more constituents that exceeded a secondary MCL (Figure 40). Sixty-five percent of the sites had TDS concentrations that exceeded the secondary MC0 of 500 mg/L (Section 4.3.3 and Figure 25).

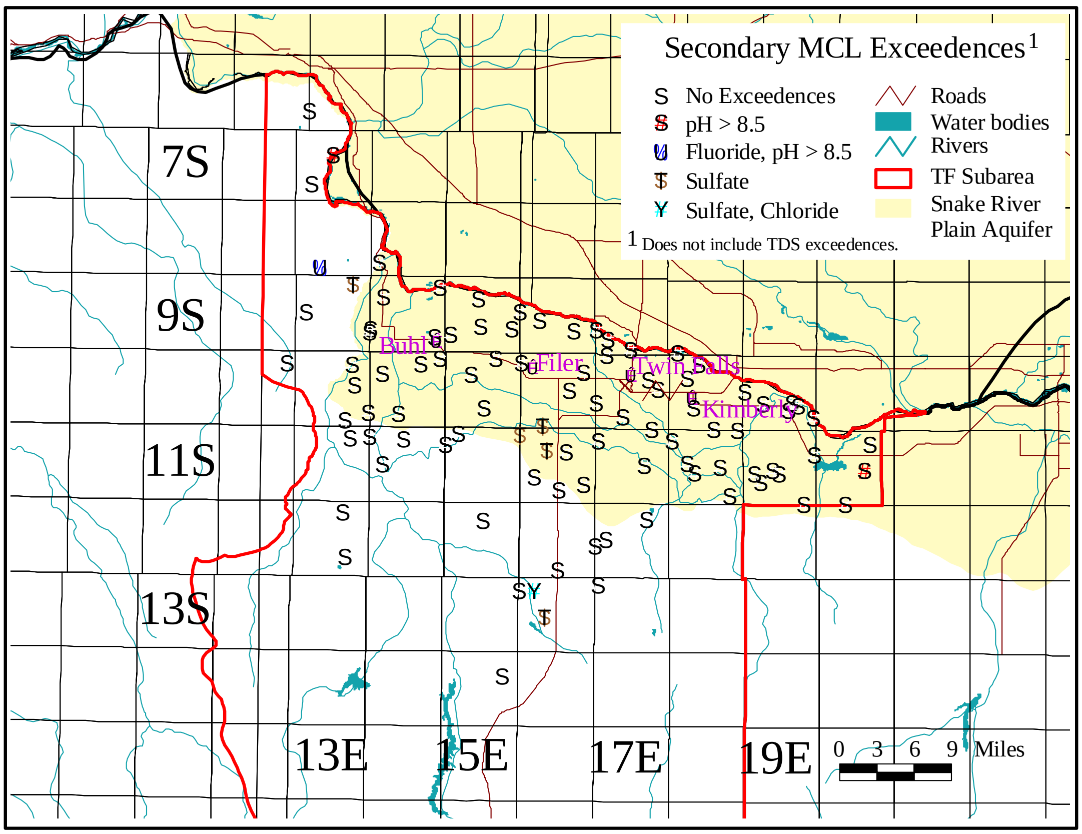

Figure 40. Statewide Program sites in the Twin Falls subarea where one or more constituents exceed the secondary MCL. This map does not show the sites where TDS exceeds the secondary MCL of 500 mg/L (see Figure 26).

[1]Fluoride also has a primary MCL of 4 mg/L.

4.10.1. Chloride

High levels of chloride in water can cause undesirable taste and can increase corrosiveness. The secondary MCL for chloride is 250 mg/L. Chloride concentrations ranged from 7.2 to 410 mg/L with one site exceeding the secondary MCL (Figure 40).

4.10.2. Copper

High concentrations of copper in water can cause gastrointestinal distress (short term exposure) and kidney or liver damage (long term exposure). Copper has a primary MCL of 1,300 µg/L and a secondary MCL of 1,000 µg/L. Copper concentrations for the 93 Twin Falls sites ranged from less than the minimum laboratory reporting limit of 1 µg/L to 93 µg/L.

4.10.3. Fluoride

Excessive fluoride intake may cause mottled (discolored) teeth and weakened enamel in the teeth of children. In adults, long-term intake of excessive fluoride may cause bone disease. Fluoride has a primary MCL of 4 mg/L and a secondary MCL of 2 mg/L.

Fluoride concentrations for the 93 Twin Falls sites ranged from less than the minimum laboratory reporting limit of 0.1 mg/l to 3 mg/L with the median value being 0.7 mg/l. Only one site had a fluoride concentration that exceeded 2 mg/L (Figure 40). The water temperature associated with this well was 22.5° C, the pH was 8.96, the hardness was 3 mg/l, and the well is 534 feet deep. The fluoride, pH and hardness values may indicate that the water sample is a mixture of non-thermal and geothermal waters (geothermal water is often high in fluoride).

4.10.4. Manganese

Manganese can produce undesirable staining and bacterial problems when the concentration exceeds the secondary MCL of 50 µg/l (manganese reference 2)(manganese reference 3). Manganese concentrations for the 93 Twin Falls sites ranged from less than the minimum laboratory reporting limit of 1 µg/l to 49 µg/l.

4.10.5. Sulfate

Sulfate can occur naturally in drinking water and high concentrations may cause diarrhea. The secondary MCL for sulfate in water is 250 mg/L. Sulfate is one of the constituents that EPA is considering for regulation. Six sites in the Twin Falls subarea had sulfate concentrations that exceeded the secondary MCL of 250 mg/L (Figure 40). Three of the sites are clustered together in an area about 6 miles south of Filer. The southern site in this cluster had a concentration of 460 mg/L. Two sites with high sulfate occurred near each other in the south-central part of the subarea about 15 miles south of the previously described cluster. One of these sites has a sulfate concentration of 510 mg/L.

4.11. Characterization Summary

Ground water in the Twin Falls subarea is withdrawn from aquifers in the Idavada Volcanics, Banbury Basalt, Glenns Ferry Formation, and Snake River Group. The Twin Falls subarea

has several areas where geothermal water is produced. Therefore, it is quite likely that the ground water chemistry in some parts of the subarea is affected by the geothermal conditions.

Hardness and TD S concentrations are very high throughout the subarea. The high mineralization is probably the result of the types of host rocks and the influences from geothermal waters. However, infiltration of surface water may be influencing the water quality in the aquifers.

From 1991 through 2000, 15 of the 93 sites (16 percent) had one or more constituents with a concentration greater than an existing primary MCL. Adjusted gross alpha, fecal coliform bacteria, and nitrate were the constituents that exceeded a primary MCL. Secondary MCLs were exceeded at some sites for chloride, fluoride, pH, TDS, and sulfate.

The occurrences of nitrate, fecal coliform bacteria, pesticides, and VOCs in the ground water indicate that impacts from land uses have occurred. The median nitrate concentration, which was 3.6 mg/L for the sites sampled in 1991 through 1994, was the highest nitrate median of the 20 subareas in the Statewide Program. The occurrence of some constituents, such as chloride, gross alpha, pH, sulfate, and TDS are probably related to natural conditions.

5. TREND MONITORING

5.1. Program Approach

The trend monitoring objective of the Statewide Program is being accomplished in two ways. First, about 1,200 monitoring sites called **Rotational** sites are currently being sampled once every five years[1]. This approach will allow for wide areal coverage at a sampling frequency that is considered adequate for determining long-term changes in overall ground water quality. Second, about 100 sites called **Annual** sites are being sampled once every year to provide data for short-term trend analyses. The collection frequency at Annual sites may be useful for determining whether concentration changes are associated with long-term trends or are being affected by unique events or conditions such as precipitation extremes or patterns.

The network of monitoring sites was developed from 1991 through 1994 when about 400 new sites were added during each of these four years. The sample collection that occurred during these years is called **First Round** sampling. The Twin Falls subarea gained about 24 new monitoring sites during each of the four years in the First Round. Prior to the 1995 field season, sites were designated as either Rotational or Annual sites. Most of the Rotational sites sampled in 1991 through 1994 were re-sampled in 1995 through 1998, respectively (i.e., 1991 sites were re-sampled in 1995, etc.); this sampling period is known as the **Second Round**. About 16 percent of the sites could not be re-sampled for a variety of reasons. **Third Round** sampling began in 1999. Most Annual wells have been sampled six or seven times by the end of the 2000 field season.

The Statewide Program has endeavored to standardize on laboratories and analyses to facilitate comparisons. Second Round samples were analyzed for the same constituents and parameters (except mercury, cyanide and radon) using the same laboratory methods in all cases except for the volatile organic compounds. VOCs were analyzed by the Idaho State Health Laboratory in 1991 using EPA Method 502.2 and by the USGS laboratory in 1992 using EPA Method 524.2. VOC analyses were performed by Alpha Analytical Laboratory in Sparks, Nevada, using EPA Method 524.2 from 1993 through 2000.

5.2. First Round to Second Round Comparisons

Seventy-seven of the 93 sites (84 percent) were sampled in both the First and Second Rounds. The Wilcoxon signed-rank test was used to test for differences in the median values between the two rounds. The differences will be approximately symmetrical (i.e., about half of the differences will be above zero and about half of the differences will be below zero) if the two groups are from the same, or from an unchanged, population (Helsel and Hirsch, 1992). The test also compares the magnitude of the differences to see if variability and skewness between the two groups is significantly different.

[1]Prior to 2001, rotational sites were sampled once every four years. In 2001, new monitoring sites are being added to the Statewide Program network. Some of these sites are replacements for dropped sites and some of them are sites in areas of data gaps. In order to accommodate these new sites into the sampling schedules, all Rotational Sites will be sampled once every five years, instead of once every four years, beginning in 2001.

The median nitrate value for the 77 paired Twin Falls sites increased from 3.6 mg/L (First Round) to 4.0 mg/L (Second Round). However, the change in the median nitrate values from the First Round to the Second Round was not significant at the 95 percent confidence level.

Nitrate concentrations increased at 48 of the 77 Twin Falls subareas sites (62 percent) sampled in both the First and Second Rounds. Individual increases ranged 0.03 mg/L to 10.8 mg/L. Nitrate concentrations decreased at 26 sites (34 percent) and remained unchanged at 3 sites (four percent). Fifteen sites (19 percent) had increases greater than 1.0 mg/L and 11 sites (14 percent) had decreases greater than 1.0 mg/L. Clustering of sites with increases or decreases greater than 1.0 mg/L occurred in some areas (Figure 41). In the northern part of the subarea along a band extending from east of Kimberly to Buhl, 11 sites had nitrate increases greater than 1.0 mg/L while only two sites had decreases greater than 1.0 mg/L. A clustering of sites with decreases greater than 1.0 mg/L occurred in an area southwest of Twin Falls (Figure 41).

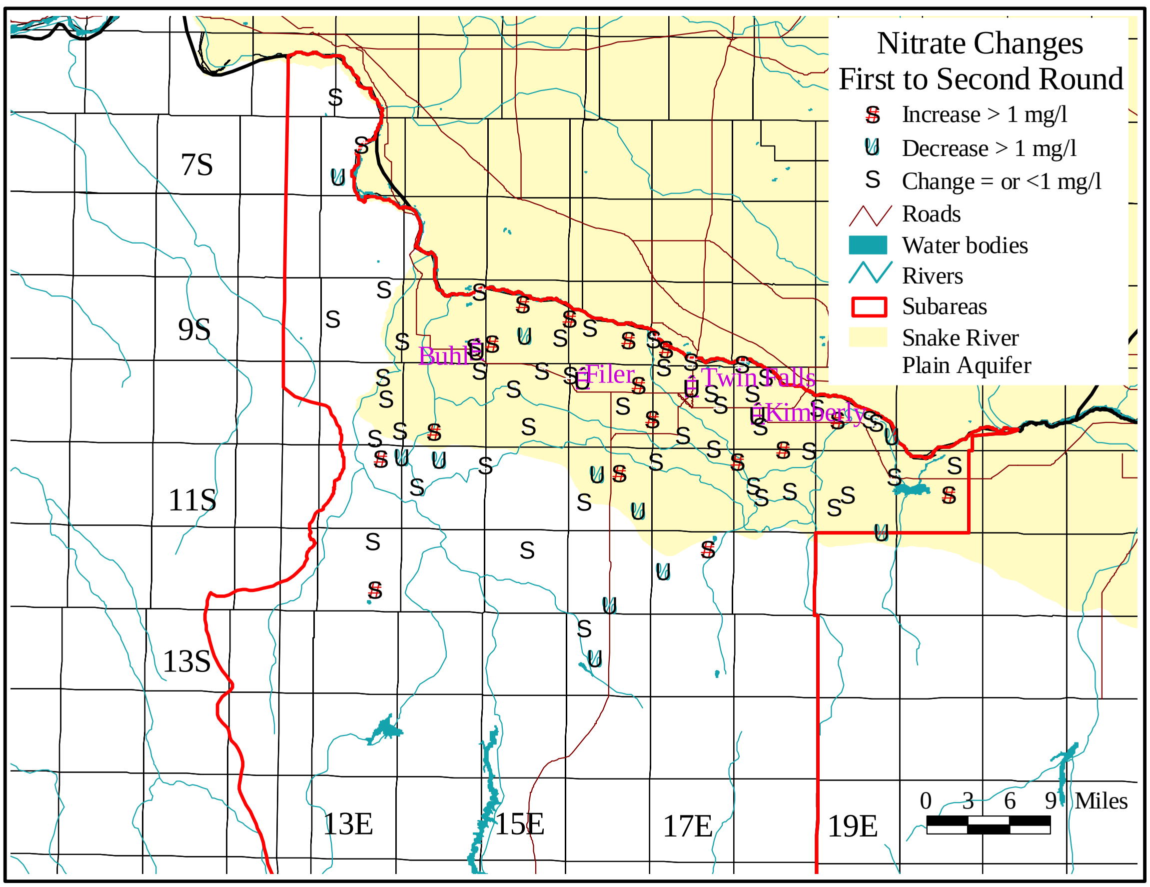

Figure 41. Nitrate changes from the First Round to the Second Round for Statewide Programs in the Twin Falls subarea.

Four sites had nitrate concentrations that exceeded the MCL in both the First and Second Rounds. The number of sites with nitrate concentrations exceeding 5 mg/L increased slightly from 20 in the First Round to 22 in the Second Round.

TDS results from the First and Second Rounds showed some variability between rounds; however, Kruskal-Wallis test results indicated that the median values were not significantly different at the 95 percent confidence level.

5.3. Results from Annual Sites

There are six annual Statewide Program sites in the Twin Falls subarea (Figure 42); each site had been sampled at least six times by the end of the 2000 field season. Visual interpretations of Time versus Concentration plots suggest that nitrate concentrations have increased at four sites and decreased slightly at two sites (Figures 43 and Figure 44). Statistical analyses for trends at the Twin Falls annual sites may be possible after one or two more sampling events.

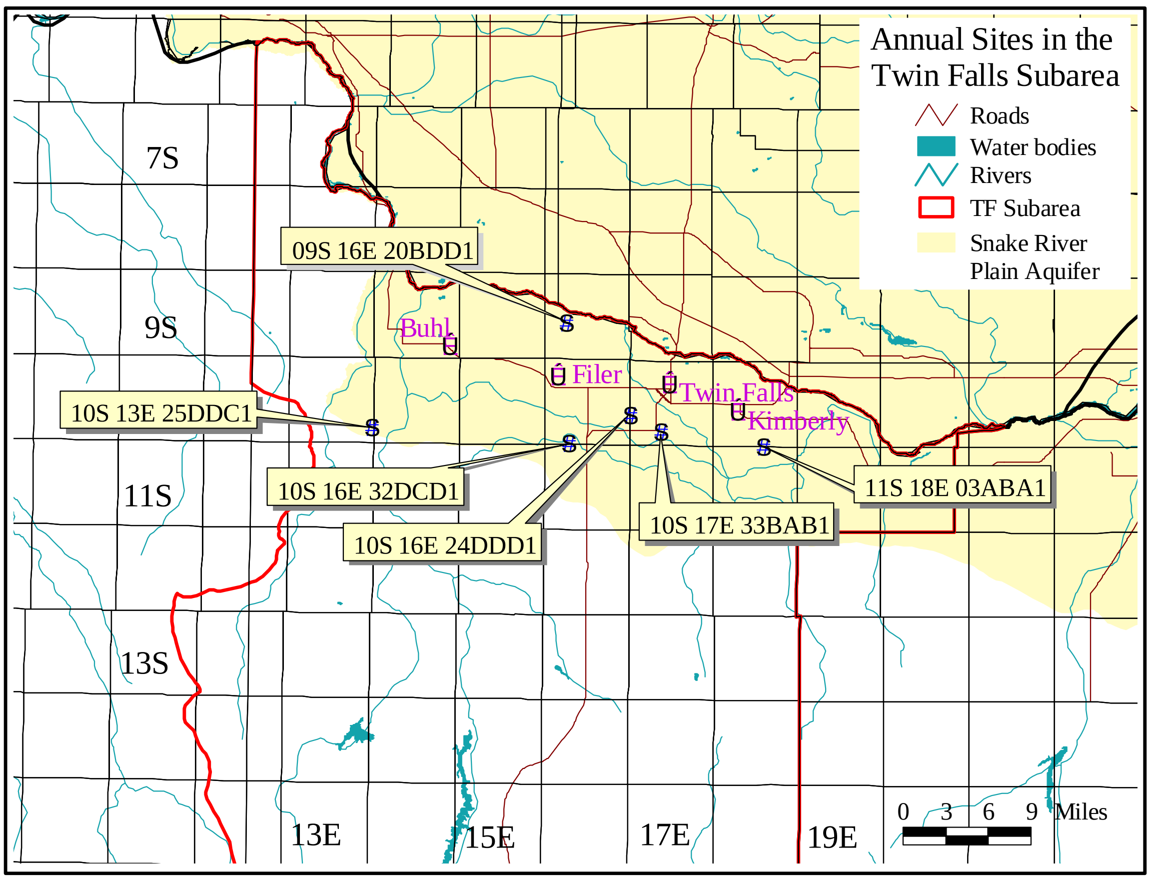

Figure 42. Annual sites in the Twin Falls subarea

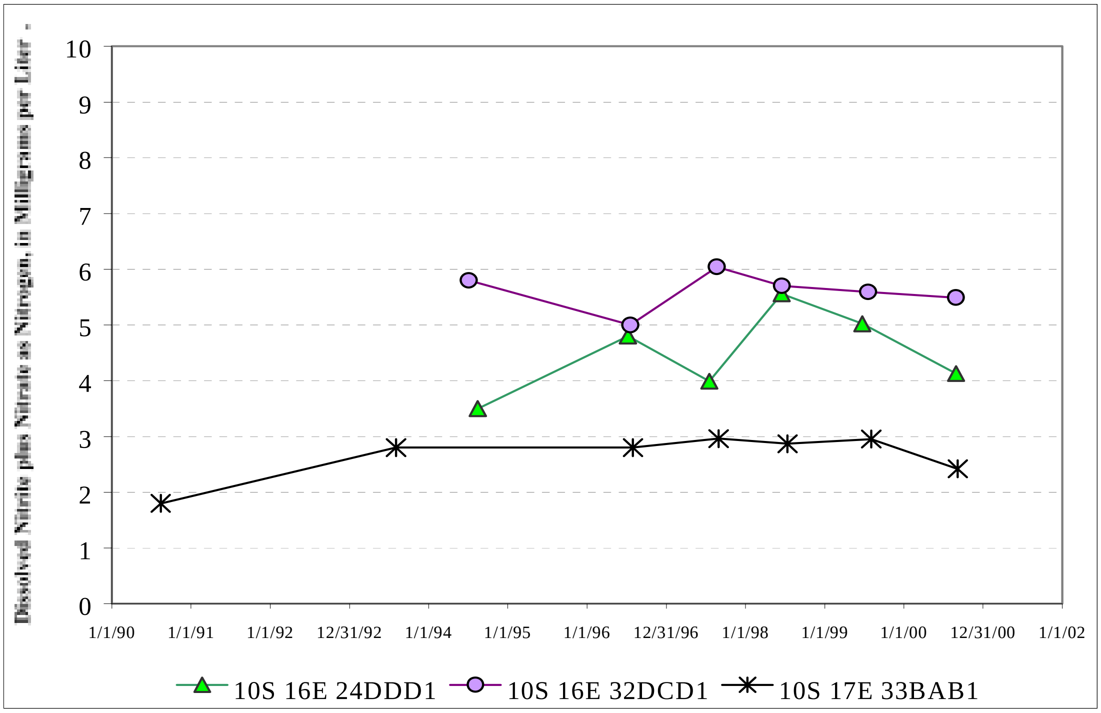

Figure 43. Graphs of nitrate concentrations versus time for three of the Annual sites in the Twin Falls subarea: 10S 16E 24DDD1, 10S 16E 32DCD1, and 10S 17E 33BAB1.

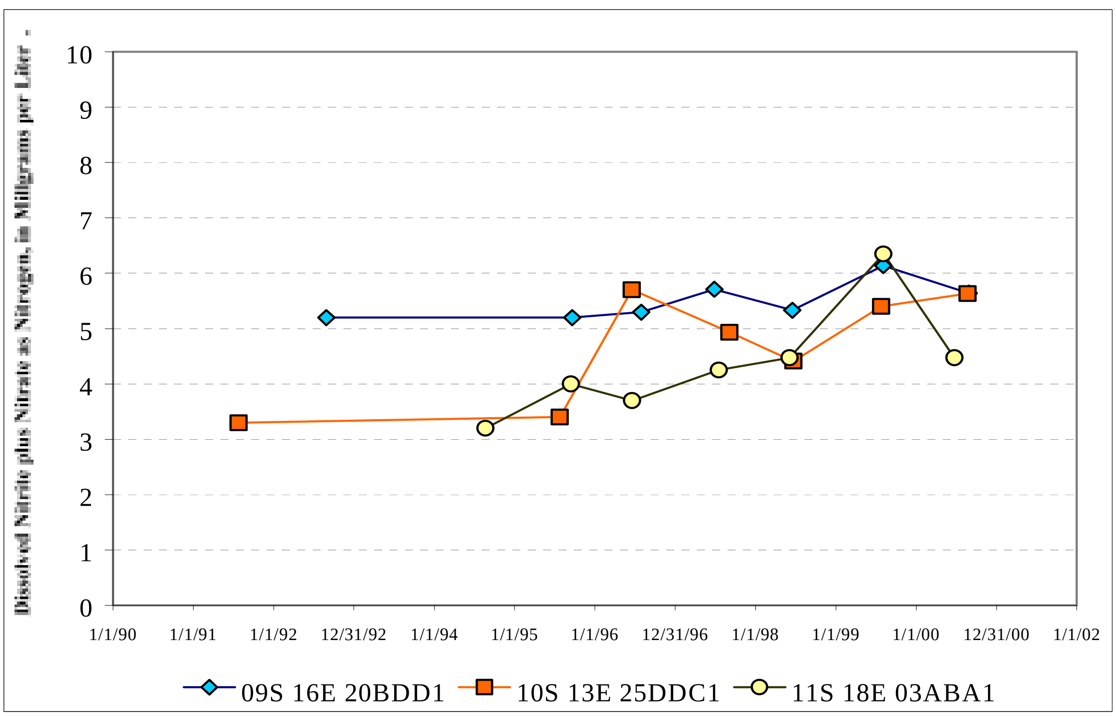

Figure 44. Graphs of nitrate concentrations versus time for three of the Annual sites in the Twin Falls subarea: 09S 16E 20BDD1, 10S 13E 25DDC1, and 11S 18E 03ABA1.

5.4. Sites with Multiple GC Pesticide Results

Table 6 shows the Twin Falls sites that have had multiple GC pesticide analyses. More GC data are needed to determine if trace concentrations of pesticides have changed over time.

Table 6. Results from seven Twin Falls subarea sites with two gas chromatography pesticide analyses in separate years.

	1993	1994	1995	1996	1999
10S 13E 11ABC1	-	Alachlor (0.0030 µg/l) Deethylatrazine (0.0050 µg/l)	EPTC (0.0090 µg/l)	-	-
10S 13E 25DDC1	-	-	Atrazine (0.180 µg/l) Deethylatrazine (0.096 µg/l) Simazine (0.0060 µg/l)	Atrazine (0.15 µg/L) Deethylatrazine (0.028 µg/L) Simazine (0.003 µg/L)	-
10S 13E 34DAA1	No Detects	-	-	Atrazine (0.006 µg/L) Deethylatrazine (0.005 µg/L)	-
10S 17E 14BAB1	-	-	No Detects	Deethylatrazine (0.0028 µg/L)	-
10S 17E 33BAB1	No Detects	-	-	-	Deethylatrazine (0.007 µg/L)
11S 18E 07BAB1	-	-	-	Atrazine (0.007 µg/L) Carbaryl (0.003 µg/L) Deethylatrazine (0.005 µg/L) Simazine (0.003 µg/L)	Atrazine (0.006 µg/L) Dacthal (0.001 µg/L) Deethylatrazine (0.005 µg/L) Simazine (0.002 µg/L)
12S 17E 18DDD2	No Detects	-	-	Atrazine (0.003 µg/L) Deethylatrazine (0.003 µg/L)	-

6. Areas of Ground Water Quality Concerns

The third objective of the Statewide Program is to identify areas where ground water quality problem exist or may be emerging. The Statewide Program monitoring network was designed primarily to address overall ambient ground water quality and, consequently, the density of sites is not adequate to define and delineate regional ground water quality problems, or to screen for all possible areas of local contamination. However, the data and interpretations can be used to indicate where there are sites and/or areas of concern that may require follow-up investigations.

Since 16% of the Twin Falls Statewide Program sites had one or more constituents with concentrations exceeding primary MCLs (Figure 45), and on the basis of the widespread impacts from nitrate (Section 4.4.1), it is likely that the entire subarea could be designated as an area of existing or emerging ground water quality problems. Additional studies that would incorporate all of the ground water quality data available for the county could be useful for determining the magnitude of the problems.

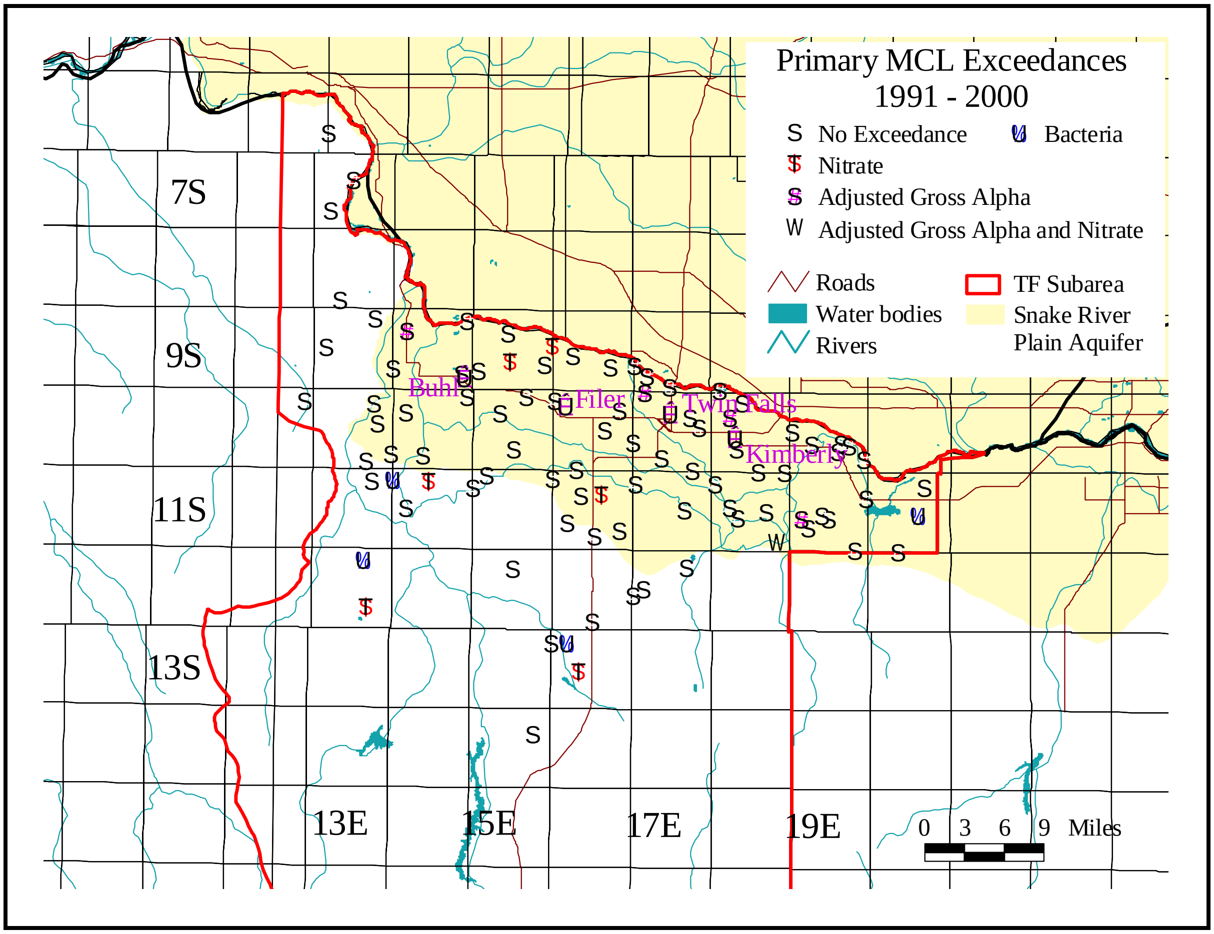

Figure 45. Twin Falls sites where one or more primary MCL was exceeded, 1991-2000.

Ground water quality concerns in the Twin Falls can generally be placed into one of two categories: naturally-occurring, and human-related. Adjusted gross alpha is considered to be naturally-occurring constituents. Fecal coliform bacteria, nitrate, pesticides, and volatile organic compounds fall into the human-related category. Each of these constituents need to be studied which respect to their occurrences and concentrations to determine whether the extent of their impacts.

Nitrate contamination in the ground water of the Twin Falls subarea is recognized as one of the most extensive ground water quality problem in Idaho. The IDEQ has identified Twin Falls County as the pilot project for the 33 ground water degraded areas indentified in the state. The Twin Falls Ground Water Quality Advisory Committee was formed in September, 2000, and is developing a plan for the county to protect the ground water from additional nitrate impacts.

In addition to nitrate, other constituents, such as pesticides and volatile organic compounds may need to be investigated to see if their presence in the ground water is a signficant concern. The distribution of arsenic in ground water in the Twin Falls subarea may necessitate further work depending on the final drinking water standard.

7. OTHER GROUND WATER QUALITY MONITORING PROGRAMS IN TWIN FALLS COUNTY

The ISDA began a regional ground water quality monitoring program in Twin Falls County in 1999. ISDA plans to monitor 75 wells for five years (Figure 46). Regional monitoring in Twin Falls County is being done to better define the extend of the nitrate ground water quality problems in this area.

In addition to IDWR and ISDA monitoring wells, ground water quality in Twin Falls County is also monitored on a regular basis at 59 public drinking water supply wells and at three wastewater treatment facilities (Figure 46). Additional ground water quality monitoring results are available from the USGS, and may be available from the ISDA (as part of the Dairy program), and the Idaho Farm Bureau (as part of their county by county nitrate assessment program).

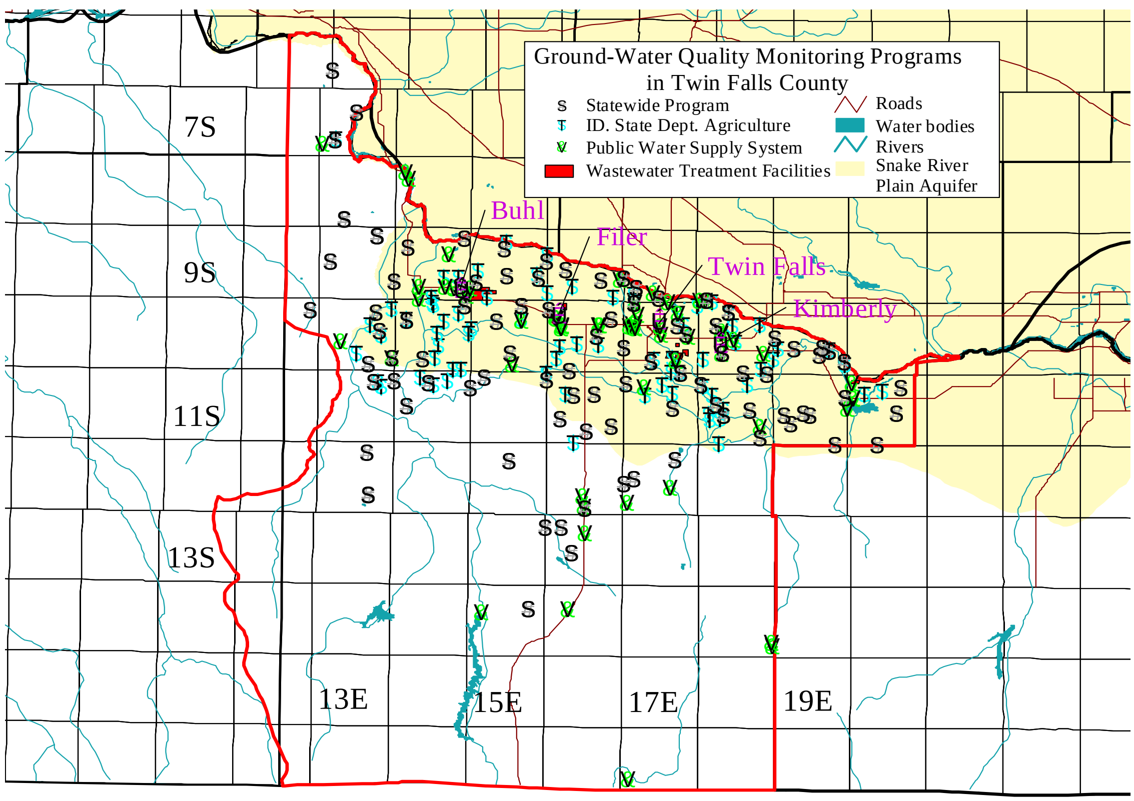

Figure 46. Ground water quality monitoring programs in Twin Falls County. This map includes programs where data are being collected at regular defined intervals.

IDEQ has begun assessing 33 areas in Idaho that have degraded ground water quality due to nitrate impacts. The pilot project for these 33 areas is Twin Falls County. IDEQ has formed the Twin Falls Ground water Advisory Committee in an effort to address nitrate problems in the county. The committee is made up of representatives from industries and agencies, and citizens who want to help prevent further degradation of ground water quality in Twin Falls County. The committee began meeting in September, 2000.

IDWR recommends that a thorough compilation, analysis, and reporting of nitrate data from all available sources be done for Twin Falls County. The purpose of this effort is to assist the Twin Falls Ground Water Advisory Committee with the evaluation of the nitrate problem in the county. The nitrate data needs to be compiled using Geographic Information System technology. Locational data must have a degree of accuracy equivalent to a 24,000 topographic map (+/- 40 feet). A project of this scope is the responsibility of the IDEQ as defined by the Ground Water Quality Plan. IDWR, ISDA and other agencies, as well as county and local entities, could have a role in this project to assist IDEQ with data compilation, graphical display, and interpretation.

8. RECOMMENDATIONS

Continued Statewide Program monitoring is needed for the Twin Falls subarea because it is one of the most impacted areas in the state with respect to nitrates and pesticides. Long-term monitoring will be important to determine if nitrate concentrations are increasing and to ascertain the possible sources of the nitrate in the ground water. IDWR recommends the following actions:

1. Continue to sample Rotational and Annual sites according to their specific time schedules (IDWR and USGS).
2. Select replacements for the sites that have been dropped. Add these sites in 2001 and 2002 (IDWR and USGS).
3. Determine if the current level of ground water quality monitoring, which includes the Statewide Program, the regional monitoring being conducted by the ISDA, and the monitoring be done for the public drinking water systems, is sufficient. If is not, add more Statewide Program sites to the network (IDWR, ISDA, and IDEQ).
4. Determine if the occurences of nitrates and pesticides are related to land uses. Determine if ground water probability mapping is useful for Twin Falls County (ISDA and IDEQ).
5. Determine if managed recharge will affect the ground water quality in Twin Falls County (IDWR and IDEQ).
6. Determine if seasonal variability is significant for nitrates and pesticides (IDEQ and ISDA).
7. Compile, analyze, and report all nitrate data from all available sources for Twin Falls County (IDEQ with assistance from other agencies).

8. Assess whether “emerging” contaminants of concern, such as pharmaceuticals, endrocrine disrupting chemicals, viruses, etc., should be analyzed as part of the Statewide Program (IDWR and USGS).
9. Determine the effects of geothermal water on the quality of the non-thermal aquifer systems in Twin Falls County.

9. SUMMARY AND CONCLUSIONS

The Twin Falls subarea, located in south-central Idaho, is one of 20 hydrogeologic subareas in the Statewide Ambient Ground Water Quality Monitoring Program. Ground water quality samples from 93 Statewide Program monitoring sites in the Twin Falls subarea were analyzed for this report. Data have been collected according to Rounds which are four year time periods: First Round (1991 through 1994); Second Round (1995 though 1998); and Third Round (begun in 1999). Most sites are now scheduled to be sampled once every four years; however six sites in the Twin Falls subarea are sampled annually.

Ground water in the Twin Falls subarea is quite mineralized; 65 percent of the sites had TDS concentrations over the secondary MCL of 500 mg/L. The high mineralization is considered to be naturally-occurring related to the dissolution of aquifer materials.

The Statewide Program data indicate that the ground water quality in the Twin Falls subarea has extensive impacts from natural and human-related sources. Fifteen of the 93 sites (16 percent) had one or more constituents with concentrations that exceeded the primary MCLs as established by the Environmental Protection Agency for public water supplies. The contaminants detected above primary MCLs were adjusted gross alpha, fecal coliform bacteria, and nitrate. Secondary MCLs were exceeded at some sites for chloride, fluoride, pH, sulfate and TDS. The proposed MCL for radon (option 2) was exceeded at about ½ of the sites tested for radon. Arsenic and uranium concentrations at some sites may pose health concerns depending on the results of the studies currently being conducted by EPA.

Ground water quality impacts in the Twin Falls subarea that are related to human activities are associated with the presence of fecal coliform bacteria, nitrate, pesticides, and volatile organic compounds. Nitrate impacts in the Twin Falls subarea are prevalent; 84 percent of the Statewide Program sites had nitrate concentrations equal to or greater than 2 mg/L. Forty-two percent of the sites showed more severe nitrate impacts with concentrations exceeding 5 mg/L. Seven of the 93 sites (eight percent) had nitrate concentrations greater than the primary MCL of 10 mg/L.

Pesticides were detected at 32 of the 93 Twin Falls sites (34 percent) using immunoassay methods. Pesticides were also detected in 37 of the 61 sites tested using gas chromatography methods. None of the immunoassay or gas chromatography pesticide detections exceeded any MCLs, Health Advisories, or Reference Doses.

Continued monitoring is needed for the Twin Falls subarea because of the documented impacts to ground water quality. The author suggests that a complete compilation of the available nitrate data be conducted by IDEQ, with assistance from other agencies and entities, and presented using a geographic information system. This effort is necessary to determine the sources and extent of the nitrate contamination and to assist with future regional and local monitoring.

10. REFERENCES

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11. APPENDICES