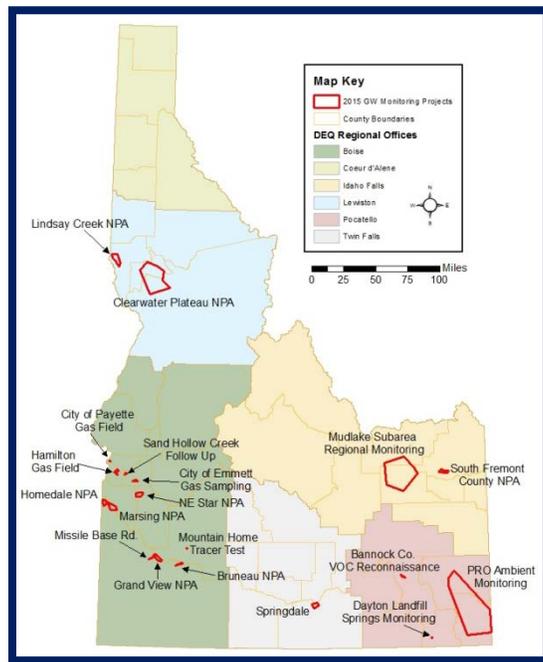


Summary Report for the Idaho Department of Environmental Quality Ground Water Quality Monitoring Projects—2015

Ground Water Quality Technical Report No. 49



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Summary Report for the Idaho Department of Environmental Quality Ground Water Quality Monitoring Projects— 2015

January 2017



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Compiled and edited by Kathryn Elliott.

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Table of Contents

Table of Contents	iii
Acronyms, Abbreviations, and Symbols	xi
1 Introduction.....	1
2 Summary of Ground Water Quality Projects by Region	3
2.1 Boise Region	4
2.1.1 Bruneau Nitrate Priority Area Ground Water Monitoring Project	4
2.1.2 City of Emmett Baseline Ground Water Monitoring Project	10
2.1.3 Grand View Nitrate Priority Area Ground Water Monitoring Project	16
2.1.4 Hamilton Gas Field Ground Water Monitoring Project	22
2.1.5 Homedale Nitrate Priority Area Ground Water Monitoring Project	35
2.1.6 Marsing Nitrate Priority Area Ground Water Monitoring Project	41
2.1.7 Missile Base Road Synoptic Ground Water Monitoring Project.....	47
2.1.8 City of Mountain Home Tracer Test Project	59
2.1.9 Northeast Star Nitrate Priority Area Ground Water Monitoring Project.....	69
2.1.10 City of Payette Gas Field Ground Water Monitoring Project	79
2.1.11 Sand Hollow Creek Follow-Up Ground Water Monitoring Project.....	87
2.2 Idaho Falls Region.....	94
2.2.1 Mud Lake Subarea Ground Water Monitoring Project	94
2.2.2 South Fremont County Nitrate Priority Area Potential Nitrate Source Evaluation Monitoring Project.....	114
2.3 Coeur d’Alene Region.....	128
2.4 Lewiston Region.....	128
2.4.1 Clearwater Plateau NPA Ground Water Monitoring Project	128
2.4.2 Lindsay Creek NPA Ground Water Monitoring Project	134
2.5 Pocatello Region.....	139
2.5.1 PRO Ambient Ground Water Quality Monitoring Project	139
2.5.2 Bannock County Volatile Organic Compound Reconnaissance	149
2.5.3 Dayton Landfill Springs Monitoring Project.....	155
2.6 Twin Falls Region	164
2.6.1 Springdale Ground Water Monitoring Project	164
3 DEQ Cooperative Projects.....	177
3.1 DEQ–ISDA Ground Water Monitoring Project	177
3.1.1 Purpose	177
3.1.2 Methods and Results.....	177
3.1.3 Conclusions.....	178
3.1.4 Recommendations.....	178
References.....	179

Appendix A. Missile Base Road Appendix	187
Appendix B. Project Analyte Lists	193
Appendix C. Idaho State Department of Agriculture (ISDA) 2015 Data.....	195

List of Tables

Table 1. Water quality field parameters—Bruneau Nitrate Priority Area Ground Water Monitoring Project.....	7
Table 2. Inorganic and bacteria results—Bruneau Nitrate Priority Area Ground Water Monitoring Project.....	7
Table 3. Typical $\delta^{15}\text{N}$ values from various nitrogen sources.....	9
Table 4. Water quality field parameters—City of Emmett Baseline Ground Water Monitoring Project.....	13
Table 5. Major ions, total dissolved solids, and alkalinity—City of Emmett Baseline Ground Water Monitoring Project.....	13
Table 6. Metals—City of Emmett Baseline Ground Water Monitoring Project.	14
Table 7. Hydrocarbons—City of Emmett Baseline Ground Water Monitoring Project.....	14
Table 8. Water quality field parameters—Grand View Nitrate Priority Area Ground Water Monitoring Project.....	18
Table 9. Inorganic and bacteria results—Grand View Nitrate Priority Area Ground Water Monitoring Project.....	19
Table 10. Water quality field parameters—Hamilton Gas Field Ground Water Monitoring Project.....	24
Table 11. Common ions and TDS results—Hamilton Gas Field Ground Water Monitoring Project.....	25
Table 12. Nutrients and bacteria results—Hamilton Gas Field Ground Water Monitoring Project.....	26
Table 13. Uranium and heavy metals results—Hamilton Gas Field Ground Water Monitoring Project.....	26
Table 14. Additional metals results—Hamilton Gas Field Ground Water Monitoring Project. ..	27
Table 15. BTEX, TPH, and methane results—Hamilton Gas Field Ground Water Monitoring Project.....	28
Table 16. Lead sample result trend in Wells 2028, 2030, and 2032—Hamilton Gas Field Ground Water Monitoring Project.....	33
Table 17. Comparison table of dissolved methane sample results over time—Hamilton Gas Field Ground Water Monitoring Project.	34
Table 18. Water quality field parameters—Homedale Nitrate Priority Area Ground Water Monitoring Project.....	37
Table 19. Inorganic and bacteria results—Homedale Nitrate Priority Area Ground Water Monitoring Project.....	38
Table 20. Water quality field parameters—Marsing Nitrate Priority Area Ground Water Monitoring Project.....	43
Table 21. Inorganic and bacteria results—Marsing Nitrate Priority Area Ground Water Monitoring Project.....	44

Table 22. Water quality field parameters—Missile Base Road Synoptic Ground Water Monitoring Project.....	50
Table 23. Common ions and nitrate—Missile Base Road Synoptic Ground Water Monitoring Project.....	51
Table 24. TDS and alkalinity—Missile Base Road Synoptic Ground Water Monitoring Project.....	52
Table 25. Uranium, gross alpha, and gross beta results—Missile Base Road Synoptic Ground Water Monitoring Project.....	53
Table 26. Heavy metal results—Missile Base Road Synoptic Ground Water Monitoring Project.....	55
Table 27. Dissolved metals results—Missile Base Road Synoptic Ground Water Monitoring Project.....	55
Table 28. BTEX, TPH, and methane results—Missile Base Road Synoptic Ground Water Monitoring Project.....	56
Table 29. Comparison of analytes detected in project wells—Missile Base Road Synoptic Ground Water Monitoring Project.....	57
Table 30. Water quality field parameters—City of Mountain Home Tracer Test Project.	63
Table 31. Inorganic, nutrient, and bacteria results—City of Mountain Home Tracer Test Project.....	64
Table 32. Fluorescein dye results—City of Mountain Home Tracer Test Project.	66
Table 33. Project wells identified as sampled by DEQ, ISDA, or IDWR.	71
Table 34. Water quality field parameters—Northeast Star Nitrate Priority Area Ground Water Monitoring Project.....	72
Table 35. Nutrient, bacteria, nitrogen isotope, and anion results—Northeast Star Nitrate Priority Area Ground Water Monitoring Project.....	73
Table 36. Comparison of 2010 and 2015 nutrient, bacteria, nitrogen isotope, and anion results—2015 Northeast Star Nitrate Priority Area Ground Water Monitoring Project.....	76
Table 37. A Comparison of Samples taken in 2010 and 2015 in the Northeast Star NPA—Northeast Star Nitrate Priority Area Project.....	78
Table 38. Water quality field parameters—City of Payette Gas Field Ground Water Monitoring Project.....	81
Table 39. Common ion results—City of Payette Gas Field Ground Water Monitoring Project..	82
Table 40. Total dissolved solids—City of Payette Gas Field Ground Water Monitoring Project.....	82
Table 41. Uranium and other metals results—City of Payette Gas Field Ground Water Monitoring Project.....	83
Table 42. Additional metals results—City of Payette Gas Field Ground Water Monitoring Project.....	83
Table 43. BTEX, TPH, and methane results—City of Payette Gas Field Ground Water Monitoring Project.....	84
Table 44. ISDA Dairy Bureau nitrate concentration and nitrogen isotope data—Sage Dairy site production well.	89
Table 45. Water quality field parameters—Sand Hollow Creek Follow-Up Ground Water Monitoring Project.....	92

Table 46. Nutrient and bacteria results—Sand Hollow Creek Follow-Up Ground Water Monitoring Project.....	92
Table 47. Water quality field parameters—Mud Lake Subarea Ground Water Monitoring Project.....	98
Table 48. Nutrient and bacteria results—Mud Lake Subarea Regional Ground Water Quality Monitoring Project.....	100
Table 49. Common ion results—Mud Lake Subarea Regional Ground Water Quality Monitoring Project.....	102
Table 50. Stable isotope analytical results—Mud Lake Subarea Regional Monitoring Project.	109
Table 51. Total Inorganic Carbon, Arsenic, Bromide, and trace element results—Mud Lake Subarea Regional Monitoring Project.	113
Table 52. Water quality field parameters—South Fremont County Nitrate Priority Area Ground Water Monitoring Project.....	117
Table 53. Common ion, nutrient, and bacteria results—South Fremont County Nitrate Priority Area Ground Water Monitoring Project.	119
Table 54. Stable isotope analytical results—South Fremont County Nitrate Priority Area Ground Water Monitoring Project.....	123
Table 55. Total inorganic carbon, arsenic, bromide, and trace element results—South Fremont County Nitrate Priority Area Ground Water Monitoring Project.....	127
Table 56. Water quality field parameter data—Clearwater Plateau NPA Ground Water Monitoring Project.....	131
Table 57. Nitrate results—Clearwater Plateau NPA Ground Water Monitoring Project.	132
Table 58. Temperature data—Lindsay Creek NPA Ground Water Monitoring Project.	135
Table 59. Nitrate results—Lindsay Creek NPA Ground Water Monitoring Project.....	137
Table 60. Water quality field parameters—PRO Ambient Regional Ground Water Monitoring Project.....	142
Table 61. Major ion results—PRO Ambient Regional Ground Water Monitoring Project.	143
Table 62. Inorganic, nutrient, isotope, and bacteria results—PRO Ambient Regional Ground Water Monitoring Project.....	144
Table 63. 1976 and 2015 comparison of chloride, sulfate, and nitrate+nitrite—PRO Ambient Regional Ground Water Monitoring Project.	147
Table 64. Water quality field parameters—Bannock County Volatile Organic Compound Reconnaissance Project.	151
Table 65. Selected organic compound results—Bannock County Volatile Organic Compounds Reconnaissance Project.	153
Table 66. Water quality field parameters—Dayton Landfill Springs Monitoring Project.	158
Table 67. Major ion results—Dayton Landfill Springs Monitoring Project.....	158
Table 68. Inorganic and nutrient analytical results—Dayton Landfill Springs Monitoring Project.....	160
Table 69. Organic and chemical oxygen demand analytical results—Dayton Landfill Springs Monitoring Project.....	162
Table 70. Water quality field parameters—Springdale Ground Water Monitoring Project.	167
Table 71. Major ion and nutrient results—Springdale Ground Water Monitoring Project.	168
Table 72. Major stable isotope results—Springdale Ground Water Monitoring Project.	174
Table 73. Bacteria results—Springdale Ground Water Monitoring Project.....	176
Table A1. WELL 2482 = ISDA Well 8650301, Owyhee County, Near Grandview.	187

Table A2. VOC results - Missile Base Rd. sampling event.....	190
Table A3. Pesticide Results - Missile Base Rd. Synoptic Ground Water Monitoring Project 2015.....	192
Table C1. DEQ–ISDA Ground Water Monitoring Project data.....	195

List of Figures

Figure 1. Idaho Department of Environmental Quality 2015 ground water quality project locations by region.....	3
Figure 2. Bruneau NPA and ground water contours and elevations—Bruneau Nitrate Priority Area Ground Water Monitoring Project.....	5
Figure 3. Sample locations and nitrate concentrations—Bruneau Nitrate Priority Area Ground Water Monitoring Project 2015.....	8
Figure 4. Locations of project wells—City of Emmett Baseline Ground Water Monitoring Project 2015.....	12
Figure 5. Grand View NPA and ground water contours and elevations—Grand View Nitrate Priority Area Ground Water Monitoring Project.....	17
Figure 6. Sample locations and nitrate concentrations—Grand View Nitrate Priority Area Ground Water Monitoring Project.....	20
Figure 7. Location of Hamilton Field production wells, sampling network wells (private and municipal), and ground water contours and flow direction—Hamilton Gas Field Ground Water Monitoring Project.....	23
Figure 8. Uranium detections—Hamilton Gas Field Ground Water Monitoring Project.....	30
Figure 9. Uranium concentrations from Wells 2023, 2024, and 2025 over time—Hamilton Gas Field Ground Water Monitoring Project.....	31
Figure 10. Lead detections—Hamilton Gas Field Ground Water Monitoring Project.....	32
Figure 11. Dissolved methane detections over time—Hamilton Gas Field Ground Water Monitoring Project.....	34
Figure 12. Ground water contours and elevations—Homedale Nitrate Priority Area Ground Water Monitoring Project.....	36
Figure 13. Private domestic drinking water well sample locations and nitrate concentrations— Homedale Nitrate Priority Area Ground Water Monitoring Project.....	39
Figure 14. Ground water contours and elevations—Marsing Nitrate Priority Area Ground Water Monitoring Project.....	42
Figure 15. Private domestic drinking water and irrigation well sample locations and nitrate concentrations—Marsing Nitrate Priority Area Ground Water Monitoring Project.....	45
Figure 16. Well locations and ground water elevations—Missile Base Road Synoptic Ground Water Monitoring Project.....	48
Figure 17. Historic ground water nitrate (NO ₃) sampling data, 1998–2009.....	49
Figure 18. City of Mountain Home Project Area and stormwater infiltration basin—City of Mountain Home Tracer Test Project.....	60
Figure 19. Location of City of Mountain Home stormwater infiltration basin and project wells (identified by DEQ Site ID [well name])—City of Mountain Home Tracer Test Project.....	61

Figure 20. Piper diagram—City of Mountain Home Tracer Test Project 2015. The dark symbols represent samples collected in May; the light symbols represent samples collected in June.	67
Figure 21. Scatter plot of positive fluorescein detections (both water and charcoal packet samples) from Well 2459—City of Mountain Home Tracer Test Project.	68
Figure 22. Ground water contours and elevations—Northeast Star Nitrate Priority Area Ground Water Monitoring Project.....	70
Figure 23. Private domestic drinking water and irrigation well sample locations and nitrate concentrations—Northeast Star Nitrate Priority Area Ground Water Monitoring Project.....	74
Figure 24. City of Payette ground water elevations and ground water flow direction—City of Payette Gas Field Ground Water Monitoring Project.	80
Figure 25. Location of Sage Dairy within the Emmett North Bench Nitrate Priority Area on the Rim Fire Ranch LLC property.....	88
Figure 26. ISDA Dairy Bureau nitrate concentrations—Sage Dairy site production well.	90
Figure 27. Sample location—Sand Hollow Creek Follow-Up Ground Water Monitoring Project.....	91
Figure 28. Nitrate concentrations at Well 2232, 2013–2015—Sand Hollow Creek Follow-Up Ground Water Monitoring Project.....	93
Figure 29. Monitoring sites, Idaho Falls Regional Office.	95
Figure 30. Mud Lake regional subarea nitrite plus nitrate concentrations and ground water flow direction—Mud Lake Subarea Regional Ground Water Quality Monitoring Project.....	96
Figure 31. Piper diagram—Mud Lake Subarea Ground Water Quality Monitoring Project.....	105
Figure 32. Comparison of chloride versus sulfate concentrations—Mud Lake Subarea Ground Water Quality Monitoring Project 2015.....	106
Figure 33. Nitrite plus nitrate versus sulfate/chloride (in mg/L)—Idaho Falls Regional Office monitoring projects.....	107
Figure 34. $\delta^{15}\text{N}_{\text{nitrate}}$ versus sulfate/chloride — Idaho Falls Regional Office monitoring projects 2015.	110
Figure 35. $\delta^{15}\text{N}_{\text{nitrate}}$ versus $\delta^{18}\text{O}_{\text{nitrate}}$ —Idaho Falls Regional Office monitoring projects 2015. Ranges for typical nitrate sources are from Kendall et al. 2007.	111
Figure 36. Stable oxygen and deuterium ($\delta^{18}\text{O}$ versus $\delta^2\text{H}$)—Idaho Falls Regional Office monitoring projects.....	112
Figure 37. Well locations and nitrite plus nitrate concentrations—South Fremont County Nitrate Priority Area Ground Water Monitoring Project 2015.	115
Figure 38. Piper diagram—South Fremont County NPA Ground Water Quality Monitoring Project 2015.....	118
Figure 39. Comparison of chloride versus sulfate concentrations—South Fremont County NPA Ground Water Monitoring Project.....	121
Figure 40. Nitrite plus nitrate versus sulfate/chloride (in mg/L)—South Fremont County NPA Ground Water Quality Monitoring Project.....	121
Figure 41. $\delta^{15}\text{N}_{\text{nitrate}}$ versus sulfate/chloride (in mg/L)—South Fremont County NPA Ground Water Monitoring Project 2015.....	124

Figure 42. $\delta^{15}\text{N}_{\text{nitrate}}$ versus $\delta^{18}\text{O}_{\text{nitrate}}$ —South Fremont County NPA Ground Water Quality Monitoring Project 2015. Ranges for typical nitrate sources are from Kendall et al. 2007.	125
Figure 43. Stable oxygen and deuterium ($\delta^{18}\text{O}$ versus $\delta^2\text{H}$)—South Fremont County Ground Water Quality Monitoring Project 2015.	126
Figure 44. Sampling locations and nitrate concentrations—Clearwater Plateau NPA Ground Water Monitoring Project, March 2015.	130
Figure 45. Histogram of nitrate concentrations for all nitrate samples (n = 47)—Clearwater Plateau NPA Ground Water Monitoring Project area. The median nitrate concentration value is below the MCL of 10 mg/L.	133
Figure 46. Sample locations and March nitrate concentrations—Lindsay Creek NPA Ground Water Monitoring Project.	136
Figure 47. Histogram of nitrate concentrations of all nitrate samples (n = 23)—Lindsay Creek NPA Ground Water Quality Monitoring Project area, 2015. The median nitrate concentration value does not exceed the MCL of 10 mg/L.	138
Figure 48. 2014 Google Earth map of approximate locations of 103 wells from Seitz and Norvitch (1979).	140
Figure 49. Well locations and nitrate concentrations for September 2015 sampling— PRO Ambient Regional Ground Water Monitoring Project.	141
Figure 50. Piper diagram—PRO Ambient Regional Ground Water Monitoring Project.	145
Figure 51. Stiff diagrams—PRO Ambient Regional Ground Water Monitoring Project.	146
Figure 52. TCE detections in project wells—Bannock County Volatile Organic Compound Reconnaissance Project.	150
Figure 53. Pathway for anaerobic microbial degradation of chlorinated ethenes to form vinyl chloride (VC) (from WHO 1999).	154
Figure 54. Time-series graph of TCE concentrations in selected project wells (data prior to 2015 from IDWR 2016). Wells 2545, 2549, and 2550 are not shown.	154
Figure 55. Spring and landfill monitoring well locations—Dayton Landfill Springs Monitoring Project.	156
Figure 56. Water chemistry data shown with Stiff diagrams—Dayton Landfill Springs Monitoring Project.	159
Figure 57. Pathway for anaerobic microbial degradation of chlorinated ethenes to form vinyl chloride (VC) (from WHO 1999).	163
Figure 58. Project location map—Springdale Ground Water Monitoring Project.	165
Figure 59. Piper trilinear diagram—Springdale Ground Water Monitoring Project. (The symbol size is determined by the TDS concentration for each sample.)	169
Figure 60. Sampling locations and nitrate concentrations—Springdale Ground Water Sampling Project.	170
Figure 61. Total dissolved solids versus nitrate concentrations—Springdale Ground Water Sampling Project.	171
Figure 62. Sulfate/chloride mass ratio versus chloride concentration—Springdale Ground Water Monitoring Project.	172
Figure 63. Chloride versus nitrate concentrations—Springdale Ground Water Monitoring Project.	172
Figure 64. $\delta^{15}\text{N}$ versus $\delta^{15}\text{N}_{\text{nitrate}}$ —Springdale Ground Water Monitoring Project.	173

Figure 65. $\delta^{15}\text{N}_{\text{nitrate}}$ versus $\delta^{18}\text{O}_{\text{nitrate}}$ —Springdale Ground Water Monitoring Project. The $\delta^{15}\text{N}_{\text{nitrate}}$ results used in this figure are the results from the batch rerun..... 175

Figure C1. Elmore and Owyhee Counties nitrate concentrations, 2015 ISDA data..... 201

Figure C2. Fremont County nitrate concentrations, 2015 ISDA data..... 202

Figure C3. Gooding County nitrate concentrations, 2015 ISDA data..... 203

Figure C4. Idaho County nitrate concentrations, 2015 ISDA data..... 204

Figure C5. Jefferson County nitrate concentrations, 2015 ISDA data..... 205

Figure C6. Jefferson and Bonneville Counties nitrate concentrations, 2015 ISDA data..... 206

Figure C7. Jerome and Minidoka Counties nitrate concentrations, 2015 ISDA data..... 207

Figure C8. Kootenai County nitrate concentrations, 2015 ISDA data..... 208

Figure C9. Latah County nitrate concentrations, 2015 ISDA data..... 209

Figure C10. Lewis and Idaho Counties nitrate concentrations, 2015 ISDA data..... 210

Figure C11. Lincoln County nitrate concentrations, 2015 ISDA data..... 211

Figure C12. Nez Perce County nitrate concentrations, 2015 ISDA data..... 212

Figure C13. Owyhee County nitrate concentrations, 2015 ISDA data..... 213

Figure C14. Owyhee, Canyon, and Ada Counties nitrate concentrations, 2015 ISDA data..... 214

Figure C15. Twin Falls and Jerome Counties nitrate concentrations, 2015 ISDA data..... 215

Figure C16. Twin Falls and Cassia Counties nitrate concentrations, 2015 ISDA data..... 216

Figure C17. Washington County nitrate concentrations, 2015 ISDA data..... 217

Acronyms, Abbreviations, and Symbols

°C	degrees Celsius
µg	micrograms
µS	microsiemens
bgs	below ground surface
BMP	best management practice
BTEX	benzene, toluene, ethylbenzene, and xylene
CaCO ₃	calcium carbonate
cfu	colony-forming unit
cm	centimeter
DEQ	Idaho Department of Environmental Quality
DO	dissolved oxygen
<i>E. coli</i>	<i>Escherichia coli</i>
EPA	United States Environmental Protection Agency
ESRP	Eastern Snake River Plain
FSP	field sampling plan
GMWL	global meteoric water line
GWQM	ground water quality management
IBL	Idaho Bureau of Laboratories
IDAPA	refers to citations of Idaho's administrative rules
IDWR	Idaho Department of Water Resources
ISDA	Idaho State Department of Agriculture
L	liter
LMWL	local meteoric water line
m+p-xylene	meta-xylene plus para-xylene
MCL	maximum contaminant level
mg	milligrams
mL	milliliter
MPN	most probable number
NA	not applicable
NAU CPSIL	Northern Arizona University–Colorado Plateau Stable Isotope Laboratory
ND	nondetect
NPA	nitrate priority area

NS	not sampled
NPDWR	National Primary Drinking Water Regulation
NSDWR	National Secondary Drinking Water Regulation
o-xylene	ortho-xylene
PCE	tetrachloroethene
pCi	picoCurie
per mil (‰)	parts per thousand
PRO	Pocatello Regional Office
PWS	public water system
QAPP	quality assurance project plan
RDL	reporting detection limit
SFC	South Fremont County
TC	total coliform
TCE	trichloroethene
TDS	total dissolved solids
TMDL	total maximum daily load
TPH	total petroleum hydrocarbons
UIASL	University of Idaho Analytical Sciences Laboratory
USGS	US Geological Survey
VOC	volatile organic compound
VSMOW	Vienna Standard Mean Ocean Water
$\delta^{15}\text{N}$	ratio of the two stable nitrogen isotopes ^{15}N and ^{14}N
$\delta^{15}\text{N}_{\text{nitrate}}$	ratio of the two stable nitrogen isotopes ^{15}N and ^{14}N of the nitrate molecule
$\delta^{18}\text{O}$	ratio of the two stable oxygen isotopes ^{18}O and ^{16}O
$\delta^{18}\text{O}_{\text{nitrate}}$	ratio of the two stable oxygen isotopes ^{18}O and ^{16}O of the nitrate molecule
$\delta^2\text{H}$	ratio of the two stable hydrogen isotopes ^1H and ^2H (deuterium), also denoted as δD

1 Introduction

Ground water is a key resource in Idaho—providing drinking water to 95% of Idahoans—and a critical component of the state’s economy. The economic and social vitality of every Idaho community depends on access to a safe and clean ground water supply.

Idaho Code §39-120, “Environmental Quality - Health,” designates the Idaho Department of Environmental Quality (DEQ) as the primary agency to coordinate and administer ground water quality protection programs for the state. DEQ is also responsible for collecting and analyzing data for ground water quality management purposes. Idaho Code §39-120 further directs DEQ, the Idaho Department of Water Resources (IDWR), and the Idaho State Department of Agriculture (ISDA) to conduct ground water quality monitoring and promote public awareness of ground water issues by making results of ground water quality investigations available to the public.

Public water systems (PWSs) are regulated by DEQ under the federal Safe Drinking Water Act and the “Idaho Rules for Public Drinking Water Systems” (IDAPA 58.01.08). These regulations require chemical analysis of drinking water for various contaminants. DEQ ensures that follow-up monitoring is conducted when contaminants of concern are detected in PWSs. The United States Environmental Protection Agency (EPA) has set National Primary Drinking Water Regulation standards (NPDWR), expressed as maximum contaminant levels (MCLs), that are legally enforceable standards that apply to PWSs. These levels are set to protect public health by limiting the amount of contaminants in drinking water. EPA has also set National Secondary Drinking Water Regulations (NSDWRs), which are nonmandatory standards that are established as guidelines to assist PWSs in managing their drinking water for aesthetic considerations such as taste, color, and odor.

Although these limits only apply to PWSs, they can be used to evaluate water quality in private wells, as is done throughout this report. Total coliform and *Escherichia coli* (*E. coli*) sampling results were compared to the Idaho Ground Water Quality Standards set forth in Idaho’s Ground Water Quality Rule (IDAPA 58.01.11), rather than national regulations. The single samples collected during these projects were not appropriate for comparison to the national standards, which are based on exceedances during a month-long sampling period.

DEQ also responds to detections of contaminants of concern that are identified by monitoring programs implemented by other entities, such as the Statewide Ambient Ground Water Quality Monitoring Program, administered by IDWR. Follow-up investigations may develop into a DEQ local or regional monitoring project to assess conditions and identify areas where public health may be threatened. The investigation results can facilitate management decisions that protect the resource and promote public awareness for ground water protection.

Field measurements taken during follow-up investigations and monitoring projects should be considered estimates and are not used for determining exceedances at PWS wells. They are used to monitor well water during purging to ensure water in the wellbore is removed from the well prior to sampling. Field measurements are also used to qualitatively evaluate water quality variability between wells.

The ground water quality monitoring results can also be used to define and prioritize degraded ground water quality areas, such as nitrate priority areas (NPAs). In 2014, DEQ identified 34 areas in the state as having elevated concentrations of nitrate in ground water. These NPAs are ranked based on population, water quality, and water quality trends. The basis for an NPA is that 25% or more of the wells sampled within the designated area have nitrate concentrations that meet or exceed 5 milligrams per liter (mg/L). EPA has established an MCL for nitrate at 10 mg/L, and Idaho adopted this MCL as the Ground Water Quality Standard. The NPAs are re-evaluated and reranked approximately every 5 years. Additional information about NPA delineation and ranking is available from the *2014 Nitrate Priority Area Delineation and Ranking Process* document (DEQ 2014a).

Prioritization is necessary to effectively allocate resources for water quality improvement strategies. DEQ has worked in coordination with state and federal agencies, as well as stakeholders, to develop ground water quality improvement plans, also known as ground water quality management plans, that address ground water degradation in NPAs. Ground water quality data are used to evaluate the effectiveness of plan implementation.

The Ground Water Program at DEQ has implemented regional ground water monitoring using a statistically based approach to determine the monitoring network design. Most of these regional projects have focused in areas designated as NPAs. This report provides an overview of DEQ's ground water monitoring projects and investigation activities accomplished with public funds during 2015. It does not include results from privately funded activities, including monitoring required by permits and monitoring associated with ongoing environmental remediation projects, Kootenai County Aquifer Protection District funding, or PWS requirements.

2 Summary of Ground Water Quality Projects by Region

This section presents data from ground water quality monitoring and investigation projects that were conducted by DEQ in calendar year 2015. Projects are presented by DEQ regional office and identified in Figure 1.

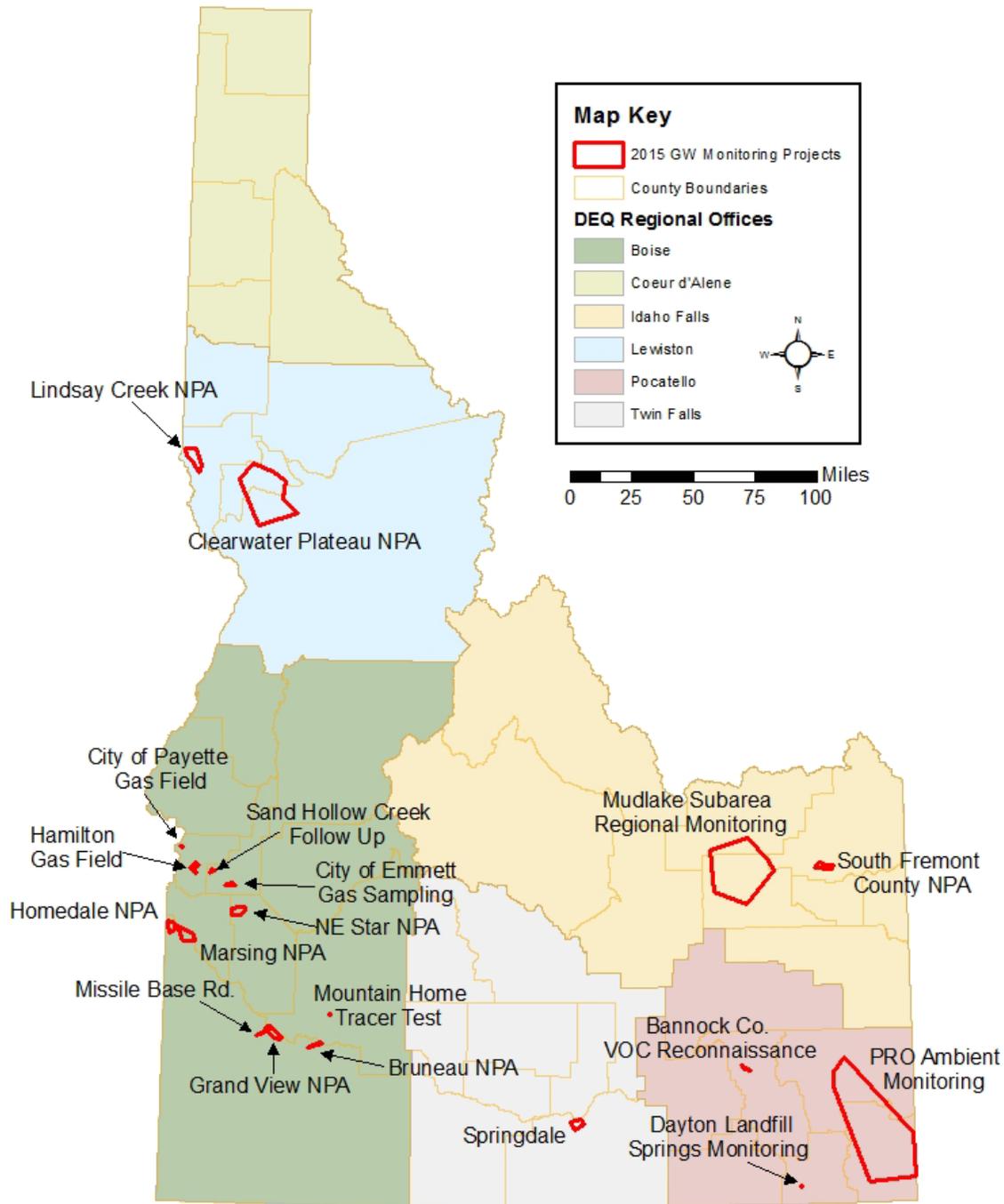


Figure 1. Idaho Department of Environmental Quality 2015 ground water quality project locations by region.

All ground water quality data contained in this section are available through an [interactive mapping application](#) available on DEQ's website. The application contains ground water quality data that DEQ or its contractors have collected from 1987 to the present. The application can be used to view and download data collected for over 350 contaminants, ranging from nitrate—a widespread ground water contaminant—to emerging contaminants such as personal care products and pharmaceuticals. The application was developed to help citizens, local officials, researchers, water quality professionals, consultants, and other stakeholders make informed decisions about land-use activities. The application also provides private well owners with an indication of ground water quality conditions in an area when considering treatment options for protecting their family's health.

2.1 Boise Region

Eleven ground water quality monitoring projects were conducted in the Boise region in 2015 using public funds.

2.1.1 Bruneau Nitrate Priority Area Ground Water Monitoring Project

2.1.1.1 Purpose and Background

This ground water monitoring project was designed to evaluate the water quality and nitrate concentrations in the Bruneau NPA in Owyhee and Elmore Counties, northwest of Bruneau, Idaho (Figure 2). In 2014, the Bruneau NPA ranked as the 8th-most impacted NPA in Idaho. The Bruneau NPA is bound by the Snake River to the north, CJ Strike Reservoir to the west, and by a portion of CJ Strike Reservoir known as the Bruneau Arm to the south. The northeastern section of the NPA is intersected by the Snake River, resulting in a portion of the NPA extending into Elmore County. The primary land use in the Bruneau NPA is agriculture, including both cropland and confined animal feeding operations. All of the residences within the NPA are served by private wells.

DEQ's review of well logs confirmed the presence of a blue clay confining layer between 105 and 600 feet below ground surface (bgs) in the Owyhee County portion of the NPA. The Elmore County portion of the NPA does not appear to have a solid blue clay confining layer; instead, a sandy clay layer can be found at 101 feet bgs. Typically these confining or lower permeable materials form confining units that can separate shallow aquifers from deeper aquifers. Project wells were generally completed at depths ranging from 60 to 592 feet bgs. Attempts were made by project staff to sample wells in the uppermost aquifer (completed above confining layers). The ground water flow direction is not well characterized within the Bruneau NPA and may be influenced by the Snake River (Figure 2).

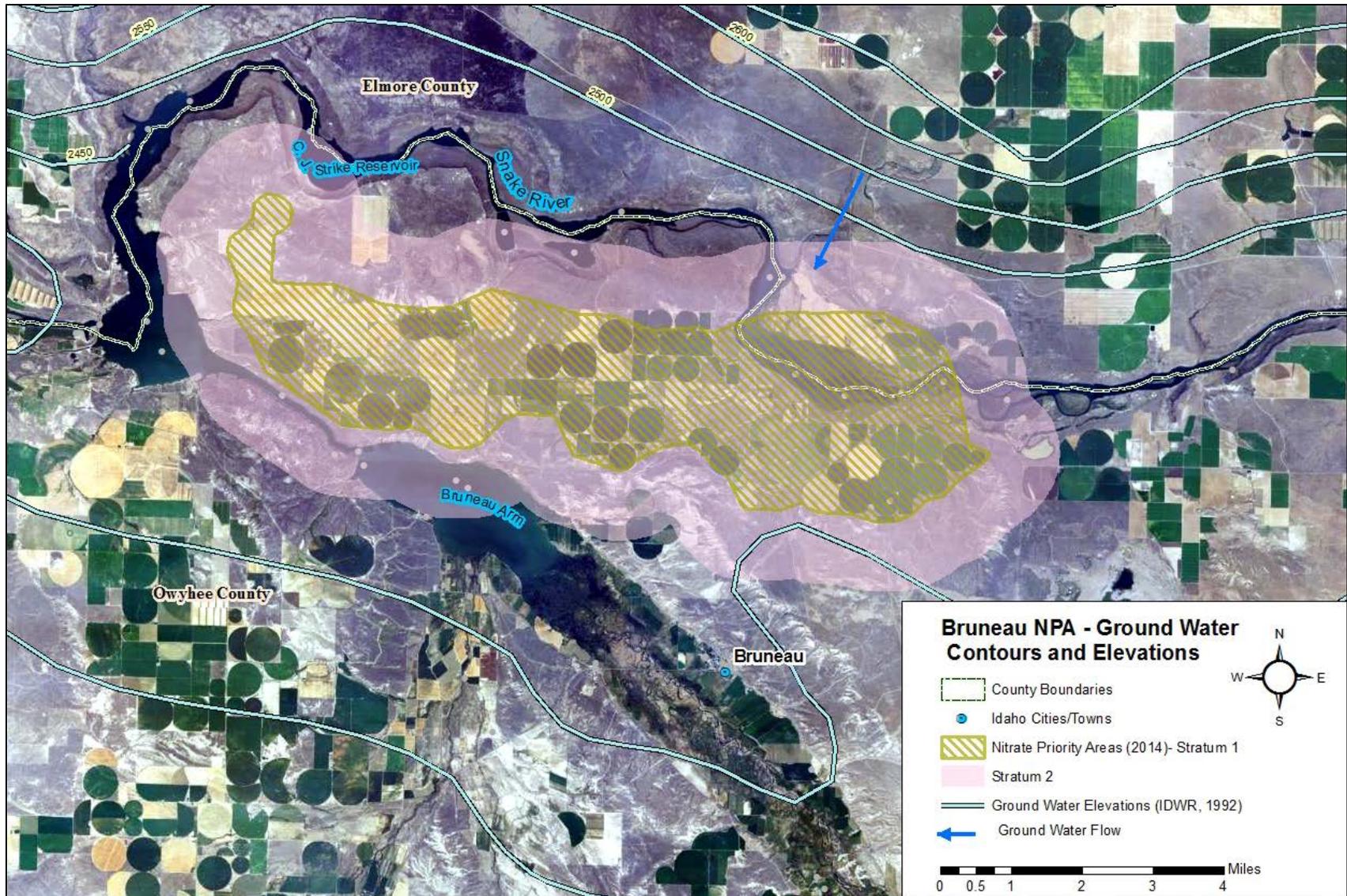


Figure 2. Bruneau NPA and ground water contours and elevations—Bruneau Nitrate Priority Area Ground Water Monitoring Project.

In 2015, DEQ collected ground water samples from six domestic and/or irrigation wells in the Bruneau NPA. Program objectives, design, and well selection processes are identified in the regional ground water monitoring network design (DEQ 2011a). DEQ analyzed the ground water samples for common water quality analytes including nitrate, nitrite, and bacteria (total coliform and *E. coli*) to assess the water quality in the project area.

2.1.1.2 Methods and Results

The Bruneau NPA is a medium-sized monitoring area as defined in the regional ground water monitoring network design (DEQ 2011a) and requires a statistical analysis to determine the number of wells needed to meet a certain confidence level criteria; however, there are only 11 wells with well logs located within either the Bruneau NPA (Stratum 1) or the 1-mile buffer around the Bruneau NPA (Stratum 2). Currently, 4 of the 11 wells (with well logs) are included in the IDWR statewide monitoring network and generally not sampled by DEQ. Due to the lack of wells with available well logs in the Bruneau NPA, the statistical method for selecting the number of wells in a medium-sized monitoring area would not produce statistically valid results. As such, the Bruneau NPA was treated as a small-sized monitoring area and the census sampling method (sampling all qualifying wells) was used, as described in the regional ground water monitoring network design (DEQ 2011a). A total of six wells were sampled as part of this project, with four wells in Stratum 1 and two wells in Stratum 2. Of the six wells sampled, five were located north of the Snake River, in Elmore County, and one was located south of the Snake River in Owyhee County (Figure 3).

DEQ staff confirmed through coordination with ISDA and IDWR and a query of DEQ's ground water database that five of the six wells had not been previously sampled (by ISDA, IDWR, or DEQ); one well (2477) was sampled by IDWR in 2004 and 2009. IDWR did not object to DEQ sampling this well in 2015. Permission was obtained from the well owners for DEQ staff to access all six wells and collect samples for laboratory analysis. The owner of Well 2478 included a note with his permission form indicating there were several tons of "rotten" potatoes buried close to his well.

Samples were collected in September 2015 from each well in accordance with the appropriate quality assurance project plan (QAPP) (DEQ 2014b) and field sampling plan (FSP) (DEQ 2015a).

Water quality field parameters (pH, temperature, specific conductivity, and dissolved oxygen [DO]) were measured at each well prior to sample collection (Table 1). Field measurements are used to monitor well water during purging to ensure water in the wellbore is removed from the well prior to sampling. When field parameters stabilize, samples are considered to be representative of ground water in the aquifer. Field measurements are also used to qualitatively evaluate water quality variability between wells.

Table 1. Water quality field parameters—Bruneau Nitrate Priority Area Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	Sample Date	Water Temperature (°C)	pH ^a	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)
2476	101	9/14/2015	16.67	6.99	868	1.97
2477	60	9/14/2015	18.01	7.35	1,170	4.66
2478	60	9/14/2015	15.64	7.31	1,500	2.04
2479	80	9/14/2015	17.05	7.45	975	3.93
2480	592	9/14/2015	23.32	7.85	681	2.11
2481	115	9/14/2015	18.89	7.93	386	1.63

Note: microsiemens per centimeter (µS/cm)

^a Contaminant with a National Secondary Drinking Water Regulation standard. The NSDWR for pH is 6.5-8.5. NSDWR standards are recommended limits for public water systems but can be applied to private wells to evaluate water quality.

Samples collected from each well were analyzed for nitrate, nitrite, total coliform (TC), and *E. coli* (Table 2). Wells with a DO less than 2.00 mg/L, as determined by field analysis, were also analyzed for ammonia as required by the FSP. Nitrogen isotope samples were collected at each sampling location, frozen, and stored at DEQ pending nitrate analysis. After DEQ received nitrate analysis results, those nitrogen isotope samples from wells with nitrate concentrations greater than 5 mg/L were sent to the University of Arizona Environmental Isotope Geosciences Laboratory in Tucson for nitrogen isotope analysis.

Table 2. Inorganic and bacteria results—Bruneau Nitrate Priority Area Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	Sample Date	Nutrient Concentrations				Bacteria	
			Ammonia	Nitrate ^a	Nitrite ^a	δ ¹⁵ N (‰)	Total Coliform ^b	<i>E. coli</i> ^b
<i>Primary or Secondary Standard:</i>			NA	10	10	NA	1 cfu/100 mL	<1 cfu/100 mL
2476	101	9/14/2015	0.33	5.69	<0.30	7.8	<1.0	<1.0
2477	60	9/14/2015	NA	19.0	<0.30	7.4	<1.0	<1.0
2478	60	9/14/2015	NA	7.23	<0.30	8.0	<1.0	<1.0
2479	80	9/14/2015	NA	1.54	<0.30	NA	<1.0	<1.0
2480	592	9/14/2015	NA	0.299	<0.30	NA	<1.0	<1.0
2481	115	9/14/2015	0.81	<0.18	<0.30	NA	<1.0	<1.0

Notes: Bolded red numbers indicate EPA's National Primary Drinking Water Regulation (NPDWR) standard, expressed as a maximum contaminant level (MCL), was reached or exceeded. These regulations are applicable for public water systems only but are recommended limits and can be applied to private wells to evaluate water quality.

^a Contaminant with a National Primary Drinking Water Regulation standard.

^b Total coliform and *E. coli* standards are from the Idaho Ground Water Quality Rule (IDAPA 58.01.11.200). An exceedance of the primary ground water quality standard for total coliform is not a violation of these rules. Total coliform is not a health threat in itself; it is used to indicate whether other potentially harmful bacteria may be present. Although the standards are given in colony-forming units per 100 milliliters (cfu/100 mL), analytical results provided in most probable number per 100 milliliters (MPN/100 mL) are acceptable for comparison to the standard.

Nitrate Results

The reported nitrate concentrations ranged from <0.18 mg/L to 19.0 mg/L; three of the six wells sampled (2476, 2477, and 2478) had nitrate concentrations of 5 mg/L or greater. The nitrate MCL of 10 mg/L was exceeded in one sample (Well 2477). The spatial distribution of nitrate concentrations is shown in Figure 3.

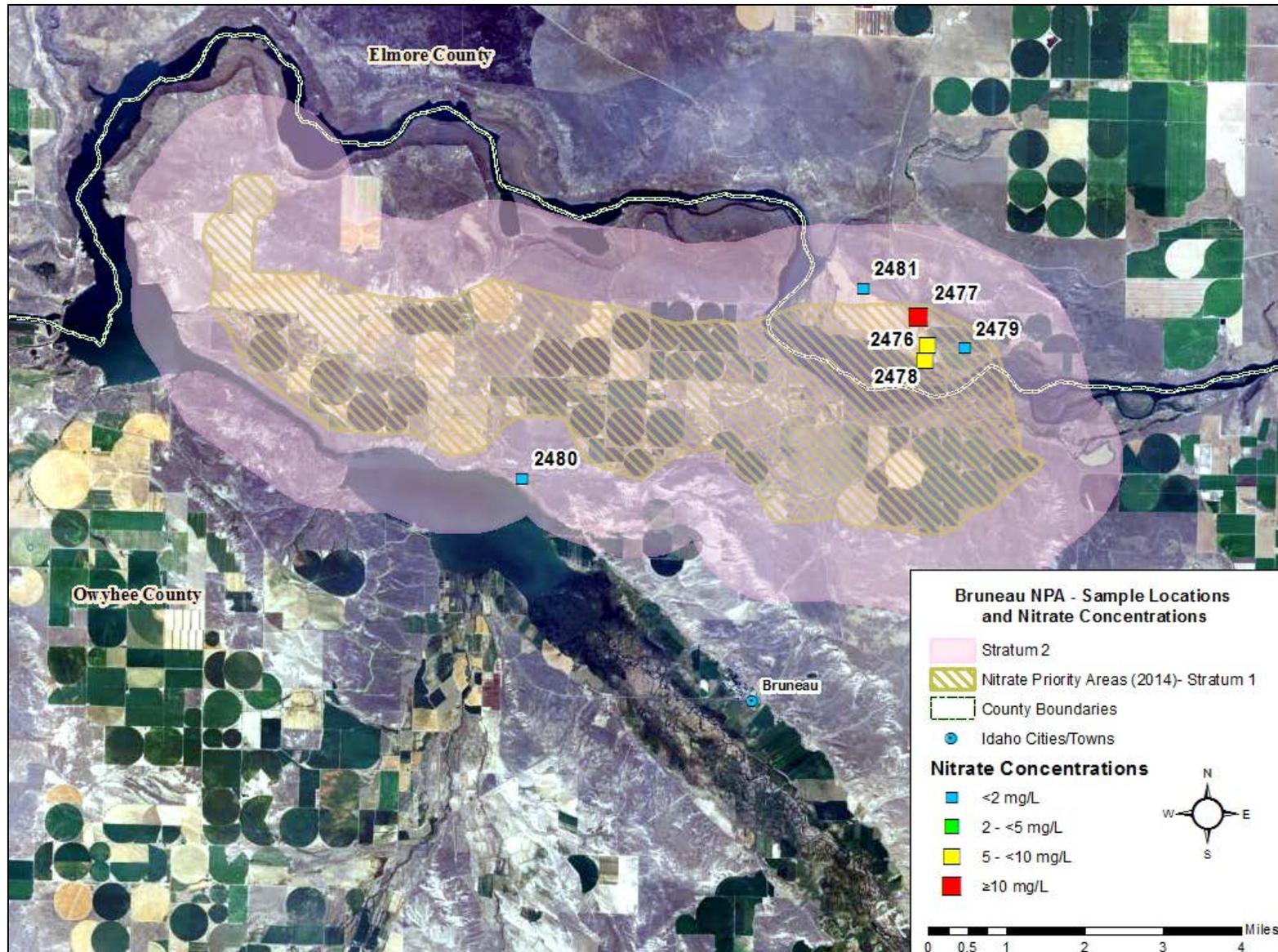


Figure 3. Sample locations and nitrate concentrations—Bruneau Nitrate Priority Area Ground Water Monitoring Project 2015.

Bacteria Results

TC bacteria are a group of bacteria common in the environment (such as soil) and are generally not harmful. *E. coli* bacteria (a type of coliform bacteria) are found in animal fecal matter. The presence of *E. coli* in ground water provides strong evidence that human or animal fecal waste is present; therefore, a greater potential for pathogenic organisms exists. TC and *E. coli* concentrations are reported in the most probable number per 100 milliliters (MPN/100 mL). All six wells were negative for both TC and *E. coli*.

Nitrogen Isotope Results

Nitrogen isotope ratios, denoted as $\delta^{15}\text{N}$, can be helpful in determining the potential sources of nitrate in the ground water. Nitrogen isotope ratios were determined for the three samples with nitrate concentrations greater than or equal to 5 mg/L (Table 2). Nitrogen from human or animal waste and fertilizer sources has distinguishable $\delta^{15}\text{N}$ signatures. Typical $\delta^{15}\text{N}$ values for various nitrogen sources are listed in Table 3.

Table 3. Typical $\delta^{15}\text{N}$ values from various nitrogen sources

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

Source: Seiler 1996

The $\delta^{15}\text{N}$ results for this project ranged from 7.4‰ to 8.0‰ (Table 2). All three $\delta^{15}\text{N}$ values were in the +4‰ to +9‰ range, suggesting the source of nitrate in the ground water is most likely from organic nitrogen in soil or a mixed nitrogen source (Seiler 1996).

Ammonia Results

Ammonia samples were collected for the 2 wells (2476 and 2481) with a DO field measurement of less than 2.00 mg/L, per the project FSP (DEQ 2015a). The ammonia concentrations at Wells 2476 and 2481 were 0.33 mg/L and 0.81 mg/L, respectively (Table 2). There is currently no MCL for ammonia.

2.1.1.3 Conclusions

A total of six wells were sampled in September 2015 as part of the Bruneau NPA Ground Water Monitoring Project. Four of the six wells are located within Stratum 1; two wells are located within Stratum 2. All Stratum 1 wells are located in the Elmore County portion of the NPA. The primary land use in the Bruneau NPA is agriculture in the form of cropland and confined animal feeding operations.

The criterion for an NPA is at least 25% of the wells sampled within the area meet or exceed 5 mg/L nitrate. This value is half the MCL of 10 mg/L. In this project, three of the six wells sampled (50%) had nitrate values ≥ 5 mg/L. The nitrate MCL of 10 mg/L was exceeded in one of these samples; Well 2477 had a concentration of 19.0 mg/L (Table 2). Well 2477 was drilled in

1991 to a depth of 60 feet bgs and completed in a subsurface pit, adjacent to a cultivated field. The older well construction, shallower depth, and close proximity to nitrogen sources could be contributing to the elevated concentrations in ground water at this well. Other potential sources of nitrate, such as the owner's septic system, were not evaluated as part of this project.

The three wells (2476, 2477, and 2478) with elevated nitrate concentrations are located in an area within Elmore County with agricultural cropland and several confined animal feeding operations. Due to the uncertainty of ground water flow in the project area, these sources may be a potential source of nitrate. The isotopic signature of the nitrate at these locations is consistent with organic nitrogen in the soil or mixed sources, which could be reflective of the agricultural activities in the area.

Additionally, the owner of Well 2478 indicated that there were several tons of rotten potatoes buried close to his well. While DEQ was sampling Well 2478, the owner stated that the property owner to the east had dug trenches in the fall and buried "rotten" potatoes in the trenches. This account by the homeowner has not been confirmed by DEQ staff; however, if true, the burial of waste (cull) potatoes may be a contributing factor to the nitrogen levels in Wells 2476 and 2478.

2.1.1.4 Recommendations

DEQ recommends that property owners with private domestic drinking water wells sample their well on an annual basis. Southwest District Health can provide Owyhee County property owners with information and guidance. Central District Health can provide Elmore County property owners with information and guidance.

In addition, property owners may benefit from education on the use of commercial fertilizers and pesticides on their lawns and gardens and education on proper maintenance of their wells and septic systems. DEQ has assisted Owyhee County and Elmore County in developing and implementing ground water quality improvement and drinking water source protection plans (DEQ 2010a, 2014c). These plans include information for private well owners aimed at reducing source water contamination, including activities to reduce nitrate contamination.

DEQ will review the Bruneau NPA boundary during the next 5-year reranking of the NPAs. IDWR currently samples four wells within the Owyhee County portion of the Bruneau NPA as part of its statewide monitoring program. Since DEQ generally does not sample wells monitored by ISDA or IDWR, DEQ will continue to rely on other state agency data within the Owyhee County portion of the Bruneau NPA unless other wells become available.

The owner of Well 2478 was encouraged to continue monitoring for nitrate, ammonia, and bacteria. If nitrate or ammonia increases over time in Well 2478, follow-up on the homeowner's report of disposal of cull or waste potatoes is recommended.

2.1.2 City of Emmett Baseline Ground Water Monitoring Project

2.1.2.1 Purpose and Background

Southwest Idaho has become an area of interest for natural gas development since the discovery of production quantities of natural gas in Payette County. Establishing and developing natural gas fields includes, but is not limited to, well drilling and drilling-related activities,

treatment/enhancement of wells to increase production, gas production, pipeline construction, and other production-related activities. In April 2016, Idaho Department of Lands reported 8 producing oil and gas wells and 9 oil and gas wells identified as “shut-in pending pipeline” in southwest Idaho; all 17 gas wells are located in Payette County.

Gem County is located in southwest Idaho to the east of Payette County and in the western Snake River Plain. The majority of agricultural and other development is along the Payette River, which flows from east to west in southern Gem County.

The general aquifer system in the western Snake River Plain includes three units: an upper and middle unit of sedimentary deposits and volcanic rock and a lower unit of volcanic rock. Wells completed in the upper unit generally produce water from sand or gravel layers. A layer of blue-colored clay is often found within the upper unit, which acts as a barrier to downward ground water movement and separates the shallow aquifer from deeper aquifers (Newton 1991).

In spring 2015, the City of Emmett (in Gem County) and DEQ discussed initiating ground water quality monitoring of the city’s PWS wells prior to establishing or developing natural gas fields in Gem County. On August 12, 2015, DEQ and the city signed an agreement to mutually conduct a project to assess the quality of ground water at four public water supply wells owned by the city. The agreement stated that DEQ would sample the wells, review sample analytical data, and provide the city with a summary and interpretation of the sample analyses. The city would provide access to the wells and be responsible for the costs of sample shipment and laboratory analyses.

The City of Emmett Baseline Ground Water Monitoring Project was designed to provide baseline water quality data at four city-owned PWS wells. Constituents chosen for laboratory analysis were selected based on identifying changes in aquifer chemistry potentially resulting from natural gas field development.

2.1.2.2 Methods and Results

On November 17, 2015, DEQ collected water samples from the four project wells using procedures outlined in the QAPP (DEQ 2015b) and FSP (DEQ 2015c). Three of the wells (Wells 2580, 2581, and 2582) are located within or directly adjacent to the Emmett city limits; one well (2583) is located approximately 2.5 miles west of Emmett (Figure 4). Water samples were collected from sampling points located prior to any water treatment. Water quality field parameters (pH, temperature, specific conductivity, and DO) were measured at each well prior to sample collection (Table 4).

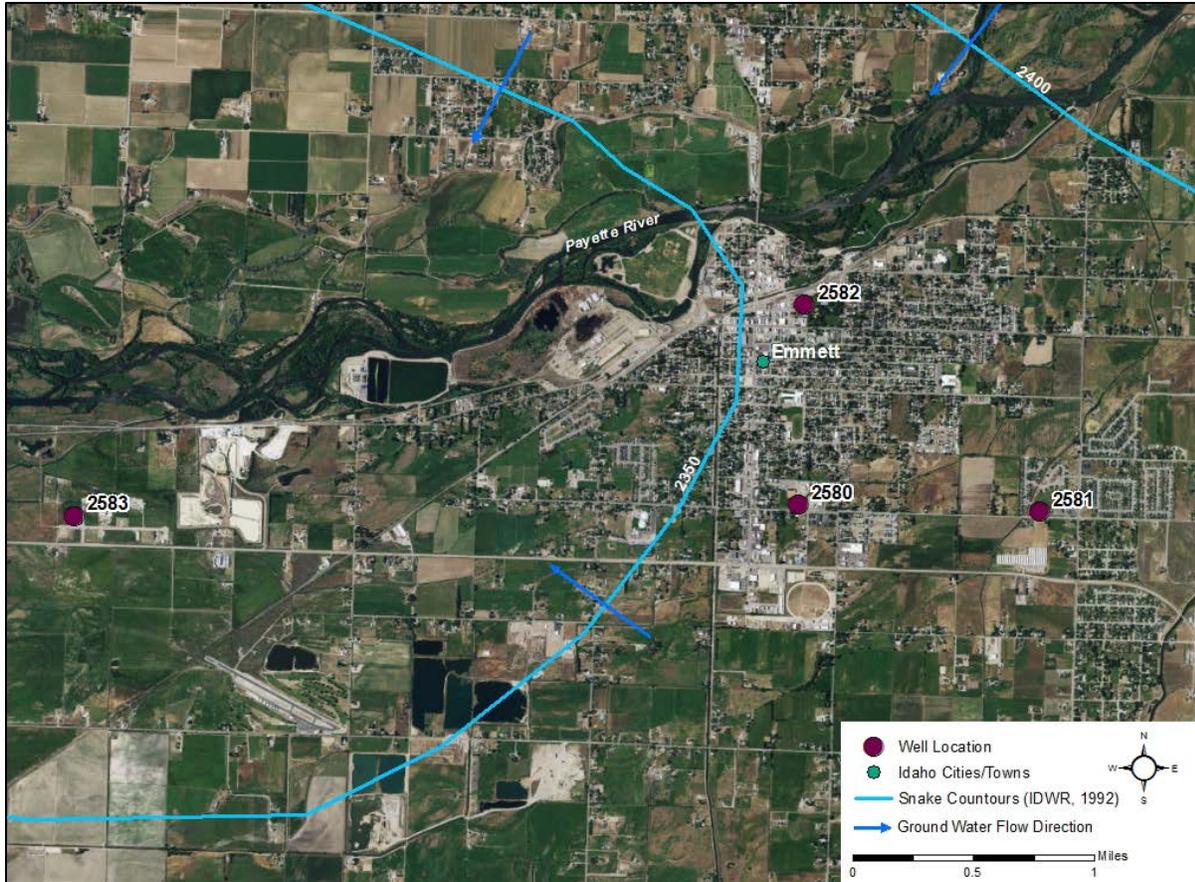


Figure 4. Locations of project wells—City of Emmett Baseline Ground Water Monitoring Project 2015.

The water samples were submitted to ESC Lab Sciences (ESC) in Mount Juliet, Tennessee, using procedures outlined in the QAPP and FSP. ESC analyzed the samples for major ions (cations and anions) that included bromide, chloride, sulfate, calcium, and potassium; metals (arsenic, barium, boron, chromium, iron, manganese, selenium, and uranium); total dissolved solids (TDS); alkalinity (reported as calcium carbonate [CaCO_3]); hydrocarbons (methane, ethane, ethene, benzene, toluene, ethylbenzene, and total xylenes (m+p-xylene and o-xylene)); and total petroleum hydrocarbons (high fraction/diesel range organics). Table 4 presents the field parameters measured during sample collection; Table 5 presents the laboratory analyses for major ions, TDS, and alkalinity; Table 6 presents the laboratory analyses for metals; and Table 7 presents the laboratory analyses for hydrocarbons.

Table 4. Water quality field parameters—City of Emmett Baseline Ground Water Monitoring Project.

DEQ Well ID	Project Well Name	Well Depth (feet)	Sample Date	Water Temperature (°C)	pH ^a	Specific Conductance (µS/cm)	Dissolved Oxygen (mg/L)
2580	No. 8	319	11/17/2015	18.5	8.1	290	4.13
2581	No. 9	535	11/17/2015	19.5	7.9	359	5.09
2582	No. 6	202	11/17/2015	16.1	6.9	455	3.34
2583	No. 1	133	11/17/2015	11.7	8.1	280	8.63

^a Contaminant with a National Secondary Drinking Water Regulation standard. The NSDWR for pH is 6.5-8.5. NSDWR standards are recommended limits for public water systems but can be applied to private wells to evaluate water quality.

Table 5. Major ions, total dissolved solids, and alkalinity—City of Emmett Baseline Ground Water Monitoring Project.

DEQ Well ID	Project Well Name	Well Depth (feet)	Sample Date	Major Ions (mg/L)					Total Dissolved Solids ^a (mg/L)	Alkalinity (as CaCO ₃) (mg/L)
				Bromide	Chloride ^a	Sulfate ^a	Calcium	Potassium		
<i>Primary or Secondary Standard:</i>				<i>NA</i>	<i>250</i>	<i>250</i>	<i>NA</i>	<i>NA</i>	<i>500</i>	<i>NA</i>
2580	No. 8	319	11/17/2015	<1.00	8.27	6.98	18.8	<1.00	234	110
2581	No. 9	535	11/17/2015	<1.00	10.8	37.0	33.2	1.65	197	109
2582	No. 6	202	11/17/2015	<1.00	12.6	45.5	40.8	3.43	234	141
2583	No. 1	133	11/17/2015	<1.00	5.46	<5.00	10.3	<1.00	154	119

^a Contaminant with a National Secondary Drinking Water Regulation standard. NSDWR standards are recommended limits for public water systems but can be applied to private wells to evaluate water quality.

Table 6. Metals—City of Emmett Baseline Ground Water Monitoring Project.

DEQ Well ID	Project Well Name	Well Depth (feet)	Sample Date	Metals (mg/L)							Uranium ^a (µg/L)
				Arsenic ^a	Barium ^a	Boron	Chromium ^a	Iron ^b	Manganese ^b	Selenium ^a	
<i>Primary or Secondary Standard:</i>				<i>10</i>	<i>2</i>	<i>NA</i>	<i>100</i>	<i>0.3</i>	<i>0.05</i>	<i>50</i>	<i>30</i>
2580	No. 8	319	11/17/2015	<0.00200	<0.00500	<0.200	<0.00200	0.136	0.0394	<0.00200	<0.0100
2581	No. 9	535	11/17/2015	<0.00200	<0.00500	<0.200	<0.00200	<0.100	<i>0.164</i>	<0.00200	<0.0100
2582	No. 6	202	11/17/2015	0.00372	0.00709	<0.200	<0.00200	<i>0.313</i>	<i>0.0947</i>	<0.00200	<0.0100
2583	No. 1	133	11/17/2015	<0.00200	0.00549	<0.200	<0.00200	<0.100	0.0200	<0.00200	<0.0100

Notes: Italicized red numbers indicate EPA's National Secondary Drinking Water Regulation standard was exceeded. These regulations are applicable for public water systems only but are recommended limits and can be applied to private wells to evaluate water quality. Microgram per liter (µg/L).

^a Contaminant with a National Primary Drinking Water Regulation standard

^b Contaminant with a National Secondary Drinking Water Regulation standard

Table 7. Hydrocarbons—City of Emmett Baseline Ground Water Monitoring Project.

DEQ Well ID	Project Well Name	Well Depth (feet)	Sample Date	Hydrocarbons (µg/L)							Total Petroleum Hydrocarbons—High Fraction/ Diesel Range Organics (mg/L)
				Methane ^a	Ethane	Ethene	Benzene ^b	Toluene ^b	Ethylbenzene ^b	Total Xylenes ^b	
<i>Primary Standard:</i>				<i>NA</i>	<i>NA</i>	<i>NA</i>	<i>5</i>	<i>1,00</i>	<i>700</i>	<i>10,000</i>	<i>NA</i>
2580	No. 8	319	11/17/2015	4,510	<13.0	<13.0	<1.00	<5.00	<1.00	<1.00	0.225
2581	No. 9	535	11/17/2015	610	<13.0	<13.0	<1.00	<5.00	<1.00	<1.00	0.115
2582	No. 6	202	11/17/2015	396	<13.0	<13.0	<1.00	<5.00	<1.00	<1.00	0.156
2583	No. 1	133	11/17/2015	31.1	<13.0	<13.0	<1.00	<5.00	<1.00	<1.00	<0.100

^a The US Department of the Interior Office of Surface Mining advises well owners with dissolved methane levels greater than 28 mg/L (28,000 µg/L) to immediately remove any potential ignition sources and vent the gas away from any confined spaces (Eltschlager et al. 2001).

^b Contaminant with a National Primary Drinking Water Regulation standard.

General Ground Water Chemistry (Major Ions, TDS and Alkalinity) Results

The four project wells were sampled for the following major ions to evaluate the general ground water chemistry: bromide, chloride, sulfate, calcium, and potassium. Samples were also analyzed for TDS and alkalinity (as CaCO₃). Concentrations of chloride and TDS did not exceed EPA's NSDWR standards.

Metals Results

Iron was detected in two of the four samples. Well 2582 exceeded the NSDWR standard of 0.3 mg/L with a concentration of 0.313 mg/L.

Manganese was detected in all four samples. Well 2581 (0.164 mg/L) and Well 2582 (0.0947 mg/L) exceeded the NSDWR standard of 0.05 mg/L

Arsenic and barium were detected at low concentrations in Well 2582 (Table 6). Boron, chromium, selenium, and uranium were not detected above the laboratory reporting limit.

Hydrocarbon Results

Methane was detected in all four samples at concentrations ranging from 0.0311 mg/L (Well 2583) to 4.51 mg/L (Well 2580). There is no MCL or NSDWR standard for dissolved methane in ground water. The hazard with methane in ground water results when dissolved methane exsolves (outgasses) from the water into the surrounding air or a confined space, where it can potentially ignite and/or explode.

Total petroleum hydrocarbons (TPH) (high fraction/diesel range organics) were detected in three samples (Wells 2580, 2581, and 2582) at concentrations ranging from 0.115 mg/L to 0.180 mg/L. There is currently no MCL or NSDWR standard for TPHs in ground water.

2.1.2.3 Conclusions

As a result of interest in natural gas production within neighboring Payette County, the City of Emmett requested assistance from DEQ to help determine baseline ground water quality in its PWS wells. In November 2015, DEQ collected samples from four city-owned wells. The samples were analyzed for major ions, alkalinity, TDS, metals, and hydrocarbon constituents including dissolved methane; benzene, toluene, ethylbenzene, and xylene (BTEX); and TPH (high fraction/diesel range organics).

Sample results indicated concentrations of either iron or manganese above the NSDWR standard in two of the four wells. Dissolved methane was detected at low-level concentrations in all four samples. Low concentrations of TPH were also detected in three of the four samples (Wells 2580, 2581, and 2582). Well 2583 had slightly different water chemistry than the other wells as shown by the lower concentrations of chloride, sulfate, calcium, and TDS. Well 2583 had low level detections of barium and magnesium; however, it had no detections of BTEX or TPH above the laboratory reporting limits. Well 2583 is located downgradient and approximately 2.5 miles east of Well 2580, which is the eastern most well of the other three wells. This spatial difference could be a contributing factor in the difference in water quality parameters.

2.1.2.4 Recommendations

Ground water monitoring at the project wells should be continued to establish background ground water quality and identify if ground water quality varies seasonally or if annual trends exist.

2.1.3 Grand View Nitrate Priority Area Ground Water Monitoring Project

2.1.3.1 Purpose and Background

This ground water monitoring project was designed to evaluate the water quality and nitrate concentrations in the Grand View NPA in Owyhee County (Figure 5). The monitoring results will be used by DEQ in future NPA delineation and ranking activities. Data collected for this project may also be used to identify a local monitoring project to determine potential sources and the extent of constituents exceeding a health standard. In 2014, the Grand View NPA ranked as the 7th-most impacted NPA in Idaho.

In September 2015, DEQ collected ground water samples from 14 domestic and/or irrigation wells in the Grand View NPA. Program objectives, design, and well selection processes are identified in the regional ground water monitoring network design (DEQ 2011a). DEQ analyzed the ground water samples for nitrate, ammonia, nitrogen isotope, and bacteria (TC and *E. coli*) to assess the sources of nitrogen in ground water within the project area.

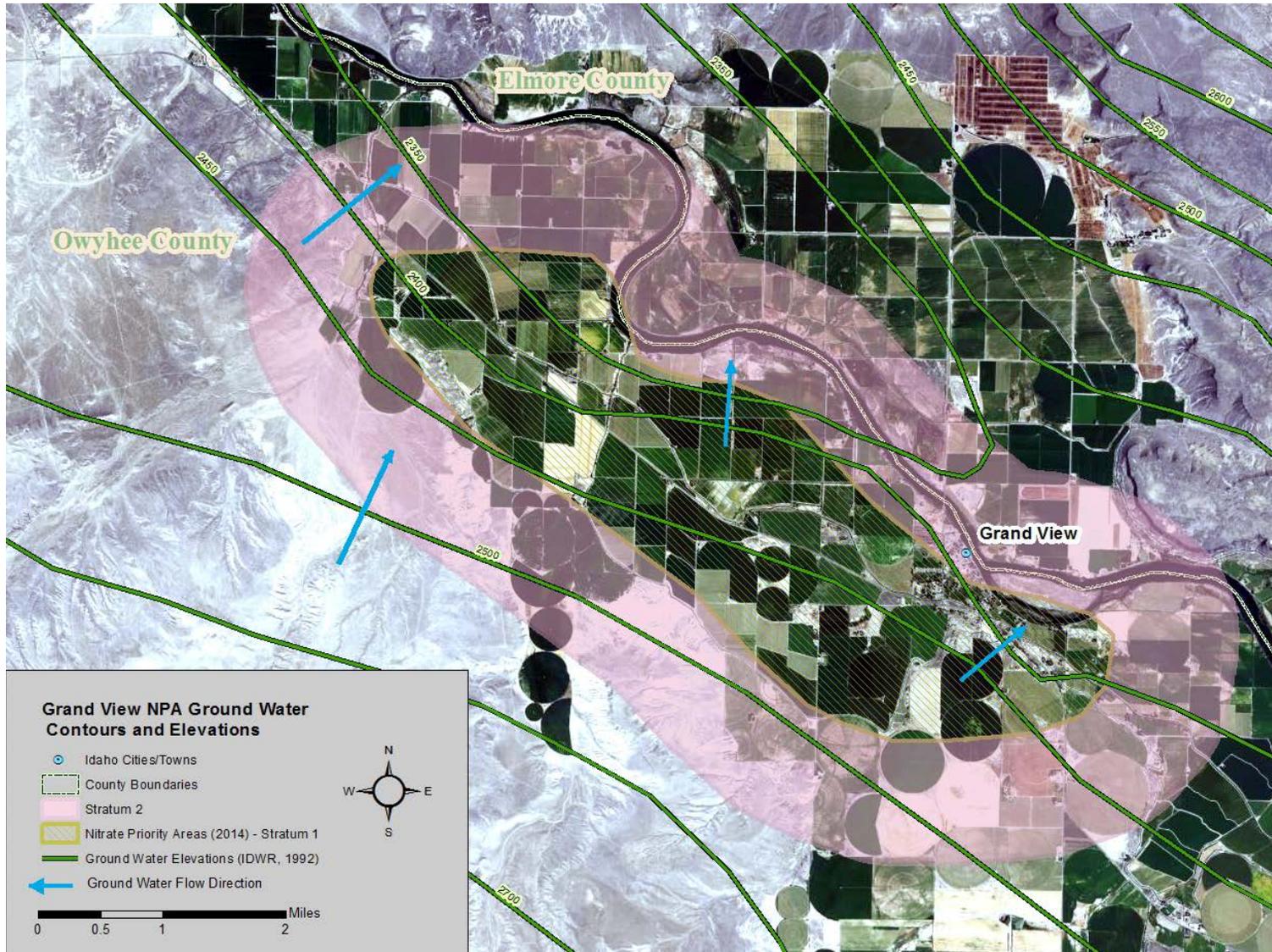


Figure 5. Grand View NPA and ground water contours and elevations—Grand View Nitrate Priority Area Ground Water Monitoring Project.

2.1.3.2 Methods and Results

The Grand View NPA is a small monitoring area as defined in the regional ground water monitoring network design (DEQ 2011a); therefore, the census sampling method (sampling all qualifying wells) was used. The area is primarily agricultural land with limited domestic wells.

A total of 14 wells were selected for this project; 12 are located within the 2014 NPA boundaries (Stratum 1) and 2 are in the 1-mile buffer zone (Stratum 2). DEQ staff confirmed 2 of the 14 wells (Wells 2484 and 2491) are part of an ISDA regional ground water monitoring project and have been sampled since 2000. ISDA did not object to DEQ sampling these wells in 2015. Permission was obtained from the well owners for DEQ staff to access all 14 wells and collect samples for laboratory analysis.

Samples were collected in September 2015 from each well in accordance with the QAPP (DEQ 2014b) and FSP (DEQ 2015d).

Water quality field parameters (i.e., pH, temperature, specific conductivity, and DO) were measured at each well prior to sample collection (Table 8).

Table 8. Water quality field parameters—Grand View Nitrate Priority Area Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	Sample Date	Water Temperature (°C)	pH ^a	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)
2482	100	9/21/2015	15.25	7.00	2,840	5.05
2483	35	9/21/2015	15.30	7.53	1,290	6.48
2484	50	9/22/2015	14.12	6.77	1,080	2.56
2485	840	9/21/2015	25.04	7.45	1,070	1.25
2486	79	9/22/2015	19.27	7.71	535	1.20
2487	34	9/21/2015	19.52	7.38	801	5.79
2488	81	9/21/2015	17.44	7.35	665	7.83
2489	40	9/22/2015	15.18	6.73	1,080	5.20
2490	51	9/22/2015	17.65	7.31	1,510	6.41
2491	78	9/21/2015	15.68	7.41	1,530	6.72
2492	42	9/22/2015	18.79	7.24	961	4.02
2493	48	9/21/2015	18.13	7.18	638	6.85
2494	120	9/21/2015	18.71	7.82	636	7.06
2495	80	9/21/2015	15.24	7.55	1,030	3.05

^a Contaminant with a National Secondary Drinking Water Regulation standard. The NSDWR for pH is 6.5-8.5. NSDWR standards are recommended limits for public water systems but can be applied to private wells to evaluate water quality.

Samples collected from each well were analyzed for nitrate, nitrite, TC, and *E. coli* (Table 9). Wells with a DO less than 2.00 mg/L as determined by field analysis were also analyzed for ammonia as required by the FSP. Nitrogen isotope samples were collected at each sampling location and frozen and stored at DEQ pending nitrate analysis. After DEQ received nitrate results, those nitrogen isotope samples from wells with nitrate concentrations greater than 5 mg/L were sent to the University of Arizona Environmental Isotope Geosciences Laboratory in Tucson for nitrogen isotope analysis.

Nitrate and Nitrite Results

Of the 14 wells samples, 12 wells had reportable concentrations of nitrate (Table 9) ranging from 0.669 mg/L to 106 mg/L; 8 wells (2482, 2483, 2484, 2489, 2490, 2491, 2492, and 2495) had nitrate concentration of 5 mg/L or greater. The nitrate MCL of 10 mg/L was exceeded in 4 wells (2482, 2483, 2490, and 2491). The spatial distribution of nitrate concentrations is shown in Figure 6.

All samples had reported nitrite concentrations less than the laboratory detection limit of 0.30 mg/L.

Table 9. Inorganic and bacteria results—Grand View Nitrate Priority Area Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	Sample Date	Nutrient Concentrations				Bacteria ^b	
			Ammonia	Nitrate ^a	Nitrite ^a	$\delta^{15}\text{N}$	Total Coliform	<i>E. coli</i>
			(mg/L)			(‰)	(MPN/100 mL)	
Primary or Secondary Standard:			NA	NA	10	1	1 cfu/100 mL	<1 cfu/100 mL
2482	100	9/21/2015	NA	106	<0.30	6.4	<1.0	<1.0
2483	35	9/21/2015	NA	19.5	<0.30	6.0	<1.0	<1.0
2484	50	9/22/2015	NA	5.19	<0.30	5.5	25.3	1.0
2485	840	9/21/2015	11.0	<0.18	<0.30	NA	<1.0	<1.0
2486	79	9/22/2015	0.21	<0.18	<0.30	NA	410.6	2.0
2487	34	9/21/2015	NA	3.73	<0.30	NA	<1.0	<1.0
2488	81	9/21/2015	NA	0.669	<0.30	NA	<1.0	<1.0
2489	40	9/22/2015	NA	6.10	<0.30	4.2	25.9	<1.0
2490	51	9/22/2015	NA	19.5	<0.30	7.1	<1.0	<1.0
2491	78	9/21/2015	NA	31.2	<0.30	5.6	<1.0	<1.0
2492	42	9/22/2015	NA	6.95	<0.30	5.5	2.0	<1.0
2493	48	9/21/2015	NA	0.808	<0.30	NA	9.8	<1.0
2494	120	9/21/2015	NA	3.81	<0.30	NA	488.4	<1.0
2495	80	9/21/2015	NA	6.31	<0.30	5.7	<1.0	<1.0

Notes: Bolded red numbers indicate either an EPA National Primary Drinking Water Regulation (NPDWR) standard, expressed as a maximum contaminant level (MCL), or an Idaho Ground Water Quality Rule (IDAPA 58.01.11.200) standard was reached or exceeded. These regulations are applicable for public water systems only but are used to evaluate water quality in private wells.

^a Contaminant with a National Primary Drinking Water Regulation standard.

^b Total coliform and *E. coli* standards are from the Idaho Ground Water Quality Rule (IDAPA 58.01.11.200). An exceedance of the primary ground water quality standard for total coliform (indicated by gray shaded numbers) is not a violation of these rules. Total coliform is not a health threat in itself; it is used to indicate whether other potentially harmful bacteria may be present. Although the standards are given in cfu/100 mL, analytical results provided in MPN/100 mL are acceptable for comparison to the standard.

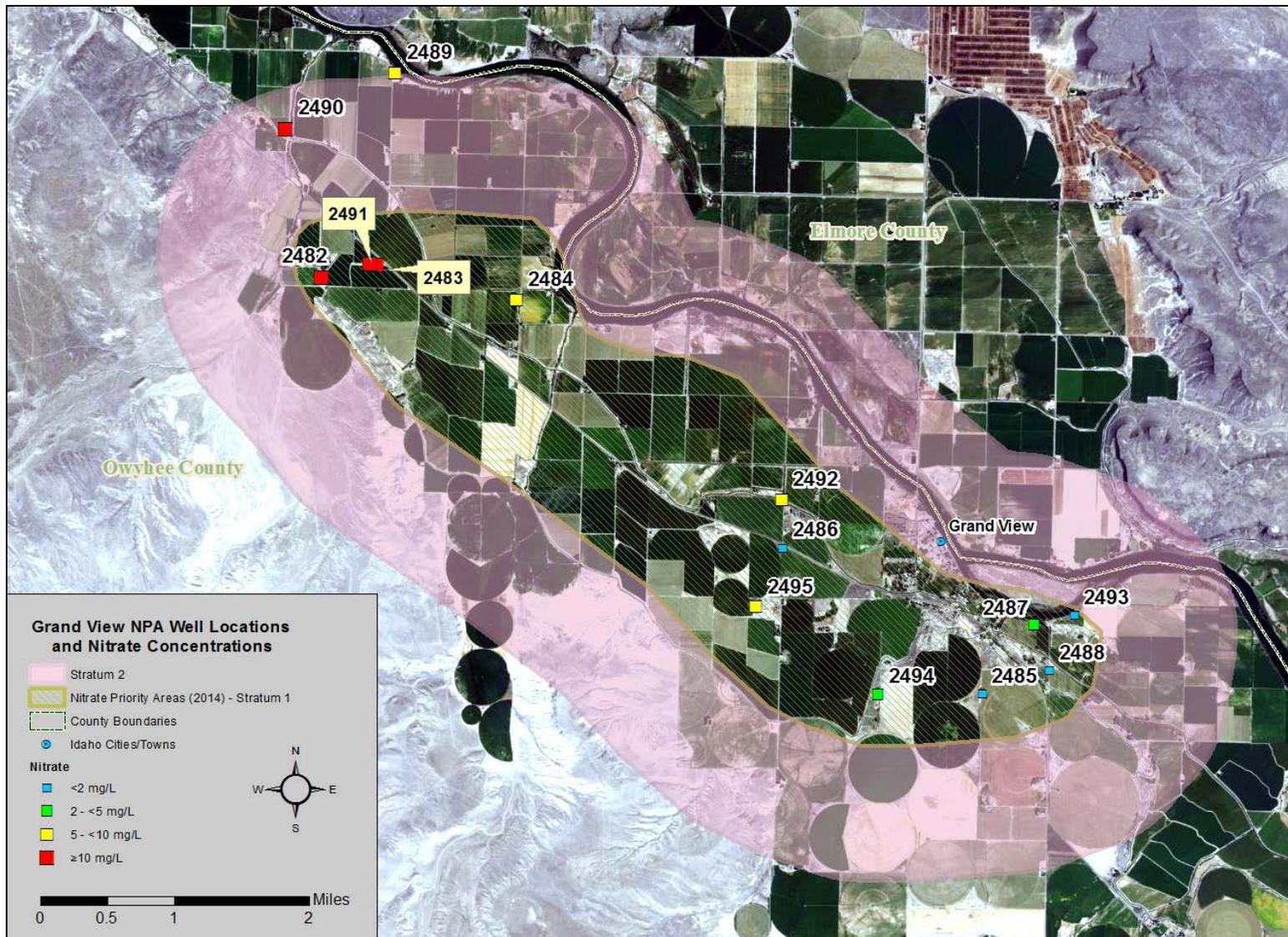


Figure 6. Sample locations and nitrate concentrations—Grand View Nitrate Priority Area Ground Water Monitoring Project.

Bacteria Results

The reported TC bacteria concentrations ranged from <1 MPN/100 mL to 488.4 MPN/100 mL; 6 of the 14 wells sampled were positive for TC (2484, 2486, 2489, 2492, 2493, and 2494) (Table 9). Wells 2484 and 2486 were positive for *E. coli* with concentrations of 1.0 MPN/100 mL and 2.0 MPN/100 mL, respectively. Homeowners were notified of the *E. coli* detections.

Nitrogen Isotope Results

Nitrogen isotope ratios, denoted as $\delta^{15}\text{N}$, can be helpful in determining the potential sources of nitrate in ground water. Nitrogen isotope ratios were determined for the 8 samples with nitrate concentrations greater than or equal to 5 mg/L (Table 9).

The $\delta^{15}\text{N}$ results from this project ranged from 4.2‰ to 7.1‰ (Table 9). All 8 wells with samples submitted for nitrogen isotope analysis had $\delta^{15}\text{N}$ values in the +4‰ to +9‰ range, suggesting the source of nitrate in the ground water is most likely from organic nitrogen in soil or a mixed nitrogen source (Table 3) (Seiler 1996).

Ammonia Results

Ammonia samples were collected for the 2 wells (2485 and 2486) with a DO measurement of less than 2.00 mg/L, per the project FSP. Well 2485 had a concentration of 11 mg/L and Well 2486 had a concentration of 0.21 mg/L (Table 9). Well 2485 is a relatively deep well with higher temperature (Table 8), which suggests that this well is unlikely impacted by surface sources of nitrogen and is more likely impacted by a naturally occurring ammonia source. There is no MCL for ammonia at this time.

2.1.3.3 Conclusions

This ground water monitoring project was designed to evaluate the water quality and nitrate concentrations in the Grand View NPA in Owyhee County. In 2014, the Grand View NPA ranked as the 7th-most impacted NPA in Idaho. The predominant land use in the NPA is agricultural. All of the residences within the NPA are served by private wells.

The criterion for an NPA is at least 25% of the wells sampled within the area meet or exceed 5 mg/L nitrate. This value is half of the MCL of 10 mg/L. A total of 14 wells were sampled within the Grand View NPA in September 2015; 8 (57%) had nitrate values of 5 mg/L or greater. The nitrate MCL of 10 mg/L was exceeded in 4 wells. Well 2482 (along Missile Base Road, south of Highway 72) continued to have an extremely high nitrate concentration of 106 mg/L, which is more than 10 times the MCL for nitrate. Wells that are side-gradient and downgradient of 2482 also have nitrate levels above the MCL. The $\delta^{15}\text{N}$ results from the 8 wells with nitrate over 5 mg/L suggest a mixture of organic nitrogen in soil, such as crop decay (e.g., legume crop plow down), or a mixed nitrogen source. This mixture of nitrogen sources is typical of an agricultural area.

Bacteria, both TC and *E. coli*, were positively detected in samples from project wells: 6 wells had positive concentrations of TC, 2 of which (Well 2484 and Well 2486) were also positive for *E. coli*. An in-depth review of potential sources for the bacteria in Wells 2484 and 2486 had not been conducted at the time of this report; however, both wells had low DO and Well 2486 had a

positive detection of ammonia with no nitrate, suggesting a possible waste source. Homeowners with positive bacteria detections were encouraged to disinfect their wells and contact the local health district with any questions or concerns.

2.1.3.4 Recommendations

DEQ will conduct further sampling of Wells 2482 and 2491 in an attempt to determine the source of high nitrate levels.

Property owners with private domestic drinking water wells should sample and analyze their well water for bacteria, arsenic, and nitrate on an annual basis. The Southwest District Health Department can provide property owners with information and guidance. In addition, property owners may benefit from education on the use of commercial pesticides on their lawns and gardens and education on proper well and septic system maintenance.

Land-use activities near the sites with elevated nitrate concentrations should be evaluated by the appropriate agency to determine if best management practice modifications should be implemented or improved to protect ground water quality from further degradation.

DEQ has assisted Owyhee County in developing and implementing the *Owyhee County Ground Water Quality Improvement and Drinking Water Source Protection Plan* (DEQ 2010a). This plan includes information for private well owners and agricultural operators aimed at reducing source water contamination, including activities to reduce nitrate contamination.

2.1.4 Hamilton Gas Field Ground Water Monitoring Project

2.1.4.1 Purpose and Background

Several counties in southwestern Idaho, including Payette County, have become an area of interest since the discovery of production quantities of natural gas. This interest has led to the establishment of two gas fields in Payette County: the Hamilton Field, which underlies the area surrounding the town of New Plymouth, and the Willow Field, which underlies the foothills northeast of New Plymouth. Gas field establishment and development includes, but is not limited to, well drilling and drilling-related activities, treatment/enhancement of wells to increase production, and pipeline construction.

The Hamilton Gas Field Ground Water Monitoring Project was designed to provide ground water quality data by sampling nearby residential and PWS wells in the area surrounding six permitted gas wells in the Hamilton Field.

The project was established with initial ground water sampling of 16 residential and City of New Plymouth PWS wells in November 2012. This initial sampling was done prior to gas field development to collect baseline ground water quality data. The same network of wells was resampled in August and December 2013 to evaluate seasonal and annual variations in ground water quality and document any potential changes in ground water quality conditions due to developing the Hamilton Field (drilling gas wells and potential production).

By December 2013, all six permitted gas wells had been drilled. One, referred to as the “Veatch” well, was drilled and then permanently closed/sealed between the August and December 2013 sampling events. The gas well referred to as “State 1-17” began production in April 2014.

In April 2015, DEQ resampled 14 of the 16 project wells to determine if gas production from the “State 1-17” well or closure of the “Veatch” gas well had a measurable effect on ground water quality. The other four gas wells were not producing.

2.1.4.2 Methods and Results

DEQ received permission to sample 14 of the original project wells from the November 2012 baseline study, including 10 of the original 12 residential wells and 4 City of New Plymouth wells (Figure 7).

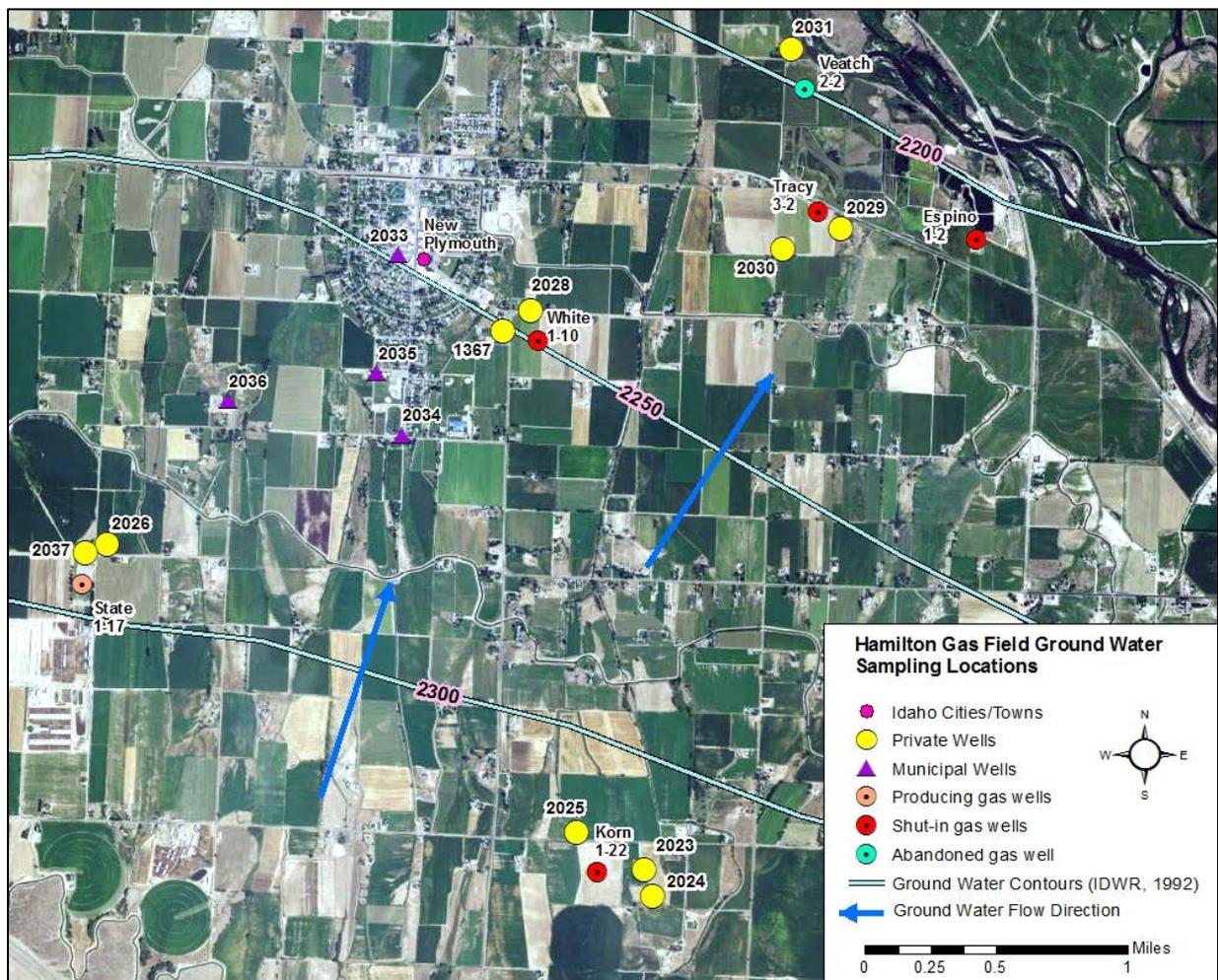


Figure 7. Location of Hamilton Field production wells, sampling network wells (private and municipal), and ground water contours and flow direction—Hamilton Gas Field Ground Water Monitoring Project.

On April 27 and 28, 2015, DEQ collected water samples from the 14 network wells using procedures outlined in the appropriate QAPP (DEQ 2015b) and FSP (DEQ 2015e).

Water quality field parameters (pH, temperature, specific conductivity, and DO) were measured at each well prior to sample collection (Table 10).

Table 10. Water quality field parameters—Hamilton Gas Field Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	Sample Date	Water Temperature (°C)	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	pH ^a
1367	38	4/27/2015	14.52	721	1.00	7.42
2023	129	4/27/2015	15.45	1340	6.84	7.15
2024	145	4/27/2015	15.71	1220	6.25	6.68
2025	—	4/27/2015	15.82	982	5.58	7.04
2026	150	4/27/2015	16.22	328	1.06	8.28
2028	44	4/27/2015	13.86	912	6.44	7.35
2029	45.5	4/27/2015	16.01	830	4.61	7.25
2030	—	4/27/2015	15.39	906	5.14	7.26
2031	204	4/27/2015	15.67	1010	1.01	7.80
2033	78	4/28/2015	14.77	570	9.01	7.70
2034	100	4/28/2015	14.63	534	3.69	7.60
2035	80	4/28/2015	14.33	697	6.16	7.69
2036	216	4/28/2015	16.57	153	6.04	8.93
2037	101	4/27/2015	15.17	1070	3.91	7.22

^a Contaminant with a National Secondary Drinking Water Regulation standard. Italicized red numbers indicate EPA's NSDWR standard was exceeded. The NSDWR for pH is 6.5-8.5. NSDWR standards are recommended limits for public water systems, but can be applied to private wells to evaluate water quality.

The water samples were submitted to four analytical laboratories for analysis using procedures outlined in the FSP. The University of Idaho Analytical Sciences Laboratory (UIASL) in Moscow analyzed the samples for common ions and TDS (Table 11); nutrients (nitrate and nitrite) (Table 12); uranium and heavy metals (arsenic, cadmium, chromium, lead, and selenium) (Table 13); and additional metals (Table 14). Idaho Bureau of Laboratories (IBL) in Boise analyzed the samples for bacteria (TC and *E. coli*) (Table 12). Dissolved methane analysis was conducted by Accutest Laboratories in Wheat Ridge, Colorado (Table 15). Anatek Labs, Inc., in Moscow, Idaho, analyzed samples for benzene, toluene, ethylbenzene, and total xylenes (m+p-xylene and o-xylene) (BTEX) and TPH (Table 15).

Table 11. Common ions and TDS results—Hamilton Gas Field Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	Sample Date	Major Ion Concentrations (mg/L)							Alkalinity (as CaCO ₃)	Total Dissolved Solids ^{b, c} (mg/L)
			Calcium	Magnesium	Sodium	Potassium	Chloride ^b	Fluoride ^a	Sulfate ^b		
<i>Standard:</i>			<i>NA</i>	<i>NA</i>	<i>NA</i>	<i>NA</i>	<i>250</i>	<i>4</i>	<i>250</i>	<i>NA</i>	<i>500</i>
1367	38	4/27/2015	50	8.1	30	1.9	22	0.23	41	150	290
2023	129	4/27/2015	84	17	86	3.2	26	0.23	73	340	<i>550</i>
2024	145	4/27/2015	72	15	88	3.1	20	0.27	61	340	<i>520</i>
2025	—	4/27/2015	80	16	46	3.0	33	0.16	71	240	440
2026	150	4/27/2015	20	0.67	22	1.6	7.3	0.26	14	80	130
2028	44	4/27/2015	63	20	29	2.2	7.0	0.37	29	250	390
2029	45.5	4/27/2015	51	21	30	2.4	2.8	0.52	7.9	260	340
2030	—	4/27/2015	60	23	25	1.7	6.5	0.44	19	360	260
2031	204	4/27/2015	9.8	2.7	31	2.2	1.3	0.54	<0.20	100	150
2033	78	4/28/2015	53	12	54	2.5	12	0.34	30	250	320
2034	100	4/28/2015	49	16	41	3.1	10	0.37	30	240	350
2035	80	4/28/2015	65	14	59	4.2	24	0.21	54	260	370
2036	216	4/28/2015	4.7	0.11	32	<1.0	1.5	0.32	5.0	78	89
2037	101	4/27/2015	63	10	80	2.5	37	0.38	85	230	450

Notes: Italicized red numbers indicate EPA's National Secondary Drinking Water Regulation (NSDWR) standard was exceeded. These regulations are applicable for public water systems only but are recommended limits and can be applied to private wells to evaluate water quality.

^a Contaminant with a National Secondary Drinking Water Regulation standard.

^b Contaminant with a National Primary Drinking Water Regulation standard.

^c All TDS data were rejected due to exceedance of the holding time and should be used with caution.

Table 12. Nutrients and bacteria results—Hamilton Gas Field Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	Sample Date	Nutrient Concentrations		Bacteria ^b	
			Nitrate ^a	Nitrite ^a	Total Coliform	<i>E. coli</i>
			(mg/L)		(MPN/100 mL)	
<i>Primary or Secondary Standard:</i>			<i>10</i>	<i>1</i>	<i>1 cfu/100 mL</i>	<i><1 cfu/100 mL</i>
1367	38	4/27/2015	0.52	<0.05	<1	<1
2023	129	4/27/2015	5.3	<0.05	<1	<1
2024	145	4/27/2015	4.7	<0.05	<1	<1
2025	—	4/27/2015	2.3	<0.05	<1	<1
2026	150	4/27/2015	<0.05	<0.05	<1	<1
2028	44	4/27/2015	6.8	<0.05	<1	<1
2029	45.5	4/27/2015	3.4	<0.05	<1	<1
2030	—	4/27/2015	4.6	<0.05	<1	<1
2031	204	4/27/2015	<0.05	<0.05	1	<1
2033	78	4/28/2015	3.0	<0.05	<1	<1
2034	100	4/28/2015	3.7	<0.05	<1	<1
2035	80	4/28/2015	2.6	<0.05	<1	<1
2036	216	4/28/2015	<0.05	<0.05	<1	<1
2037	101	4/27/2015	1.6	<0.05	<1	<1

^a Contaminant with a National Primary Drinking Water Regulation standard. These regulations are applicable for public water systems only but are recommended limits and can be used to evaluate water quality in private wells.

^b Total coliform and *E. coli* standards are from the Idaho Ground Water Quality Rule (IDAPA 58.01.11.200). An exceedance of the primary ground water quality standard for total coliform (indicated by gray shaded numbers) is not a violation of these rules. Total coliform is not a health threat in itself; it is used to indicate whether other potentially harmful bacteria may be present. Although the standards are given in cfu/100 mL, analytical results provided in MPN/100 mL are acceptable for comparison to the standard.

Table 13. Uranium and heavy metals results—Hamilton Gas Field Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	Sample Date	Arsenic ^a	Cadmium ^a	Chromium ^a	Lead ^a	Selenium ^a	Uranium ^a
			(µg/L)					
<i>Primary Standard:</i>			<i>10</i>	<i>5</i>	<i>100</i>	<i>15</i>	<i>50</i>	<i>30</i>
1367	38	4/27/2015	6.8	<0.1	<0.5	1.4	0.17	7.6
2023	129	4/27/2015	7.6	0.11	1.0	1.6	1.2	39
2024	145	4/27/2015	8.1	<0.1	1.1	1.2	0.83	30
2025	—	4/27/2015	5.6	<0.1	1.6	0.57	1.4	35
2026	150	4/27/2015	1.2	<0.1	<0.5	1.2	<0.1	<0.25
2028	44	4/27/2015	19	<0.1	0.97	1.2	0.32	8.6
2029	45.5	4/27/2015	10	<0.1	0.54	2.5	0.17	6.7
2030	—	4/27/2015	10	<0.1	1.8	2.0	0.29	8.2
2031	204	4/27/2015	0.71	<0.1	<0.5	1.2	<0.1	<0.25
2033	78	4/28/2015	9.5	<0.1	0.86	1.7	0.45	9.7
2034	100	4/28/2015	11	<0.1	<0.5	1.3	0.45	9.6
2035	80	4/28/2015	8.3	<0.1	0.57	1.3	0.68	16
2036	216	4/28/2015	1.7	<0.1	<0.5	1.4	<0.1	<0.25
2037	101	4/27/2015	6.7	<0.1	0.65	0.63	2.2	18

Notes: Bolded red numbers indicate EPA's National Primary Drinking Water Regulation (NPDWR) standard, expressed as a maximum contaminant level (MCL), was reached or exceeded. These regulations are applicable for public water systems only but are recommended limits and can be used to evaluate water quality in private wells.

^a Contaminant with a National Primary Drinking Water Regulation standard.

Table 14. Additional metals results—Hamilton Gas Field Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	Sample Date	Barium ^a	Boron	Cobalt	Copper ^b	Iron ^c	Manganese ^c	Molybdenum	Nickel (µg/L)	Vanadium	Zinc ^c
			(mg/L)									
<i>Standard:</i>			2	NA	NA	1.3	0.3	0.05	NA	NA	NA	5
1367	38	4/27/2015	0.078	0.13	<0.01	<0.020	<0.1	<i>0.0999</i>	<0.25	<2.5	<0.02	<0.02
2023	129	4/27/2015	0.069	0.31	<0.01	<0.020	<0.1	<0.005	<0.25	<2.5	<0.02	<0.02
2024	145	4/27/2015	0.070	0.39	<0.01	<0.020	<0.1	<0.005	<0.25	<2.5	<0.02	<0.02
2025	—	4/27/2015	0.12	0.17	<0.01	<0.020	<0.1	<0.005	<0.25	<2.5	<0.02	0.025
2026	150	4/27/2015	<0.02	0.25	<0.01	<0.020	<i>0.34</i>	<i>0.070</i>	<0.25	<2.5	<0.02	<0.02
2028	44	4/27/2015	0.067	0.32	<0.01	<0.020	<0.1	<0.005	<0.25	<2.5	0.042	<0.02
2029	45.5	4/27/2015	0.054	0.25	<0.01	<0.020	<0.1	<0.005	<0.25	<2.5	0.040	<0.02
2030	—	4/27/2015	0.071	0.30	<0.01	<0.020	<0.1	<0.005	<0.25	<2.5	0.041	<0.02
2031	204	4/27/2015	0.023	0.22	<0.01	<0.020	<0.1	<i>0.13</i>	<0.25	<2.5	<0.02	<0.02
2033	78	4/28/2015	0.049	0.25	<0.01	<0.020	<0.1	<0.005	<0.25	<2.5	<0.02	<0.02
2034	100	4/28/2015	0.044	0.26	<0.01	<0.020	<0.1	<0.005	<0.25	<2.5	0.044	<0.02
2035	80	4/28/2015	0.064	0.28	<0.01	<0.020	<0.1	<0.005	<0.25	<2.5	0.020	<0.02
2036	216	4/28/2015	<0.02	0.29	<0.01	<0.020	<0.1	0.010	<0.25	<2.5	<0.02	<0.02
2037	101	4/27/2015	0.062	0.40	<0.01	<0.020	<0.1	0.0069	<0.25	<2.5	<0.02	<0.02

Notes: Italicized red numbers indicate EPA's National Secondary Drinking Water Regulation (NSDWR) standard was exceeded. These regulations are applicable for public water systems only but are recommended limits and can be applied to private wells to evaluate water quality.

^a Contaminant with a National Primary Drinking Water Regulation standard.

^b EPA established a treatment technique rather than an MCL for copper. If more than 10% of tap water samples exceed the copper action level of 1.3 mg/L, water systems must take additional steps to reduce corrosiveness.

^c Contaminant with a National Secondary Drinking Water Regulation standard.

Table 15. BTEX, TPH, and methane results—Hamilton Gas Field Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	Sample Date	Benzene ^a	Toluene ^a	Ethylbenzene ^a	m+p-xylene ^a	O-xylene ^a	TPH			Methane ^b
			(µg/L)					Gasoline	Lube	Diesel	(µg/L)
<i>Primary or Secondary Standard:</i>			<i>5</i>	<i>1000</i>	<i>700</i>	<i>10,000</i>	<i>NA</i>	<i>NA</i>	<i>NA</i>	<i>NA</i>	
1367	38	4/27/2015	<0.50	<0.50	<0.50	<1.00	<0.50	<0.10	<0.50	<0.10	<0.80
2023	129	4/27/2015	<0.50	<0.50	<0.50	<1.00	<0.50	<0.10	<0.50	<0.10	<0.80
2024	145	4/27/2015	<0.50	<0.50	<0.50	<1.00	<0.50	<0.10	<0.50	<0.10	<0.80
2025	—	4/27/2015	<0.50	<0.50	<0.50	<1.00	<0.50	<0.10	<0.50	<0.10	<0.80
2026	150	4/27/2015	<0.50	<0.50	<0.50	<1.00	<0.50	<0.10	<0.50	<0.10	0.86
2028	44	4/27/2015	<0.50	<0.50	<0.50	<1.00	<0.50	<0.10	<0.50	<0.10	<0.80
2029	45.5	4/27/2015	<0.50	<0.50	<0.50	<1.00	<0.50	<0.10	<0.50	<0.10	<0.80
2030	—	4/27/2015	<0.50	<0.50	<0.50	<1.00	<0.50	<0.10	<0.50	<0.10	<0.80
2031	204	4/27/2015	<0.50	<0.50	<0.50	<1.00	<0.50	<0.10	<0.50	<0.10	247
2033	78	4/28/2015	<0.50	<0.50	<0.50	<1.00	<0.50	<0.10	<0.50	<0.10	<0.80
2034	100	4/28/2015	<0.50	<0.50	<0.50	<1.00	<0.50	<0.10	<0.50	<0.10	<0.80
2035	80	4/28/2015	<0.50	<0.50	<0.50	<1.00	<0.50	<0.10	<0.50	<0.10	<0.80
2036	216	4/28/2015	<0.50	<0.50	<0.50	<1.00	<0.50	<0.10	<0.50	<0.10	1.3
2037	101	4/27/2015	<0.50	<0.50	<0.50	<1.00	<0.50	<0.10	<0.50	<0.10	<0.80

^a Contaminant with a National Primary Drinking Water Regulation standard.

^b The US Department of the Interior Office of Surface Mining advises well owners with dissolved methane levels greater than 28 mg/L (28,000 µg/L) to immediately remove any potential ignition sources and vent the gas away from any confined spaces (Eltschlager et al. 2001).

Nitrate Results

The reported nitrate concentrations ranged from 0.52 to 6.8 mg/L; 2 of the 14 wells (Wells 2023 and 2028) had nitrate concentrations above 5 mg/L (Table 12). The MCL of 10 mg/L was not exceeded during this sampling effort.

Bacteria Results

Samples from all 14 wells were analyzed for both TC and *E. coli* bacteria. Well 2031 had a positive detection of TC with a concentration of 1 MPN/100 mL. All samples were negative for *E. coli*.

TDS Results

Samples from all 14 wells were analyzed for TDS; 2 of the 14 samples were above the NSDWR standard of 500 mg/L (Table 11). However, all TDS data were rejected due to exceedance of the holding time and should be used with caution. TDS concentrations may be higher in oil and gas formations compared to shallower drinking water formations so increases in TDS concentrations could be evaluated as a possible indicator of impacts from oil and gas activities. As such, TDS concentrations reported in 2015 were compared with TDS results from 2012 and 2013. No observable trend of increasing TDS concentrations were observed.

Arsenic Results

All 14 wells had positive detections of arsenic (Table 13). The arsenic concentrations ranged from 0.71 to 19 µg/L. A total of 4 wells exceeded the arsenic MCL of 10 micrograms per liter (µg/L); however, the concentrations remained consistent with baseline sampling conducted in November 2012 (DEQ 2014e). Elevated arsenic values have been identified in this area by various studies (Baldwin and Wicherski 1994; Neely 2000; Mitchell 2004). Elevated arsenic values were also found in this area when samples were collected by DEQ for the Lower Payette NPA in 2011 (DEQ 2013a). These exceedances may be due to naturally occurring arsenic in the granitic sediments found in the lower Payette River valley (Neely 2002; Mitchell 2004).

Uranium Results

Of the 14 wells sampled, 11 had positive detections of uranium. The uranium detections ranged from 6.7 to 39 µg/L; 3 wells (2023, 2024, and 2025) met or exceeded the uranium MCL of 30 µg/L during the April 2015 sampling event. The 3 wells with elevated uranium concentrations are located in the southern portion of the project area near the gas well identified as “Korn 1-22” (Figure 8).

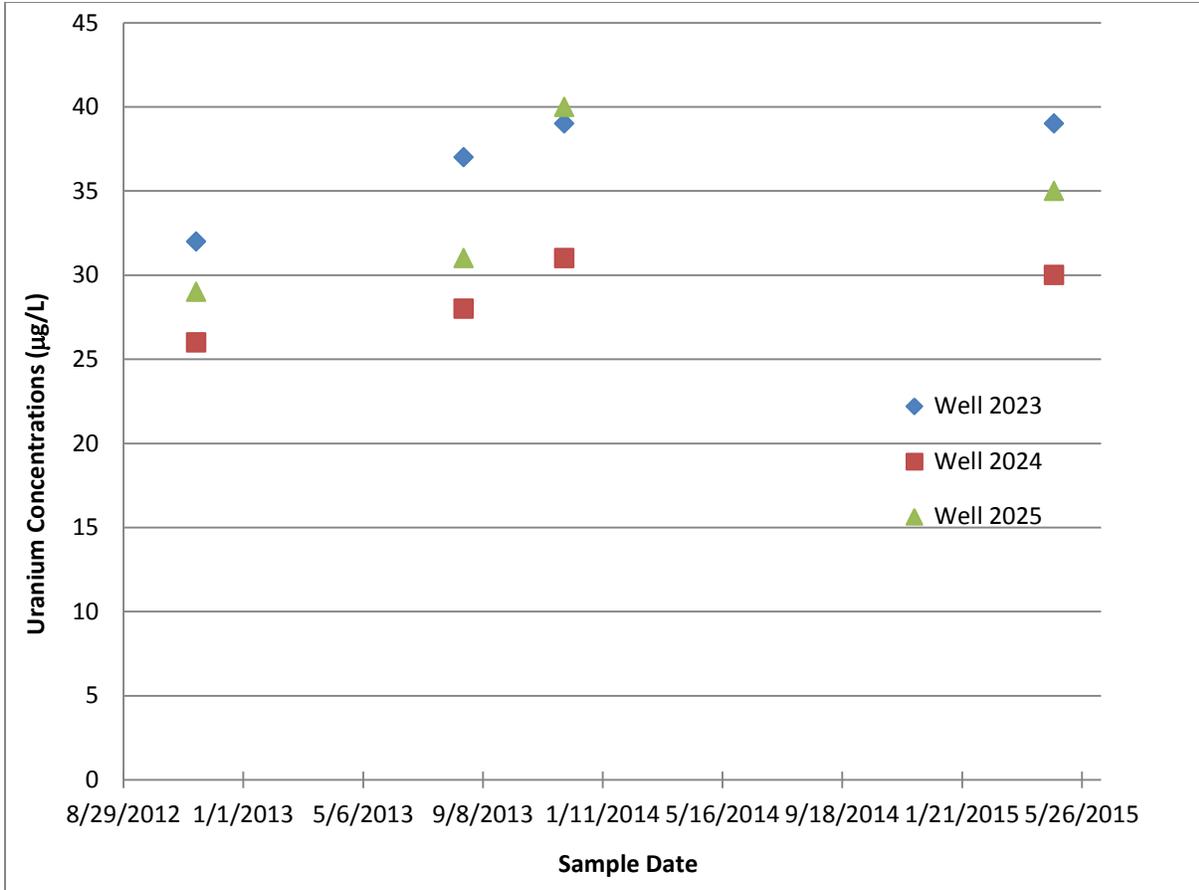


Figure 9. Uranium concentrations from Wells 2023, 2024, and 2025 over time—Hamilton Gas Field Ground Water Monitoring Project.

Lead Sampling

All 14 wells sampled in 2015 had positive detections of lead; the reported lead concentrations ranged from 0.57 µg/L to 2.5 µg/L. No wells exceeded the lead MCL of 15 µg/L during the April 2015 sampling event (Figure 10).

The 2012 and August 2013 sampling resulted in no positive detections of lead above the laboratory reporting limits. During the December 2013 sampling event, lead was detected in 3 wells (2028, 2030, and 2032); the lead concentration in Well 2032 exceeded the EPA MCL of 15 µg/L. The April 2015 sampling event detected lead from Wells 2028 and 2030 at concentrations of 1.2 µg/L and 2.0 µg/L, respectively (Table 13). Well 2032 was not resampled in 2015. The laboratory reporting limit for lead changed throughout the duration of this project, making comparisons of concentrations between years difficult.

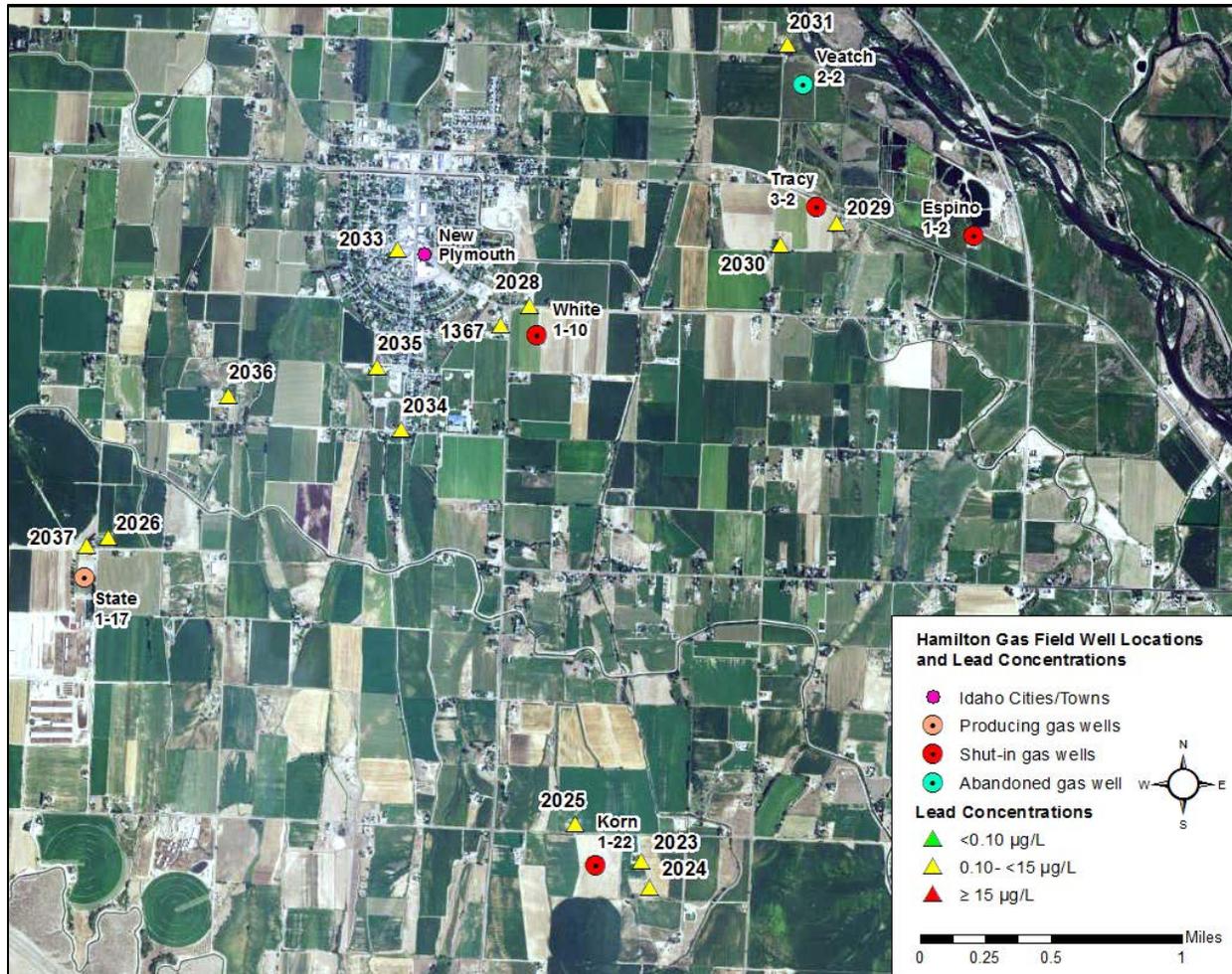


Figure 10. Lead detections—Hamilton Gas Field Ground Water Monitoring Project.

A comparison of lead concentrations in Wells 2028, 2030, and 2032 over time shows an increase in lead concentrations between August 2013 and December 2013; Well 2032 showed the greatest increase from less than the detection level to 16 µg/L. The two wells available for the April 2015 sampling event show a decrease in lead concentrations between December 2013 and April 2015 (Table 16). The only known gas field development activity in this area between August 2013 and December 2013 was the Veatch gas well abandonment.

Table 16. Lead sample result trend in Wells 2028, 2030, and 2032—Hamilton Gas Field Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	Lead Concentrations (µg/L) ^a			
		11/13/2012–11/14/2012	8/19/2013	12/2/2013	4/27/2015
Primary Standard:		15 µg/L			
2028	44	<3.0	<3.0	5.2	1.2
2030	—	<3.0	<3.0	3.5	2.0
2032	—	<3.0	<3.0	16	—

Notes: Bolded red numbers indicate EPA's National Primary Drinking Water Regulation (NPDWR) standard, expressed as a maximum contaminant level (MCL), was reached or exceeded. These regulations are applicable for public water systems only but are recommended limits and can be used to evaluate water quality in private wells. The reporting limit was 3 µg/L in 2012 and 2013 but 0.10 µg/L in 2015.

^a Contaminant with a National Primary Drinking Water Regulation standard.

Hydrocarbon Sampling

Dissolved methane was detected in 3 wells (2026, 2031, and 2036) during the April 2015 sampling event; concentrations ranged from 0.86 µg/L to 247 µg/L (Table 15). An MCL for dissolved methane does not exist. The hazard with methane in water is when dissolved methane moves from ground water into the atmosphere, where it can potentially ignite, or accumulates in a confined space where it can explode. Reported methane concentrations in water samples collected from Wells 2026, 2031, and 2036 are significantly below the actionable concentration of 28,000 µg/L.

A comparison of dissolved methane concentrations in 4 wells with repeated detections (Wells 2026, 2031, 2032, and 2036) is provided in Table 17 and Figure 11. The concentrations in Wells 2026 and 2036 seem to indicate only slight variability over the 4 sampling rounds between November 2012 and April 2015 (Table 17).

Table 17. Comparison table of dissolved methane sample results over time—Hamilton Gas Field Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	Dissolved Methane (µg/L)			
		11/13/2012	8/19/2013	12/2/2013	4/27/2015
2026	150	<0.80	0.61	0.42	0.86
2031	204	87.6	58.8	173	247
2032	—	<0.80	3.8	3.8	—
2036	133	2.05	1.3	2.0	3.1

Note: The US Department of the Interior Office of Surface Mining advises well owners with dissolved methane levels greater than 28 mg/L (28,000 µg/L) to immediately remove any potential ignition sources and vent the gas away from any confined spaces (Eltchlager et al. 2001).

The dissolved methane concentration in Well 2031 seems to show a continued increase over time, nearly tripling between August 2013 and December 2013 and increasing again by more than 40% between December 2013 and April 2015 (Table 17; Figure 11). Well 2031 is close to the abandoned Veatch well located in the northeast portion of the sampling area (Figure 7).

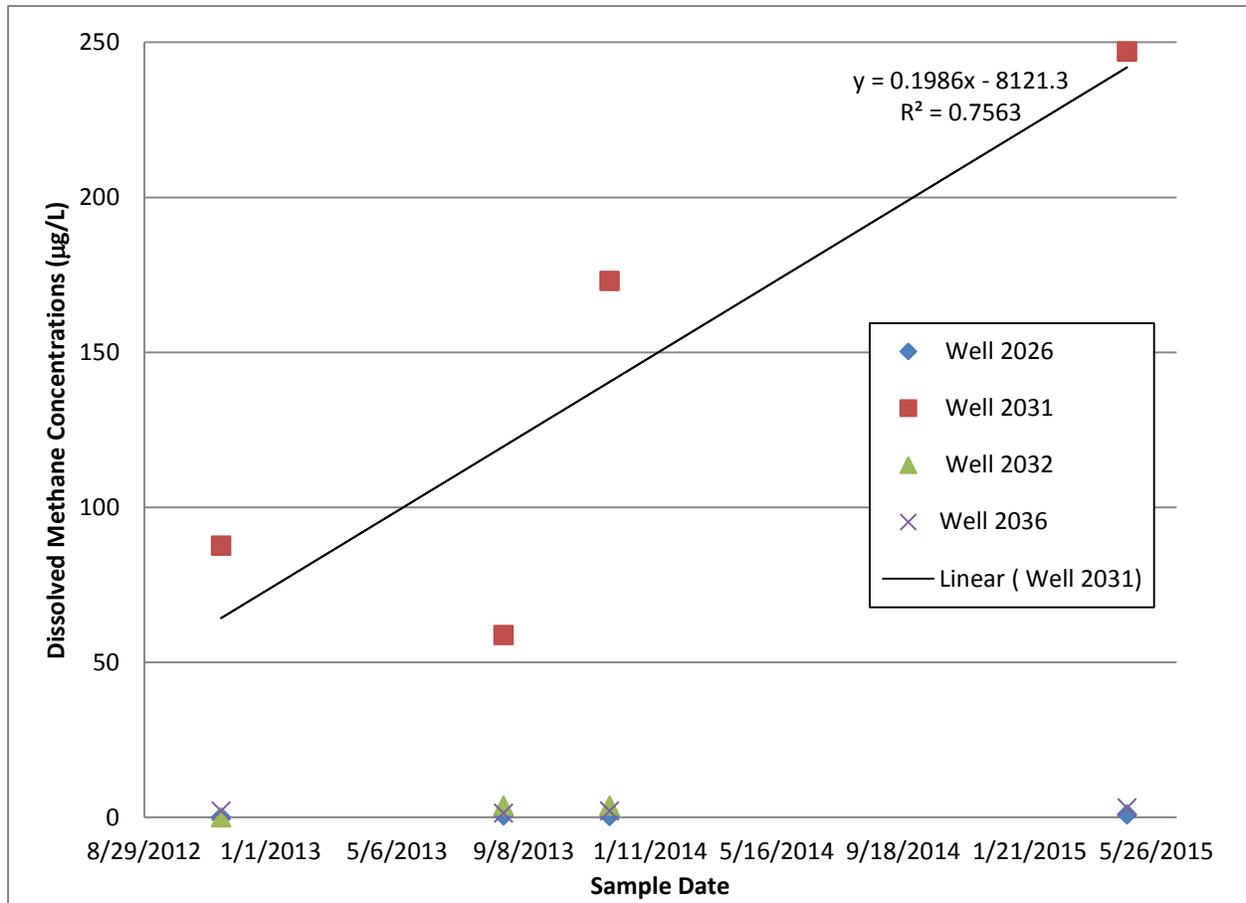


Figure 11. Dissolved methane detections over time—Hamilton Gas Field Ground Water Monitoring Project.

Benzene, ethylbenzene, toluene, xylene, gasoline, oils, and diesel were not detected in the wells sampled in April 2015 (Table 15).

2.1.4.3 Conclusions

The Hamilton Gas Field Ground Water Monitoring Project was designed to provide background ground water quality data in the area surrounding six Hamilton Field gas wells permitted by the Idaho Department of Lands. Additional samples are taken on a periodic basis in an attempt to determine the effects of drilling, production, and abandonment on ground water.

Ground water samples from 8 of the 14 wells contained various constituents with concentrations in excess of National Primary Drinking Water Regulation standards. An additional 2 wells had samples with exceedances of either a National Secondary Drinking Water Regulation standard or an Idaho Ground Water Quality Rule standard. Consistent with 2012 baseline sampling, water samples from 4 wells contained arsenic concentrations above the arsenic MCL of 10 µg/L. The arsenic appears to be associated with naturally occurring geologic deposits present in the aquifer.

Water samples from 3 wells (2023, 2024, and 2025) contained a uranium concentration at or above the uranium MCL of 30 µg/L. These results are approximately 20% higher than the 2012 baseline sampling event in November 2012. The 3 wells with elevated uranium concentrations are located within one-quarter mile of the “Korn 1-22” gas well (Figure 8).

Dissolved methane concentrations in the 3 wells with detectable concentrations were considerably lower than the recommended action level of 28 mg/L and show no increasing trend, with the exception of Well 2031. The dissolved methane concentration in Well 2031 nearly tripled between August 2013 and December 2013 and increased again by more than 40% between December 2013 and April 2015. Well 2031 is close to the abandoned Veatch well located in the northeast portion of the sampling area (Figure 7).

Idaho Department of Lands data in April 2016 reported a total of 17 oil and gas wells located in Payette County; of the 17 wells, 8 are production wells and 9 are identified as “shut-in pending pipeline.” Current information on the status of active wells can be viewed at www.idl.idaho.gov/oil-gas/regulatory/well-permits/index.

2.1.4.4 Recommendations

Based on the increasing uranium concentrations in the 3 wells located near the “Korn 1-22” gas well, and the increasing methane levels in Well 2031, ground water quality monitoring should continue as the budget allows.

Additional sampling should occur after a change in gas field activities, such as drilling new wells, bringing a new well into production, or abandoning a well.

2.1.5 Homedale Nitrate Priority Area Ground Water Monitoring Project

2.1.5.1 Purpose and Background

This ground water monitoring project was designed to evaluate the water quality and nitrate concentrations in the Homedale NPA in Owyhee County. In 2014, the Homedale NPA ranked as

the 28th-most impacted NPA in Idaho. The primary land use in the Homedale NPA is agricultural and residential. The primary agriculture uses are cropland and dairy and beef feedlots and calf operations. Most of the residences within the NPA are served by private wells.

Owyhee County, located in southwest Idaho, is bordered by Nevada on the south; Oregon on the west; Canyon, Ada, and Elmore Counties on the north; and Twin Falls County on the east. Owyhee is the second largest county by area in Idaho.

In May 2015, DEQ sampled 10 domestic drinking water wells in or near the Homedale NPA. In the project area, 8 of the 10 wells were less than 200 feet deep, one was 240 feet deep, and one was 420 feet deep. DEQ staff reviewed project area well logs from IDWR's database and determined a clay confining layer exists between 82 feet bgs in low-lying areas and 180 feet bgs in elevated areas. In most cases, attempts are made to select wells that are complete above a confining layer in an effort to sample the upper most aquifer. In areas with limited availability of wells, this may not be possible. The regional ground water flow direction is generally to the east (Figure 12).

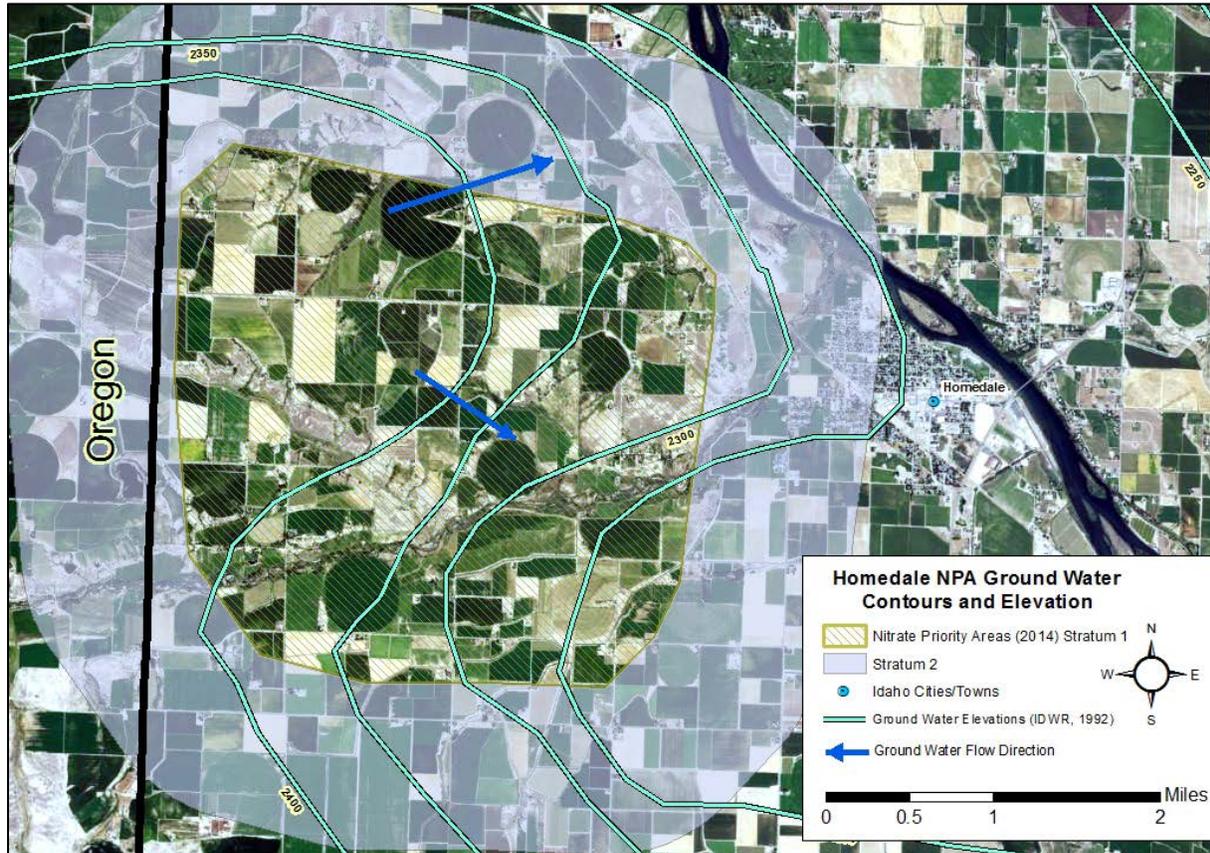


Figure 12. Ground water contours and elevations—Homedale Nitrate Priority Area Ground Water Monitoring Project.

2.1.5.2 Methods and Results

The Homedale NPA is a small monitoring area as defined in the regional ground water monitoring network design (DEQ 2011a); therefore, the census sampling method (sampling all

qualifying wells) was chosen for the Homedale NPA (Stratum 1) and a 1-mile buffer zone around the NPA (Stratum 2). A total of 10 wells were sampled for this project: 5 in Stratum 1, 4 in Stratum 2, and 1 slightly outside Stratum 2. DEQ staff coordinated with other state agencies and queried the DEQ ground water database and determined none of the 10 wells had been previously sampled. Permission was obtained from the 10 well owners for DEQ staff to collect and analyze samples.

All samples were collected in accordance with the QAPP (DEQ 2014b) and FSP (DEQ 2015f). Water quality field parameters (i.e., pH, temperature, specific conductivity, and DO) were measured at each well prior to sample collection (Table 18).

Samples were analyzed for nitrate, nitrite, TC, and *E. coli* (Table 19). Wells with a DO less than 2.00 mg/L, as determined by field analysis, were also analyzed for ammonia as required by the FSP (DEQ 2015f). Nitrogen isotope samples were collected at each sampling location and frozen and stored at DEQ pending nitrate analysis. After DEQ received nitrate analysis results, those nitrogen isotope samples from wells with nitrate concentrations greater than 5 mg/L were sent to the University of Arizona Environmental Isotope Geosciences Laboratory in Tucson for nitrogen isotope analysis (Table 19).

Table 18. Water quality field parameters—Homedale Nitrate Priority Area Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	Sample Date	Water Temperature (°C)	pH ^a	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)
1321	115	5/12/2015	15.94	7.36	1,450	3.98
1339	240	5/12/2015	16.45	7.20	2,010	5.51
1398	420	5/12/2015	18.68	6.89	2,780	1.42
2082	40	5/11/2015	15.22	7.28	2,130	7.56
2083	100	5/11/2015	15.54	7.83	1,010	1.25
2084	82	5/11/2015	14.22	6.99	1,680	5.88
2085	62	5/11/2015	15.62	7.39	1,090	7.34
2086	60	5/11/2015	14.70	6.71	3,520	1.18
2087	180	5/12/2015	14.90	7.04	2,790	6.76
2088	140	5/12/2015	15.64	7.32	1,290	6.71

^a Contaminant with a National Secondary Drinking Water Regulation standard. The NSDWR for pH is 6.5-8.5. NSDWR standards are recommended limits for public water systems but can be applied to private wells to evaluate water quality.

Table 19. Inorganic and bacteria results—Homedale Nitrate Priority Area Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	Sample Date	Nutrient Concentrations				Bacteria ^b	
			Ammonia	Nitrate ^a	Nitrite ^a	$\delta^{15}\text{N}$ (‰)	Total Coliform	<i>E. coli</i>
							(MPN/100 mL)	
Primary or Secondary Standard:			NA	10	1	NA	1 cfu/100 mL	<1 cfu/100 mL
1321	115	5/12/2015	—	9.38	<0.30	5.4	<1.0	<1.0
1339	240	5/12/2015	—	17.1	<0.30	3.7	2.0	<1.0
1398	420	5/12/2015	7.0	3.00	<0.30	—	6.3	<1.0
2082	40	5/11/2015	—	16.3	<0.30	4.1	<1.0	<1.0
2083	100	5/11/2015	5.0	0.241	<0.30	—	<1.0	<1.0
2084	82	5/11/2015	—	6.01	<0.30	9.5	<1.0	<1.0
2085	62	5/11/2015	—	7.74	<0.30	3.9	<1.0	<1.0
2086	60	5/11/2015	0.58	1.89	<0.30	—	<1.0	<1.0
2087	180	5/12/2015	—	9.61	<0.30	4.9	<1.0	<1.0
2088	140	5/12/2015	—	8.99	<0.30	5.9	<1.0	<1.0

Notes: Bolded red numbers indicate EPA's National Primary Drinking Water Regulation (NPDWR) standard, expressed as a maximum contaminant level (MCL), was reached or exceeded. These regulations are applicable for public water systems only but are recommended limits and can be applied to private wells to evaluate water quality.

^a Contaminant with a National Primary Drinking Water Regulation standard.

^b Total coliform and *E. coli* standards are from the Idaho Ground Water Quality Rule (IDAPA 58.01.11.200). An exceedance of the primary ground water quality standard for total coliform (indicated by gray shaded numbers) is not a violation of these rules. Total coliform is not a health threat in itself; it is used to indicate whether other potentially harmful bacteria may be present. Although the standards are given in cfu/100 mL, analytical results provided in MPN/100 mL are acceptable for comparison to the standard.

Nitrate and Nitrite Results

The reported nitrate concentrations ranged from 0.241 mg/L to 17.1 mg/L; 7 of the 10 wells sampled (1321, 1339, 2082, 2084, 2085, 2087, and 2088) had nitrate concentration of 5 mg/L or greater. The nitrate MCL of 10 mg/L was exceeded in 2 wells (1339 and 2082). The spatial distribution of nitrate concentrations is shown in Figure 13.

All samples had reported nitrite concentrations less than the reporting limit of 0.3 mg/L.

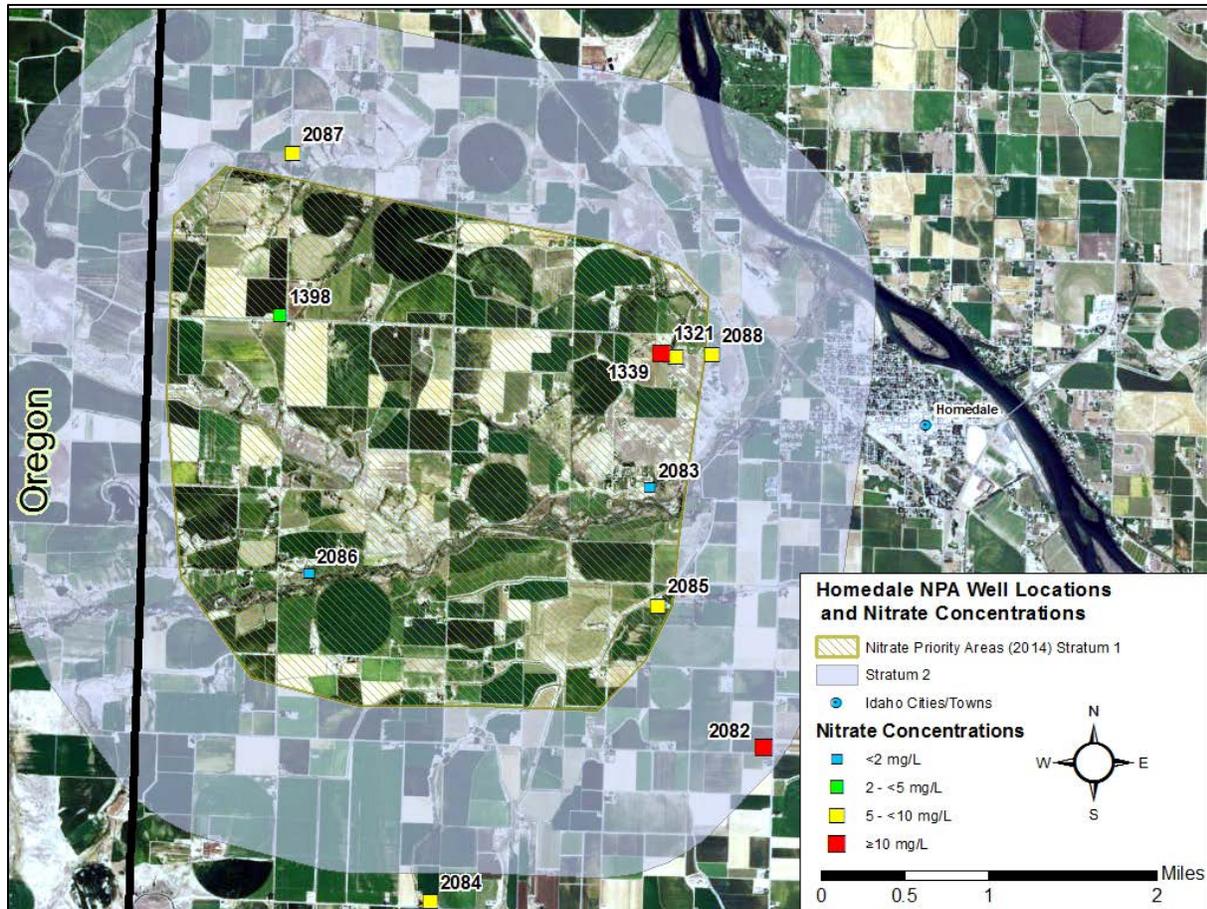


Figure 13. Private domestic drinking water well sample locations and nitrate concentrations—Homedale Nitrate Priority Area Ground Water Monitoring Project.

Bacteria Results

Of the 10 wells, 2 (1339 and 1398) had positive detections of TC bacteria; the concentrations were 2.0 and 6.3 MPN/100 mL (Table 19). All wells were negative for *E. coli*.

Ammonia Results

Three wells with low DO field measurements were sampled for ammonia; all three had positive detections. The concentrations ranged from 0.58 mg/L to 7.0 mg/L. There is currently no MCL for ammonia. Ammonia in ground water is often associated with animal or human waste or, in some cases, buried organic matter/waste crops such as cull onions or potatoes. When detected in shallow aquifers, ammonia can be an indicator of anthropogenic impacts. In deeper, anaerobic aquifers, ammonia is typically an indicator of decay of organic matter.

Nitrogen Isotope Results

Nitrogen isotope ratios, denoted as $\delta^{15}\text{N}$, can be helpful in determining the potential sources of nitrate in the ground water. Nitrogen isotope ratios were determined for the 7 samples with nitrate concentrations greater than or equal to 5 mg/L (Table 19). Nitrogen from human or

animal waste and fertilizer sources has distinguishable $\delta^{15}\text{N}$ signatures. Typical $\delta^{15}\text{N}$ values for various nitrogen sources are listed in Table 3.

The $\delta^{15}\text{N}$ results from this project ranged from 3.7‰ to 9.5‰. Two wells (1339 and 2085) had $\delta^{15}\text{N}$ values of less than 4‰, suggesting the source of nitrate in the ground water is most likely from commercial fertilizer. Four wells (1321, 2082, 2087, and 2088) had $\delta^{15}\text{N}$ values between 4‰ and 9‰, suggesting the source of nitrate in the ground water is most likely from organic nitrogen in soil or a mixed nitrogen source. One well (2084) had $\delta^{15}\text{N}$ values of greater than 9‰, suggesting the source of nitrate in the ground water is most likely from animal or human waste (Seiler 1996). Land use around Well 2084 is mostly cropland with a few smaller animal operations. Knowledge of land application of waste was not known at the time of this report.

2.1.5.3 Conclusions

The Homedale NPA is relatively small and encompasses clusters of residences among large agricultural fields. The primary agricultural uses are cropland and animal operations. The regional ground water flow direction is generally to the east.

The criterion for an NPA is at least 25% of the wells sampled within the area meet or exceed 5 mg/L nitrate. This value is half the MCL of 10 mg/L. In this project, 7 of the 10 wells sampled (70%) had nitrate values greater than 5 mg/L. The nitrate MCL of 10 mg/L was exceeded in 2 of these wells (1339 and 2082).

The $\delta^{15}\text{N}$ results from the majority of the samples suggest a mixture of organic nitrogen in soil, such as crop decay (e.g., legume crop plow down), or a mixed nitrogen source; however, 2 wells (1339 and 2085) had fertilizer signatures, and one well (2084) had a waste signature. This mixture of nitrogen sources is typical of an agricultural area.

2.1.5.4 Recommendations

DEQ recommends that property owners with private domestic drinking water wells sample their well, prior to any water treatment system and as close to the well as possible, on an annual basis. DEQ suggests that well water be tested for bacteria, arsenic, and nitrate. The Southwest District Health Department can provide Owyhee County property owners with information and guidance.

In addition, property owners may benefit from education on the use of commercial fertilizers and pesticides on their lawns and gardens and education on proper maintenance of their wells and septic systems.

DEQ has assisted Owyhee County in developing and implementing the *Owyhee County Ground Water Quality Improvement and Drinking Water Source Protection Plan* (DEQ 2010a). This plan includes outreach activities for private well owners and agricultural operators aimed at reducing source water contamination, including activities to reduce nitrate contamination.

2.1.6 Marsing Nitrate Priority Area Ground Water Monitoring Project

2.1.6.1 Purpose and Background

This ground water monitoring project was designed to evaluate the water quality and nitrate concentrations in the Marsing NPA in Owyhee County. In 2014, the Marsing NPA ranked as the 18th most impacted NPA in Idaho.

The predominant land use in the Marsing NPA is agricultural. The residences within the NPA are served by private wells.

All wells are completed in clays, sands, and gravel. The ground water flow direction is generally to the northeast (Figure 14).

In 2015, DEQ collected ground water samples from 16 domestic and irrigation wells in the Marsing NPA using procedures outlined in the appropriate QAPP (DEQ 2014b). Program objectives, design, and well selection processes are identified in the regional ground water monitoring network design (DEQ 2011a). DEQ analyzed the ground water samples for ammonia, nitrate, and bacteria (TC and *E. coli*) to assess the sources of nitrogen in the ground water within the project area. Because the project area has been identified as having potential for oil and natural gas development, samples were also analyzed for methane to evaluate the dissolved hydrocarbons in ground water prior to any future oil and gas development.

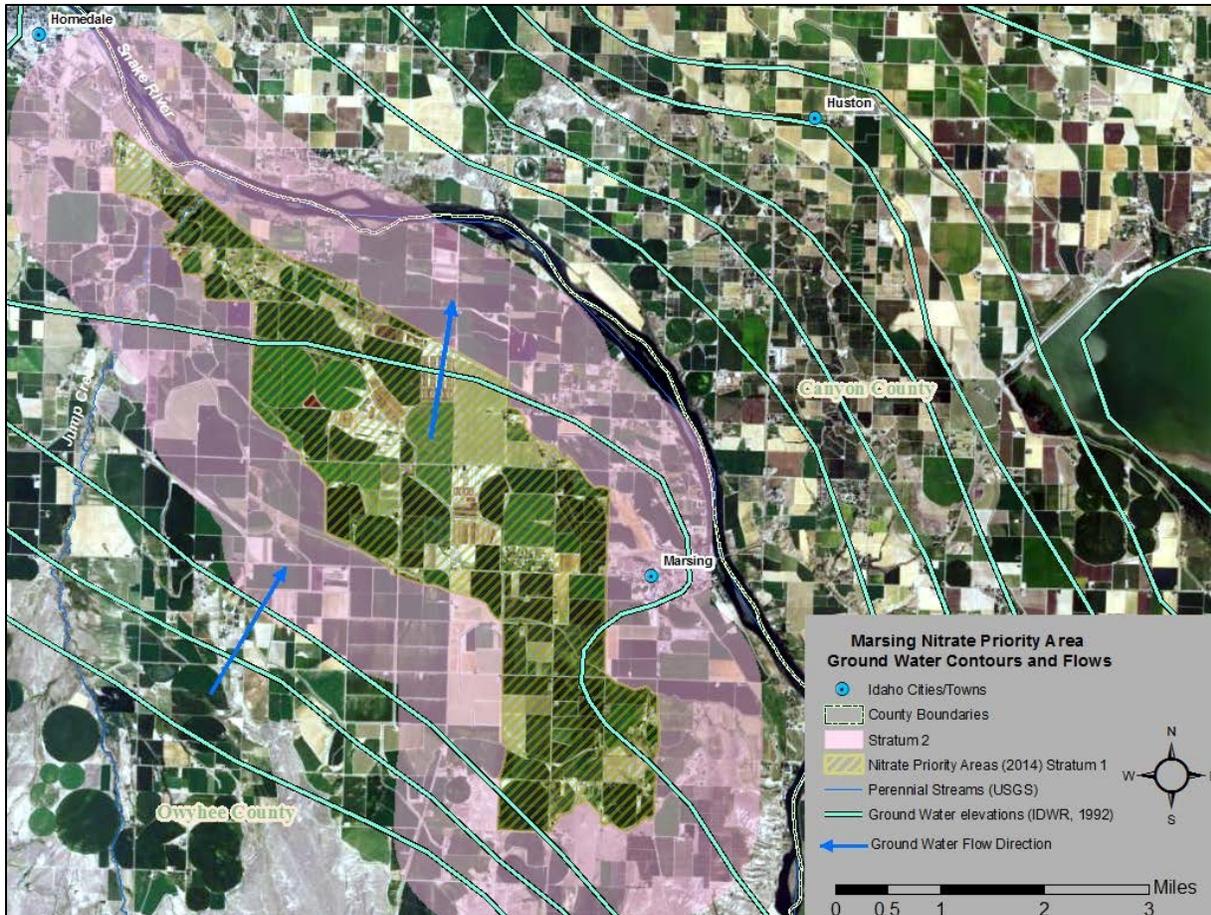


Figure 14. Ground water contours and elevations—Marsing Nitrate Priority Area Ground Water Monitoring Project.

2.1.6.2 Methods and Results

The Marsing NPA is a medium-sized monitoring area as defined in the regional ground water monitoring network design (DEQ 2011a); however, the census sampling method (sampling all qualifying wells) was chosen for the Marsing NPA. Wells were selected within the Marsing NPA (Stratum 1) and a 1-mile buffer zone around the NPA (Stratum 2).

DEQ's ground water database was queried to determine if the wells that met DEQ sampling criteria had been sampled previously. None of the wells selected for the sampling project had been previously sampled by DEQ, IDWR, or ISDA.

DEQ obtained permission from the well owners to access 16 wells and collect samples for laboratory analysis; 4 of the wells were located within the NPA boundaries (Stratum 1) but were not associated with dairies. The remaining wells were located in the 1-mile buffer zone (Stratum 2).

Samples were collected in May 2015 from each well in accordance with the appropriate QAPP (DEQ 2014b) and FSP (DEQ 2015g). Water quality field parameters (i.e., pH, temperature, specific conductivity, and DO) were measured at each well prior to sample collection (Table 20).

Table 20. Water quality field parameters—Marsing Nitrate Priority Area Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	Sample Date	Water Temperature (°C)	pH ^a	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)
1166	85	5/18/2015	14.71	7.87	834	1.46
2089	51	5/19/2015	18.77	7.66	718	1.35
2090	38	5/19/2015	16.39	7.47	751	1.17
2091	30	5/18/2015	14.90	6.97	1,350	8.41
2092	62	5/19/2015	15.01	7.26	921	8.55
2093	80	5/18/2015	17.45	7.45	940	1.79
2094	95	5/19/2015	15.96	7.75	553	0.97
2095	180	5/18/2015	16.33	7.25	4,120	1.22
2096	110	5/19/2015	15.05	7.25	924	1.07
2097	107	5/19/2015	15.15	7.22	1,080	2.45
2098	80	5/19/2015	16.96	7.76	1,010	1.14
2307	98	5/19/2015	16.40	7.69	587	1.32
2455	83	5/18/2015	15.90	7.49	1,330	0.97
2456	140	5/18/2015	17.58	8.07	894	1.02
2457	73	5/18/2015	17.30	7.63	1,000	6.45
2458	70	5/18/2015	15.91	7.56	1,010	6.45

^a Contaminant with a National Secondary Drinking Water Regulation standard. The NSDWR for pH is 6.5-8.5. NSDWR standards are recommended limits for public water systems but can be applied to private wells to evaluate water quality.

Samples collected from each well were analyzed for nitrate, nitrite, methane, TC, and *E. coli* (Table 21). Wells with a DO less than 2.00 mg/L as determined by field analysis were also analyzed for ammonia as required by the FSP. Nitrogen isotope samples were collected at each sampling location and frozen and stored at DEQ pending nitrate analysis. After DEQ received nitrate analysis results, those nitrogen isotope samples from wells with nitrate concentrations greater than 5 mg/L were sent to the University of Arizona Environmental Isotope Geosciences Laboratory in Tucson for nitrogen isotope analysis.

Table 21. Inorganic and bacteria results—Marsing Nitrate Priority Area Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	Sample Date	Ethane	Propane	Dissolved Methane ^a	Nutrient Concentrations				Bacteria ^c	
						Ammonia	Nitrate ^b	Nitrite ^b	$\delta^{15}\text{N}$ (‰)	Total Coliform	<i>E. coli</i>
						(mg/L)			(%)	(MPN/100 mL)	
<i>Primary or Secondary Standard:</i>			NA	NA	NA	NA	10	1	NA	1 cfu/100 mL	<1 cfu/100 mL
1166	85	5/18/2015	<1.6	<2.2	2.6	3.4	<0.18	<0.30	NA	<1.0	<1.0
2089	51	5/19/2015	<1.6	<2.2	1,720	5.8	<0.18	<0.30	NA	<1.0	<1.0
2090	38	5/19/2015	<1.6	<2.2	2.4	2.8	<0.18	<0.30	NA	<1.0	<1.0
2091	30	5/18/2015	<1.6	<2.2	<0.80	NA	12.1	<0.60	3.7	<1.0	<1.0
2092	62	5/19/2015	<1.6	<2.2	<0.80	NA	9.91	<0.30	5.6	<1.0	<1.0
2093	80	5/18/2015	<1.6	<2.2	402	—	0.55	<0.30	NA	<1.0	<1.0
2094	95	5/19/2015	<1.6	<2.2	4,740	2.0	<0.18	<0.30	NA	<1.0	<1.0
2095	180	5/18/2015	<1.6	<2.2	8.8	11	<0.18	<0.30	NA	<1.0	<1.0
2096	110	5/19/2015	<1.6	<2.2	1.4	0.81	<0.18	<0.30	NA	88.6	<1.0
2097	107	5/19/2015	<1.6	<2.2	<0.80	NA	10.8	<0.30	8.7	<1.0	<1.0
2098	80	5/19/2015	1.1 ^d	<2.2	9,630	7.2	<0.18	<0.30	NA	<1.0	<1.0
2307	98	5/19/2015	<1.6	<2.2	4,610	2.6	<0.18	<0.30	NA	<1.0	<1.0
2455	83	5/18/2015	<1.6	<2.2	0.52	1.5	1.18	<0.60	NA	<1.0	<1.0
2456	140	5/18/2015	1.2 ^d	<2.2	11,400	8.6	<0.18	<0.30	NA	2.0	<1.0
2457	73	5/18/2015	<1.6	<2.2	<0.80	NA	5.32	<0.60	5.1	<1.0	<1.0
2458	70	5/18/2015	<1.6	<2.2	<0.80	NA	5.32	<0.60	5.8	<1.0	<1.0

Notes: Bolded red numbers indicate EPA's National Primary Drinking Water Regulation (NPDWR) standard, expressed as a maximum contaminant level (MCL), was reached or exceeded. These regulations are applicable for public water systems only but are recommended limits and can be applied to private wells to evaluate water quality.

^a The US Department of the Interior Office of Surface Mining advises well owners with dissolved methane levels greater than 28 mg/L (28,000 µg/L) to immediately remove any potential ignition sources and vent the gas away from any confined spaces (Eltschlager et al. 2001).

^b Contaminant with a National Primary Drinking Water Regulation standard.

^c Total coliform and *E. coli* standards are from the Idaho Ground Water Quality Rule (IDAPA 58.01.11.200). An exceedance of the primary ground water quality standard for total coliform (indicated by gray shaded numbers) is not a violation of these rules. Total coliform is not a health threat in itself; it is used to indicate whether other potentially harmful bacteria may be present. Although the standards are given in cfu/100 mL, analytical results provided in MPN/100 mL are acceptable for comparison to the standard.

^d Result is below the laboratory reporting limit as is considered an estimate.

Nitrate Results

A total of 7 wells had nitrate detections, ranging from 0.55 mg/L to 12.1 mg/L; 5 of the 16 wells sampled (2091, 2092, 2097, 2457, and 2458) had nitrate concentrations of 5 mg/L or greater. The nitrate MCL of 10 mg/L was exceeded in 2 samples (2091 and 2097). The spatial distribution of nitrate concentrations is shown in Figure 15.

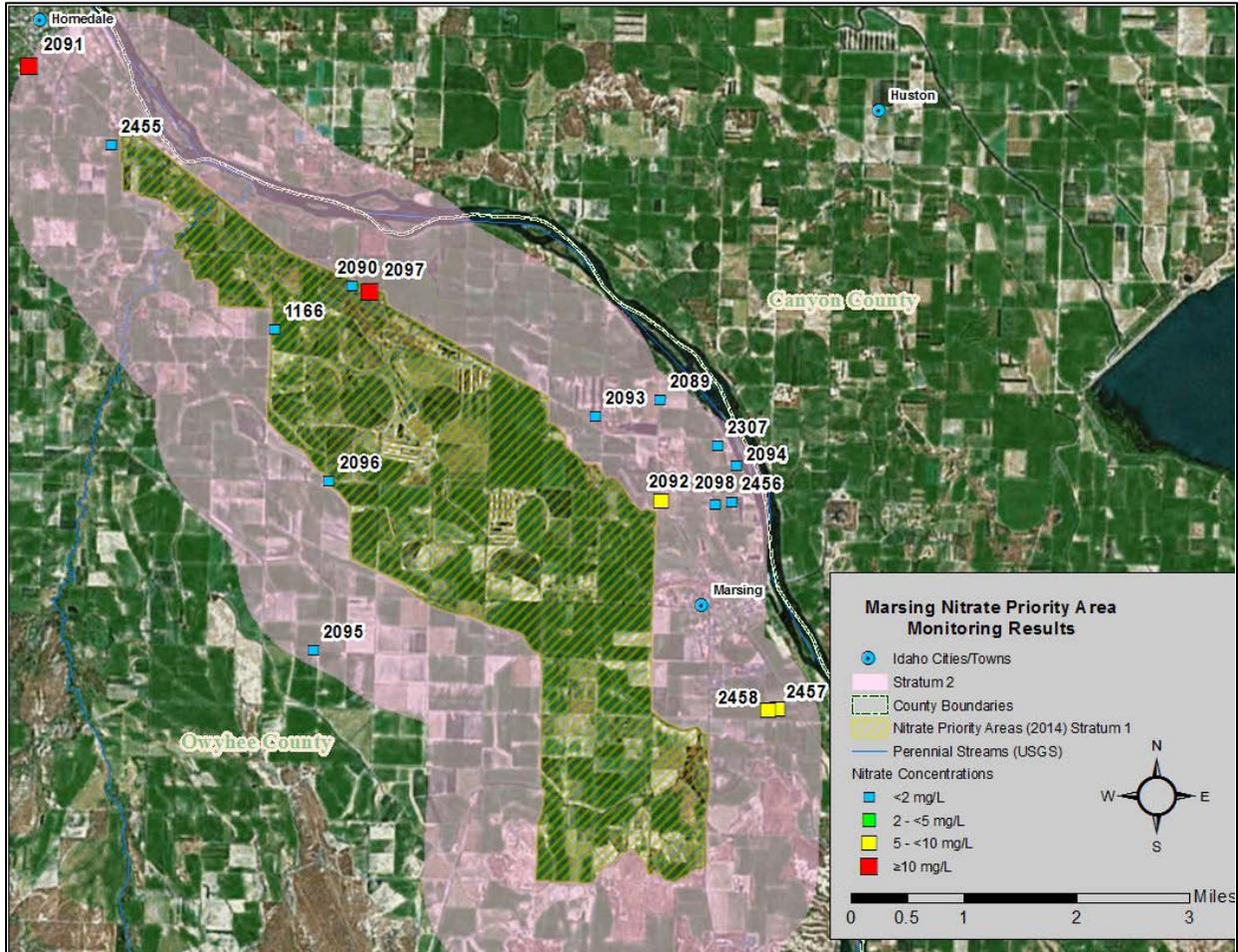


Figure 15. Private domestic drinking water and irrigation well sample locations and nitrate concentrations—Marsing Nitrate Priority Area Ground Water Monitoring Project.

Bacteria Results

Of the 16 wells sampled, Wells 2096 and 2456 were positive for TC, with concentrations of 88.6 and 2.0 MPN/100 mL, respectively (Table 21). All wells were negative for *E. coli*.

Nitrogen Isotope Results

Nitrogen isotope ratios, denoted as $\delta^{15}\text{N}$, can be helpful in determining the potential sources of nitrate in the ground water. Nitrogen isotope ratios were determined for the 5 samples with nitrate concentrations greater than or equal to 5 mg/L (Table 21). Nitrogen from human or

animal waste and fertilizer sources has distinguishable $\delta^{15}\text{N}$ signatures. Typical $\delta^{15}\text{N}$ values for various nitrogen sources are listed in Table 3.

The $\delta^{15}\text{N}$ results from this project ranged from 3.7‰ to 8.7‰. Well 2091 had $\delta^{15}\text{N}$ values of less than 4‰, suggesting the source of nitrate in the ground water is most likely commercial fertilizer.

The other 4 wells (2092, 2097, 2457, and 2458) had $\delta^{15}\text{N}$ values between 4‰ and 9‰, suggesting the source of nitrate in the ground water is most likely from organic nitrogen in soil or a mixed nitrogen source (Seiler 1996).

Methane Results

Due to the potential for oil and gas development in the area, DEQ also sampled for dissolved methane. Of the 16 wells, 11 (1166, 2089, 2090, 2093, 2094, 2095, 2096, 2098, 2307, 2455, and 2456) had measurable amounts of dissolved methane in the sample (Table 21). The highest reported concentration was 11,400 $\mu\text{g/L}$ (11.4 mg/L). The hazard with methane in water is when dissolved methane moves from ground water into the atmosphere, where it can potentially ignite, or if it accumulates in a confined space where it can explode.

Ammonia Results

Ammonia samples were collected from 10 of the 11 wells with DO less than 2.00 mg/L . All 10 wells (1166, 2089, 2090, 2094, 2095, 2096, 2098, 2307, 2455, and 2456) had measurable amounts of ammonia. Well 2093 was not sampled for laboratory analysis due to technical error. There is no MCL for ammonia at this time. Ammonia in ground water is often associated with animal or human waste or, in some cases, buried organic matter/waste crops such as cull onions or potatoes. When detected in shallow aquifers, ammonia can be an indicator of anthropogenic impacts. In deeper, anaerobic aquifers, ammonia is typically an indicator of organic matter decay.

2.1.6.3 Conclusions

The Marsing NPA is a medium-sized NPA that mostly encompasses dairy operations and general agricultural land.

The criterion for an NPA is at least 25% of the wells sampled within the area meet or exceed 5 mg/L nitrate. This value is half the MCL of 10 mg/L . In this project, 5 of the 16 wells sampled (31%) had nitrate values ≥ 5 mg/L . The nitrate MCL of 10 mg/L was exceeded in 2 of these wells (2091 and 2097).

The $\delta^{15}\text{N}$ results from the majority (4 of 5) of the samples tested suggest organic nitrogen in the soil or a mixture of nitrogen sources. This mixture of nitrogen sources is typical of an agricultural area. One sample contained nitrate from a fertilizer source (Table 21).

The Marsing NPA sample results suggest a relationship between the presence of dissolved methane and the state of nitrogen (nitrate versus ammonia). Wells with positive detections of dissolved methane had nitrogen in the form of ammonia present (and nitrate levels below the detection limit). Wells with methane levels below the analytical method detection limit (2091,

2092, 2097, 2457, and 2458) had nitrogen in the form of nitrate and at levels above 5 mg/L. Ammonia and methane appear to be associated with anaerobic conditions.

2.1.6.4 Recommendations

DEQ recommends that property owners with private domestic drinking water wells sample their well, prior to any water treatment system and as close to the well as possible, on an annual basis. Southwest District Health can provide Owyhee County property owners with information and guidance.

In addition, property owners may benefit from education on the use of commercial fertilizers and pesticides on their lawns and gardens and education on proper maintenance of their wells and septic systems.

DEQ has assisted Owyhee County in developing and implementing the *Owyhee County Ground Water Quality Improvement and Drinking Water Source Protection Plan* (DEQ 2010a). This plan includes information for private well owners and agricultural operators aimed at reducing source water contamination, including activities to reduce nitrate contamination.

2.1.7 Missile Base Road Synoptic Ground Water Monitoring Project

2.1.7.1 Purpose and Background

In September 2015, DEQ collected ground water samples from 14 domestic and/or irrigation wells in the Grand View NPA, as discussed in section 2.1.3 of this report. Results identified elevated nitrate concentrations at 4 wells near Missile Base Road in Grand View, Idaho; the elevated nitrate concentrations were between 19.95 mg/L and 106 mg/L.

The Missile Base Road Synoptic Ground Water Monitoring Project was designed to analyze samples from the area for a wide spectrum of constituents in an attempt to determine the sources of high nitrate.

Samples were collected from 3 wells, including 2 of the 3 wells found to have the highest concentration of nitrate during the Grand View NPA sampling event in September 2015 and an additional well that was considered upgradient and/or crossgradient of the degraded wells.

Determining the direction of ground water flow in the area is difficult. IDWR's 1992 ground water elevation map shows a general west to east movement (Figure 16).

Historical data collected by various agencies between 1998 and 2009 show a pattern of wells with high nitrate values beginning at Missile Base Road and following Highway 78 heading southeast toward Grand View Road (Figure 17).

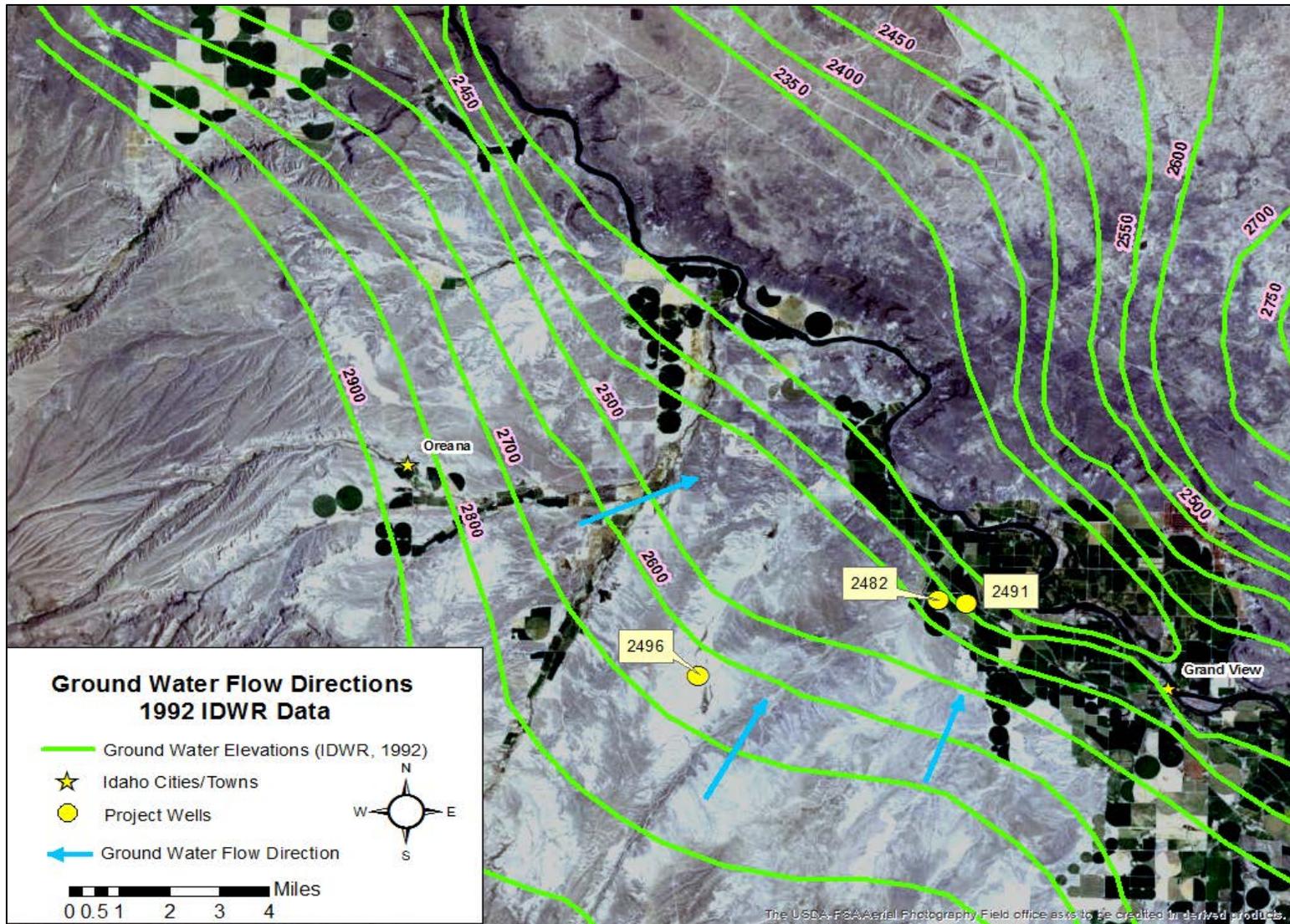


Figure 16. Well locations and ground water elevations—Missile Base Road Synoptic Ground Water Monitoring Project.

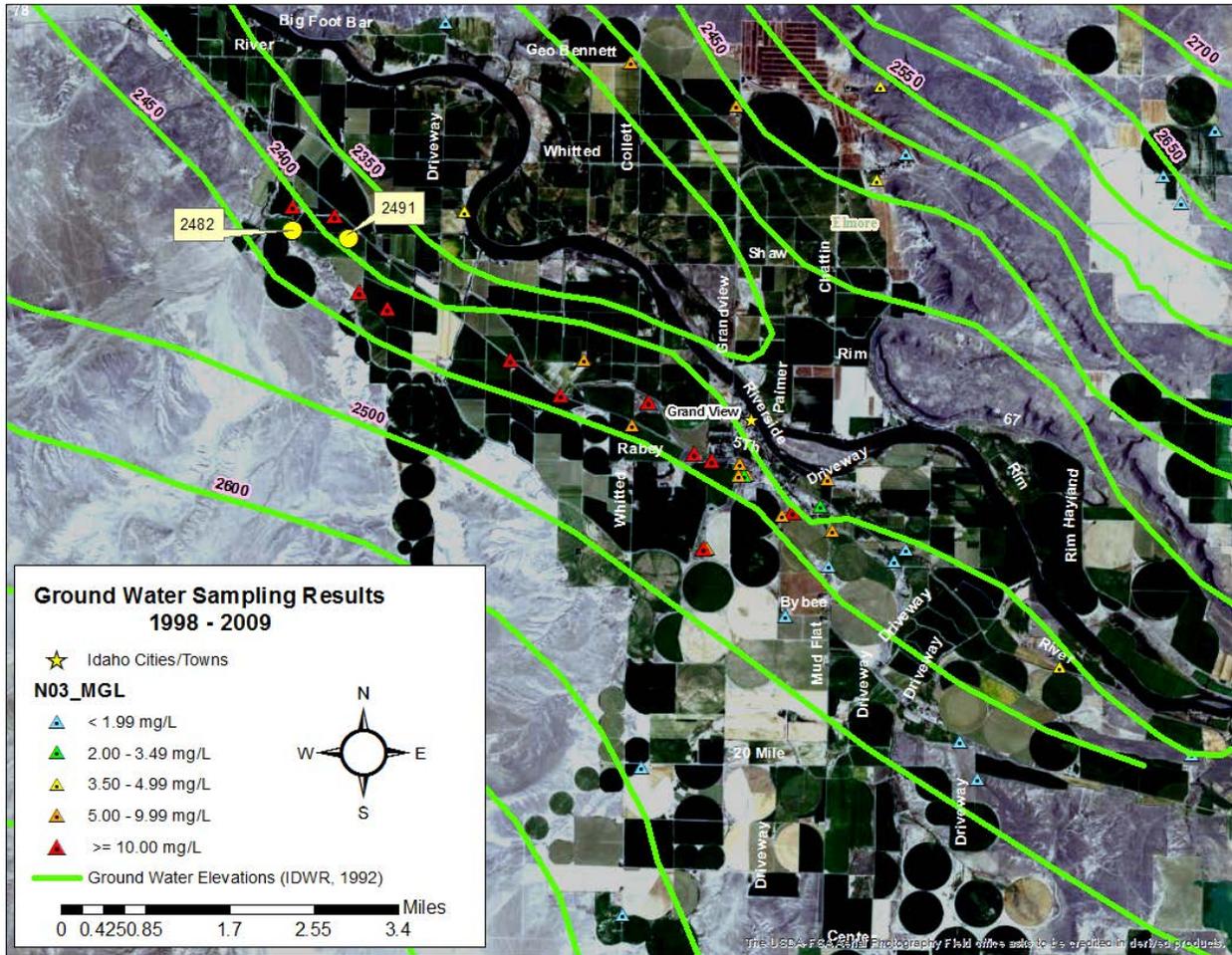


Figure 17. Historic ground water nitrate (NO₃) sampling data, 1998–2009.

2.1.7.2 Methods and Results

DEQ obtained permission from the 3 well owners to access the wells and collect samples for laboratory analysis.

On November 23, 2015, samples were collected from each well in accordance with the appropriate QAPP (DEQ 2015p) and FSP (DEQ 2015q).

A review of past sampling of Well 2482 conducted by ISDA from May 2006 through May 2014 indicated that the nitrate concentrations were consistently between 97 mg/L and 132 mg/L (Appendix A, Table A-1). This finding is consistent with the nitrate concentration of 106 mg/L detected by DEQ in September during the Grand View NPA Ground Water Monitoring Project.

Well 2491 was selected because it had the second highest nitrate concentration in the area sampled for the Grand View NPA. Well 2491 is east of Well 2482 and downgradient of Well 2482 (IDWR 1992) (Figure 16).

Well 2496 was selected because it is upgradient of Well 2482 (IDWR 1992) (Figure 16).

Water quality field parameters (pH, temperature, specific conductivity, and DO) were measured at each well prior to sample collection (Table 22).

Table 22. Water quality field parameters—Missile Base Road Synoptic Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	Sample Date	Water Temperature (°C)	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	pH ^a
2482	100	11/23/2015	13.72	2,720	12.26	7.31
2491	78	11/23/2015	15.38	1,510	5.60	7.42
2496	412	11/23/2015	19.41	731	1.34	7.75

^a Contaminant with a National Secondary Drinking Water Regulation standard. The NSDWR standard for pH is 6.5-8.5. NSDWR standards are recommended limits for public water systems but can be applied to private wells to evaluate water quality.

The water samples were submitted to four analytical laboratories for analysis using procedures outlined in the FSP. The UIASL in Moscow analyzed the samples for common ions and TDS; nutrients (nitrate and nitrite); uranium and heavy metals (arsenic, cadmium, chromium, lead, and selenium); and trace metals. Dissolved methane analysis was conducted by Accutest Laboratories in Wheat Ridge, Colorado. Anatek Labs, Inc., in Moscow, Idaho, analyzed samples for benzene, toluene, ethylbenzene, and xylenes (m+p- xylene and o-xylene) (BTEX) and TPH.

Nitrate Results

Nitrate was not detected in Well 2496 (the upgradient well). Wells 2482 and 2491 exceeded the MCL of 10 mg/L with concentrations of 110 and 38 mg/L, respectively (Table 23).

Sulfate Results

The reported sulfate concentration for Well 2496 was 10 mg/L. Wells 2482 and 2491 had sulfate concentrations of 570 and 260 mg/L, respectively, both exceeding the NSDWR standard of 250 mg/L.

Table 23. Common ions and nitrate—Missile Base Road Synoptic Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	Sample Date	Calcium	Magnesium	Potassium	Sodium	Fluoride ^a	Chloride ^b	Bromide	Ortho-phosphate	Sulfate ^b	Nitrate ^a	Nitrite ^a
(mg/L)													
<i>Primary or Secondary Standard:</i>			<i>NA</i>	<i>NA</i>	<i>NA</i>	<i>NA</i>	<i>4</i>	<i>250</i>	<i>NA</i>	<i>NA</i>	<i>250</i>	<i>10</i>	<i>1</i>
2482	100	11/23/2015	190	78	6.2	300	1.9	170	<0.50	0.031	570	110	<0.05
2491	78	11/23/2015	110	46	6.8	160	1.3	81	<0.50	0.027	260	38	<0.05
2496	412	11/23/2015	15	4.6	11	140	0.36	8.0	<0.50	0.19	10	<0.1	<0.05

Notes: Bolded red numbers indicate EPA's National Primary Drinking Water Regulation (NPDWR) standard, expressed as a maximum contaminant level (MCL), was exceeded. Italicized red numbers indicate EPA's National Secondary Drinking Water Regulation (NSDWR) standard was exceeded. These regulations are applicable for public water systems only but are recommended limits and can be applied to private wells to evaluate water quality.

^a Contaminant with a National Primary Drinking Water Regulation standard.

^b Contaminant with a National Secondary Drinking Water Regulation standard.

Total Dissolved Solids Results

The reported TDS concentrations ranged from 470 mg/L to 2,100 mg/L (Table 24). Two wells (2482 and 2491) exceeded the NSDWR standard of 500 mg/L.

Table 24. TDS and alkalinity—Missile Base Road Synoptic Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	Sample Date	Total Dissolved Solids ^a	Alkalinity (as CaCO ₃)
			(mg/L)	
<i>Secondary Standard:</i>			<i>500</i>	<i>NA</i>
2482	100	11/23/2015	<i>2,100</i>	385
2491	78	11/23/2015	<i>1,100</i>	335
2496	412	11/23/2015	470	394

Note: Italicized red numbers indicate EPA's National Secondary Drinking Water Regulation standard was exceeded.

^a Contaminant with a National Secondary Drinking Water Regulation standard.

Radionuclide (Uranium, Gross Alpha and Beta Particle) Results

The radionuclides uranium, gross alpha, and gross beta particles were sampled for this project. Radionuclides are naturally occurring elements that emit radioactive particles as they decay. They are present in every substance on the planet, usually at very low concentrations. Uranium is a naturally occurring radioactive element in rocks, soil, water, plants, and animals (including humans). Uranium is common in specific types of geologic material and can mobilize in the presence of nitrate through a series of bacterial and chemical reactions. Alpha particles are a type of radiation emitted by some radionuclides, most commonly from the decay products of uranium like radium (Ra-226), radon (Rd-222), and uranium isotopes (Ur-238). Beta particles are another type of radiation emitted by radionuclides. Sources of beta particles include tritium, strontium-90, cesium-137, and products of radium decay (California State Water Resources Control Board 2016).

Two of the 3 wells had detections of uranium, with concentrations of 24 µg/L and 26 µg/L (Table 25). None of the samples exceeded the MCL of 30 µg/L.

The reported gross alpha and beta concentrations are reported in Table 25. Well 2491 exceeded the gross alpha particle MCL of 15 picoCuries per liter (pCi/L). The reported gross beta concentrations ranged from 3.14 to 5.40 pCi/L.

Table 25. Uranium, gross alpha, and gross beta results—Missile Base Road Synoptic Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	Sample Date	Uranium ^a (µg/L)	Gross Alpha ^a (pCi/L)	Qualifier	Gross Beta ^a (pCi/L)	Qualifier
Primary or Secondary Standard:			30	15	NA	4 (mrem/yr) ^b	NA
2482	100	11/23/2015	26	11.3	± 4.26	3.14	± 1.46
2491	78	11/23/2015	24	21.4	± 3.18	4.52	± 1.48
2496	412	11/23/2015	<0.25	<1	± 1.05	5.40	± 0.97

Notes: Bolded red numbers indicate EPA's National Primary Drinking Water Regulation (NPDWR) standard, expressed as a maximum contaminant level (MCL), was exceeded. These regulations are applicable for public water systems only but are recommended limits and can be applied to private wells to evaluate water quality.

^a Contaminant with a National Primary Drinking Water Regulation standard.

^b A rem is a unit of measure describing how a specific type of radiation damages biological tissue. A millirem (mrem) is one thousandth of a rem. A Curie is a standard unit of radioactivity, where 1 Curie is the radioactivity associated with 1 gram of radium. A picocurie (pCi) is one trillionth of a curie. There is no simple conversion between a picoCurie and a millirem. Idaho's Drinking Water Program uses EPA's screening level of 50 pCi/L. If this screening level is exceeded, additional testing may be required.

Heavy Metal Results

The heavy metal sampling results can be found in Table 26. Only those heavy metals detected above the laboratory detection level are discussed below.

Arsenic Results

The reported arsenic concentrations ranged from 2.4 µg/L to 13 µg/L. Two of the three wells (2482 and 2491) exceeded the arsenic MCL of 10 µg/L.

Lead Results

The reported lead concentrations ranged from <0.1 µg/L to 0.28 µg/L. No wells exceeded the lead MCL of 15 µg/L.

Cadmium Results

Well 2482 tested positive for cadmium but did not exceed the MCL of 5 µg/L.

Chromium Results

Wells 2482 and 2491 tested positive for chromium but did not exceed the MCL of 100 µg/L.

Selenium Results

Wells 2482 and 2491 tested positive for selenium but did not exceed the MCL of 50 µg/L.

Dissolved Metal Results

The dissolved metal sampling results can be found in Table 27. Only those dissolved metals detected above the laboratory detection level are discussed below.

Barium Results

All 3 wells had confirmed detections of barium; the concentrations ranged from 0.046 mg/L to 0.14 mg/L. No wells exceeded the MCL of 2 mg/L.

Boron Results

All 3 wells had confirmed detections of boron; the concentrations ranged from 0.53 mg/L to 1.1 mg/L. Boron does not have an MCL or secondary standard at this time.

Iron Results

Well 2482 had a confirmed detection of iron at 0.43 mg/L, which exceeded the iron MCL of 0.3 mg/L.

Manganese Results

Well 2496 had a confirmed detection of manganese at 0.088 mg/L, which exceeded the manganese MCL of 0.05 mg/L.

Hydrocarbon Results

All three wells were sampled for the following hydrocarbon constituents: benzene, ethylbenzene, xylene (m+p- and o-), toluene, TPH compounds (gasoline range, lubricant oil range, and diesel range), and dissolved methane. The hydrocarbon (BTEX, TPH, and methane) results can be found in Table 28. Only those hydrocarbon compounds detected above the laboratory detection level are discussed below.

Methane Results

Well 2496 had a confirmed detection of dissolved methane at a concentration of 32.6 µg/L. Currently there is no MCL for dissolved methane. The hazard with methane in water is when dissolved methane moves from ground water into the atmosphere, where it can potentially ignite, or if it accumulates in a confined space where it can explode.

VOC and Pesticide Results

All three wells were sampled for various volatile organic compounds (VOCs) and pesticides. The full list of compounds included in the analysis can be found in Appendix A. No VOCs or pesticides were detected above the laboratory detection levels in any of the wells.

Table 26. Heavy metal results—Missile Base Road Synoptic Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	Sample Date	Arsenic ^a	Cadmium ^a	Chromium ^a	Lead ^a	Nickel	Selenium ^a	Silver ^b	Mercury ^a
			(µg/L)							
Primary or Secondary Standard:			10	5	100	15	NA	50	100	2
2482	100	11/23/2015	13	0.12	2.8	0.28	<2.5	39	<0.1	<0.5
2491	78	11/23/2015	12	<0.1	2.2	0.20	<2.5	11	<0.1	<0.5
2496	412	11/23/2015	2.4	<0.1	<0.5	<0.1	<2.5	<0.1	<0.1	<0.5

Notes: Bolded red numbers indicate EPA's National Primary Drinking Water Regulation (NPDWR) standard, expressed as a maximum contaminant level (MCL), was exceeded. These regulations are applicable for public water systems only but are recommended limits and can be applied to private wells to evaluate water quality.

^a Contaminant with a National Primary Drinking Water Regulation standard.

^b Contaminant with a National Secondary Drinking Water Regulation standard.

Table 27. Dissolved metals results—Missile Base Road Synoptic Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	Sample Date	Barium ^a	Boron	Cobalt	Copper ^b	Iron ^c	Manganese ^c	Molybdenum	Vanadium	Zinc ^c
			(mg/L)								
Primary or Secondary Standard:			2	NA	NA	1.0	0.3	0.05	NA	NA	5
2482	100	11/23/2015	0.046	1.1	<0.01	<0.020	0.43	<0.005	<0.25	<0.02	<0.02
2491	78	11/23/2015	0.046	0.54	<0.01	<0.020	<0.1	<0.005	<0.25	<0.02	<0.02
2496	412	11/23/2015	0.14	0.53	<0.01	<0.020	<0.1	0.088	<0.25	<0.02	<0.02

Notes: Italicized red numbers indicate EPA's National Secondary Drinking Water Regulation standard was exceeded. These regulations are applicable for public water systems only but are recommended limits and can be applied to private wells to evaluate water quality.

^a Contaminant with a National Primary Drinking Water Regulation standard.

^b EPA established a treatment technique rather than an MCL for copper. If more than 10% of tap water samples exceed the copper action level of 1.3 mg/L, water systems must take additional steps to reduce corrosiveness.

^c Contaminant with a National Secondary Drinking Water Regulation standard.

Table 28. BTEX, TPH, and methane results—Missile Base Road Synoptic Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	Sample Date	Benzene ^a	Toluene ^a	Ethylbenzene ^a	m+p-xylene ^a	O-xylene ^a	TPH			Dissolved Methane ^b
								Gasoline Range	Lube Oil Range	Diesel Range	
			(µg/L)					(mg/L)			(µg/L)
<i>Primary or Secondary Standard:</i>			<i>5</i>	<i>1000</i>	<i>700</i>	<i>10,000</i>		<i>NA</i>	<i>NA</i>	<i>NA</i>	<i>NA</i>
2482	100	11/23/2015	<0.50	<0.50	<0.50	<1.00	<0.50	<0.10	<0.50	<0.10	<0.80
2491	78	11/23/2015	<0.50	<0.50	<0.50	<1.00	<0.50	<0.10	<0.50	<0.10	<0.80
2496	412	11/23/2015	<0.50	<0.50	<0.50	<1.00	<0.50	<0.10	<0.50	<0.10	32.6

^a Contaminant with a National Primary Drinking Water Regulation standard.

^b The US Department of the Interior Office of Surface Mining advises well owners with dissolved methane levels greater than 28 mg/L (28,000 µg/L) to immediately remove any potential ignition sources and vent the gas away from any confined spaces (Eltzschlager et al. 2001).

2.1.7.3 Conclusion

The Grand View NPA sampling event found four wells within a small area around Missile Base Road with nitrate concentrations between 19.95 mg/L and 106 mg/L.

The Missile Base Road Synoptic Ground Water Monitoring Project was designed to collect a wide spectrum of samples from three wells in an attempt to determine the sources of high nitrate. The three wells included two wells from the Grand View NPA project (Wells 2482 and 2491) and an upgradient/crossgradient well (Well 2496).

Comparing the results from this sampling event confirm that the results from the upgradient well (Well 2496) are not similar to the results from Wells 2482 and 2491 (Table 29).

Table 29. Comparison of analytes detected in project wells—Missile Base Road Synoptic Ground Water Monitoring Project.

Analyte Detected	Well 2482	Well 2491	Well 2496
Sulfate (above standard)	✓	✓	
Nitrate	✓	✓	
TDS (above standard)	✓	✓	
Gross Alpha Particles	✓	✓	
Gross Beta Particles	✓	✓	✓
Arsenic	✓	✓	✓
Barium	✓	✓	✓
Boron	✓	✓	✓
Cadmium		✓	
Chromium	✓	✓	
Lead	✓	✓	
Selenium	✓	✓	
Uranium	✓	✓	
Iron	✓		
Manganese			✓
Methane			✓

Wells 2482 and 2491 had elevated nitrate concentrations in excess of the MCL, with the concentration at Well 2482 over 10 times greater than the MCL. Well 2496 had a nitrate concentration below the laboratory detection limit.

Well 2482 and 2491 also had TDS concentrations more than double the MCL of 500 mg/L. Well 2496 had a TDS concentration of 470, which is below the MCL.

Wells 2482 and 2491 have high levels of nitrate, arsenic, uranium, and gross alpha particles and lower concentrations of other metals and gross beta particles.

Well 2496 had positive detections of gross beta particles, a trace amount of boron and barium, dissolved methane, and manganese above the NSDWR standards.

Wells 2482 and 2491, located close to one another, appear to have similar ground water chemistry and are similar in total depth, and thus appear to draw water from the same part of the aquifer. Well 2496 is approximately 5 miles upgradient/cross-gradient and is completed to a much deeper depth. This combined with what appears to be different ground water chemistry seems to indicate that Well 2496 is drawing from a different ground water source or a different part of the aquifer than Wells 2482 and 2491.

2.1.7.4 Recommendations

DEQ has no plans for additional sampling of this project at this time. Due to exceedances of several primary drinking water regulations, Wells 2482 and 2491 are considered unsafe for consumption. Treating the water source or using an alternative supply is recommended for these well owners.

Property owners with private domestic drinking water wells should sample and analyze their well water on an annual basis. Southwest District Health can also provide property owners with information and guidance. In addition, property owners may benefit from education on the use of commercial pesticides on their lawns and gardens and education on proper well and septic system maintenance.

Land-use activities near the sites with elevated nitrate concentrations should be evaluated by the appropriate agency to determine if best management practice (BMP) modifications should be implemented or improved to protect ground water quality from further degradation.

DEQ has assisted Owyhee County in developing and implementing the *Owyhee County Ground Water Quality Improvement and Drinking Water Source Protection Plan* (DEQ 2010a). This plan includes information for private well owners and agricultural operators aimed at reducing source water contamination, including activities to reduce nitrate contamination.

2.1.8 City of Mountain Home Tracer Test Project

2.1.8.1 Purpose and Background

The Mountain Home Tracer Test Project was conducted in response to a complaint DEQ received on June 17, 2011, concerning bacterial contamination of a well in the vicinity of a stormwater infiltration basin (stormwater basin) operated by the City of Mountain Home. Both the complainant's well and stormwater basin are located along S. 5th West Street in Mountain Home, Idaho (Figure 18; Figure 19). The homeowner noted impacts to his well including cloudiness (turbidity) and bacteria, confirmed by laboratory tests. In response to the complaint, the IDWR conducted an initial investigation of the basin in 2014 to determine whether it was a shallow injection well and thus within their regulatory jurisdiction. The stormwater basin did not meet the requirements for classification as a shallow injection well; therefore, IDWR had no authority to address the suspected concerns associated with the basin. Based on the lack of IDWR jurisdiction, DEQ took responsibility for the investigation.

To determine whether there was a hydraulic connection between the stormwater basin and the complainant's well and other nearby wells, DEQ developed a fluorescein dye tracer test and ground water monitoring project.

Dye tracing is considered a safe and effective tool that can be used to help answer ground water-related questions, such as where is the water moving, how fast is the water moving, and what happens to it along the way. For this tracer test, approximately 0.5 pounds of 75% fluorescein dye was used. Fluorescein dye can also be sold as "green fluorescent dye" (Aley 2002). Fluorescein is approved for use in drinking water and is considered a conservative tracer (has relatively good resistance to adsorption onto inorganic material) (Aley 2002). Adsorption onto organic material was less of a concern considering the lack of soil and organic matter in the bottom of the stormwater basin where the dye was released. The fluorescein dye was released in the basin, along with approximately 9,000 gallons of city drinking water from a nearby city fire hydrant. Ground water data were collected from the complainant's well and six additional domestic wells within 0.5 miles of the basin (Figure 19).

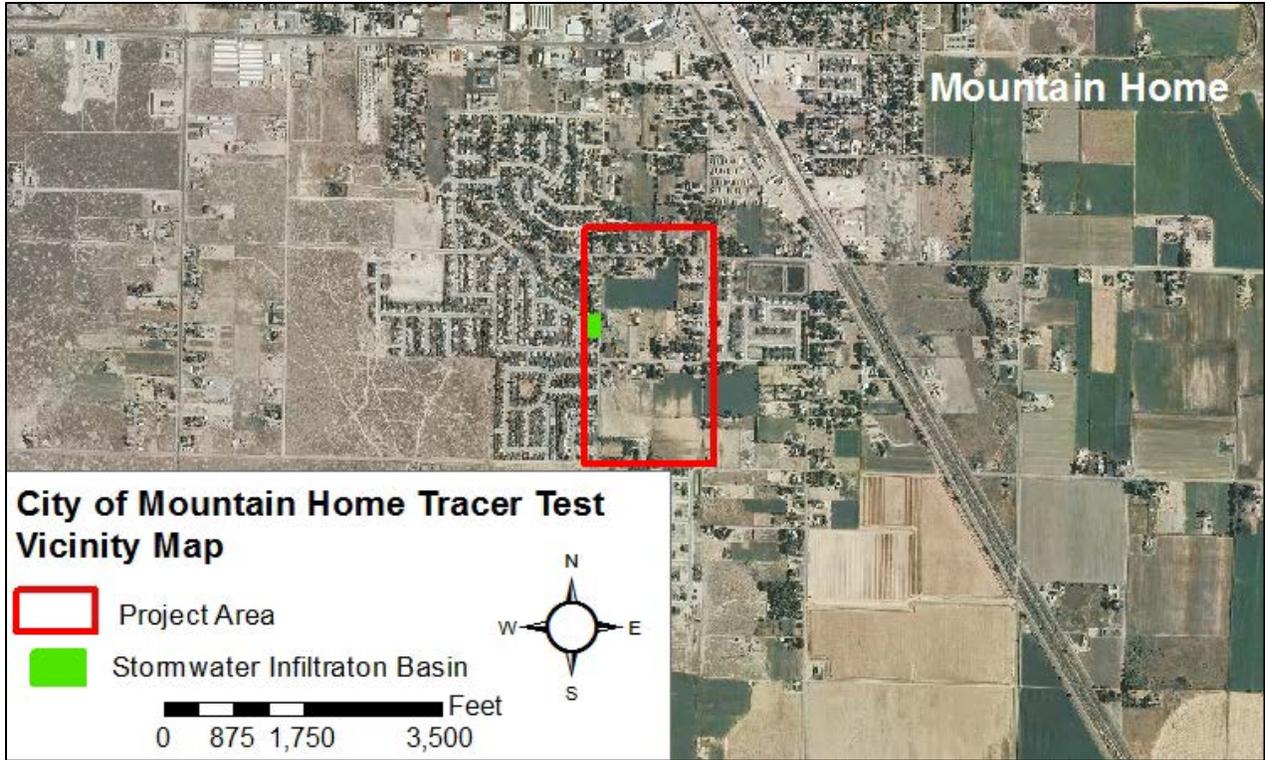


Figure 18. City of Mountain Home Project Area and stormwater infiltration basin—City of Mountain Home Tracer Test Project.



Figure 19. Location of City of Mountain Home stormwater infiltration basin and project wells (identified by DEQ Site ID [well name])—City of Mountain Home Tracer Test Project.

Well drillers reports (well logs) from wells located within and surrounding the project area indicate the lithology consists of fractured basalt overlain by sand and gravel. The depth to (static) water shown on well logs for private, domestic wells located to the east and southeast of

the stormwater infiltration basin ranges from approximately 100 to 400 feet bgs. Regional ground water occurs under unconfined conditions and is believed to flow in a southwesterly direction in the project area based on ground water elevations (IDWR 2014).

2.1.8.2 Methods and Results

On May 18, 2015, DEQ sampled the seven project wells for nitrate, nitrite, bacteria (TC and *E. coli*), TDS, and major ions, including calcium, magnesium, sodium, potassium, chloride, sulfate, and alkalinity (as CaCO₃). Follow-up ground water sampling was conducted on June 3, 2015, for six of the seven wells; the seventh well (2462) was resampled on June 22, 2015, due to the homeowner's travel schedule.

After initial well sampling on May 18, DEQ released concentrated fluorescein dye in the stormwater basin to evaluate a potential hydraulic connection between the basin and nearby domestic wells. Unfiltered and untreated ground water was sampled at seven nearby wells through direct sampling of the well water and passive sampling of household toilet tank water using activated carbon samplers (charcoal packets).

A half-pound of powder fluorescein dye was premixed (offsite) with approximately 2 gallons of water. Care was taken to eliminate cross-contamination between the dye and staff sampling. The premixed dye was transported to the field in a separate vehicle from staff conducting the pre-dye release sampling. The dye was released with approximately 6,000 gallons of flush water from a city fire hydrant at an approximate rate of 100 gallons per minute. To aid in complete drainage of the dye, an additional 3,000 gallons of flush water was added approximately an hour after the initial 6,000 gallons. A combined total of approximately 9,000 gallons of flush water was added to the stormwater basin. Flush water and dye release was directed at the portion of the basin believed to be the area of fastest drainage and nearest to the complainant's well.

All samples were collected in accordance with the appropriate QAPP (DEQ 2015h). Water quality field parameters (pH, temperature, specific conductivity, DO) were measured prior to sample collection (Table 30). The observed increases in temperature on May 19 and May 26 at Well 2459 are suspected to be a result of heating due to continuous operation of the pump to allow for a flow through effect in lieu of a toilet being used. Based on observations from the homeowner, the pump may have turned off due to overheating on one or more occasions during the study.

Table 30. Water quality field parameters—City of Mountain Home Tracer Test Project.

DEQ Site ID	Well Name	Well Depth (feet bgs)	Sample Date	Water Temperature (°C)	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	pH ^a
2459	MHTT-1	574	5/18/2015	13.90	585	10.7	7.35
			5/19/2016	16.58	308	8.36	<i>6.29</i>
			5/26/2015	20.37	629	7.84	<i>6.48</i>
			6/03/2015	14.16	505	7.52	7.24
2460	MHTT-3	728	5/18/2015	18.80	292	7.51	8.35
			6/03/2015	18.18	296	5.67	<i>8.56</i>
2461	MHTT-4	675	5/18/2015	18.72	236	7.91	8.34
			6/03/2015	19.00	226	6.11	<i>8.69</i>
2462	MHTT-5	625	5/18/2015	19.15	307	9.43	8.28
			6/22/2015	19.04	340	10.92	8.02
2463	MHTT-6	—	5/18/2015	18.69	269	11.43	8.27
			6/03/2015	18.31	246	6.93	<i>8.51</i>
2464	MHTT-7	—	5/18/2015	12.20	247	10.48	6.77
			6/03/2015	12.45	252	7.76	7.02
2465	MHTT-8	—	5/18/2015	15.57	463	10.64	7.19
			6/03/2015	15.07	414	8.06	7.26

^a Contaminant with a National Secondary Drinking Water Regulation (NSDWR) standard. Italicized red numbers indicate EPA's NSDWR standard was exceeded. The NSDWR for pH is 6.5-8.5. NSDWR standards are recommended limits for public water systems but can be applied to private wells to evaluate water quality.

The ground water samples from May 18, June 3, and June 22 were submitted to the IBL in Boise, Idaho, for analysis (Table 31). Fluorescein samples (both charcoal packets and water samples) were sent to Ozark Underground Laboratory in Protom, Missouri, for analysis. Ozark Underground Laboratory is a private consulting and contract studies firm that provides dye tracer test assistance and other hydrogeological services.

Table 31. Inorganic, nutrient, and bacteria results—City of Mountain Home Tracer Test Project.

DEQ Site ID	Well Name	Well Depth (feet bgs)	Sample Date	Major Ion Concentrations							TDS ^a	Nitrate ^b	Bacteria ^c	
				Calcium	Magnesium	Sodium	Potassium	Chloride ^a	Sulfate ^a	Alkalinity (as CaCO ₃)			Total Coliform	<i>E. coli</i>
				(mg/L)									(MPN/100 mL)	
<i>Primary or Secondary Standard:</i>				<i>NA</i>	<i>NA</i>	<i>NA</i>	<i>NA</i>	<i>250</i>	<i>250</i>	<i>NA</i>	<i>500</i>	<i>10</i>	<i>1 cfu/100 mL</i>	<i><1.0</i>
2459	MHTT-1	574	5/18/2015	44	13	57	5.8	23.8	34	203	350	5.44	42.6	<1.0
			6/03/2015	36	10	46	5.3	20.3	27.2	170	320	4.7	>2419.6	185.0
2460	MHTT-3	728	5/18/2015	23	13	16	4.2	7.72	12.2	117	180	2.20	<1.0	<1.0
			6/03/2015	23	13	16	4.1	7.52	12.1	121	200	2.13	<1.0	<1.0
2461	MHTT-4	675	5/18/2015	19	10	13	4.2	5.44	9.1	99	150	1.35	<1.0	<1.0
			6/03/2015	18.0	9.8	13	4.1	5.02	8.7	100	170	1.25	<1.0	<1.0
2462	MHTT-5	625	5/18/2015	29	16	17	5.2	10.2	14.9	141	220	2.90	<1.0	<1.0
			6/22/2015	22	16	17	5.1	10.2	14.7	152	240	2.90	<1.0	<1.0
2463	MHTT-6	—	5/18/2015	23	12	14	4.6	7.28	10.2	117	170	1.40	<1.0	<1.0
			6/03/2015	22	12	14	4.5	6.82	9.72	115	190	1.29	<1.0	<1.0
2464	MHTT-7	—	5/18/2015	29	6.9	12	4.5	9.54	8.35	107	180	0.241	<1.0	<1.0
			6/03/2015	28	6.7	12	4.4	8.75	7.62	106	200	0.210	<1.0	<1.0
2465	MHTT-8	—	5/18/2015	39	12	34	5.2	23.5	33.6	137	300	5.41	2419.6	2.0
			6/03/2015	33	10	29	4.3	18.8	24.2	126	280	4.61	435.2	<1.0

Notes: Bolded red numbers indicate either an EPA National Primary Drinking Water Regulation (NPDWR) standard, expressed as a maximum contaminant level (MCL), or an Idaho Ground Water Quality Rule (IDAPA 58.01.11.200) standard was reached or exceeded. These regulations are applicable for public water systems only but are used to evaluate water quality in private wells.

^a Contaminant with a National Secondary Drinking Water Regulation standard.

^b Contaminant with a National Primary Drinking Water Regulation standard.

^c Total coliform and *E. coli* standards are from the Idaho Ground Water Quality Rule (IDAPA 58.01.11.200). An exceedance of the primary ground water quality standard for total coliform (indicated by gray shaded numbers) is not a violation of these rules. Total coliform is not a health threat in itself; it is used to indicate whether other potentially harmful bacteria may be present. Although the standards are given in cfu/100 mL, analytical results provided in MPN/100 mL are acceptable for comparison to the standard.

DEQ also collected discrete (grab) water samples and/or passive samples (using charcoal packets) for fluorescein dye analysis on May 18, May 19, May 26, June 3, and June 22 from the complainant's well (2459). The water samples were collected from a valve on the well, inside the pump house, prior to the well's treatment system. The water samples were included in the study design for the purpose of providing validation to the results of the charcoal packet analysis. Fluorescein water samples were collected prior to release of dye on May 18 to establish background conditions, 2 hours after the dye release (May 18), approximately 24 hours after the dye release (May 19), one week after the dye release (May 26), and two weeks after the dye release (June 3) (Table 32).

Passive sampling was conducted with the use of charcoal (activated carbon) packets. This type of sampling produces a cumulative measure of the total amount of dye captured by the carbon for the duration the sampler is deployed (in contact with the water being sampled). Charcoal packets were deployed in six of the homeowners' toilet tanks (associated with Wells 2460, 2461, 2462, 2463, 2464, and 2465) prior to release of dye on May 18. The charcoal packets were then collected and new charcoal packets were redeployed on May 26. The charcoal packets deployed on May 26 were collected at the time of the follow-up ground water sampling on June 3 or 22.

A toilet without treated/filtered water was not available at the complainant's home (Well 2459), so the charcoal packets were placed in a flow-through cell connected to the well. The flow-through cell was used to simulate use of the well, similar to how it would be used when flushing the toilet. The flow-through cell was made with a 5-gallon bucket and standard garden hose. The well valve was left open enough to create a low-flow stream of water throughout the duration of the project, with possible minor disruptions. A charcoal packet was deployed in the flow through cell and collected (and replaced) prior to release of dye on May 18 to establish background conditions. The charcoal packet was collected, followed by placement of a new packet, approximately 2 hours after the dye release, then on May 19 and May 26. The charcoal packet deployed May 26 was collected June 3 at the time of follow-up sampling (Table 32).

Table 32. Fluorescein dye results—City of Mountain Home Tracer Test Project.

DEQ Site ID	Well Name	Well Depth (feet bgs)	Sample Date	Fluorescein Dye ($\mu\text{g/L}$)	
				Activated Carbon Sampler (Charcoal Packet)	Water Sample
2459	MHTT-1	574	5/18/2015 (pre-dye release)	<0.01	<0.00005
			5/18/2015 (2 hrs post-dye release)	514.2	16.5
			5/19/2016	1,770	291.0
			5/26/2015	1,460	15.4
			6/03/2015	182	5.46
2460	MHTT-3	728	5/26/2015	<0.01	—
			6/03/2015	<0.01	—
2461	MHTT-4	675	5/26/2015	<0.01	—
			6/03/2015	<0.01	—
2462	MHTT-5	625	5/26/2015	<0.01	—
			6/22/2015	<0.01	—
2463	MHTT-6	—	5/26/2015	<0.01	—
			6/03/2015	<0.01	—
2464	MHTT-7	—	5/26/2015	<0.01	—
			6/03/2015	<0.01	—
2465	MHTT-8	—	5/26/2015	<0.01	—
			6/03/2015	<0.01	—

Notes: (—) = data are unavailable or were not analyzed

Common Ion Results/General Water Chemistry

All sample results for common ions were below the National Secondary Drinking Water Regulation standards for public water systems. Two wells (2459 and 2465) had elevated concentrations (relative to the other project wells) of nitrate, chloride, sulfate, TDS, sodium, and calcium. These two wells were the same two wells with positive bacteria detections (see Bacteria Results section below). A Piper diagram was created to evaluate the water chemistry. Water chemistry data collected before and after the release of the fluorescein dye are plotted in Figure 20.

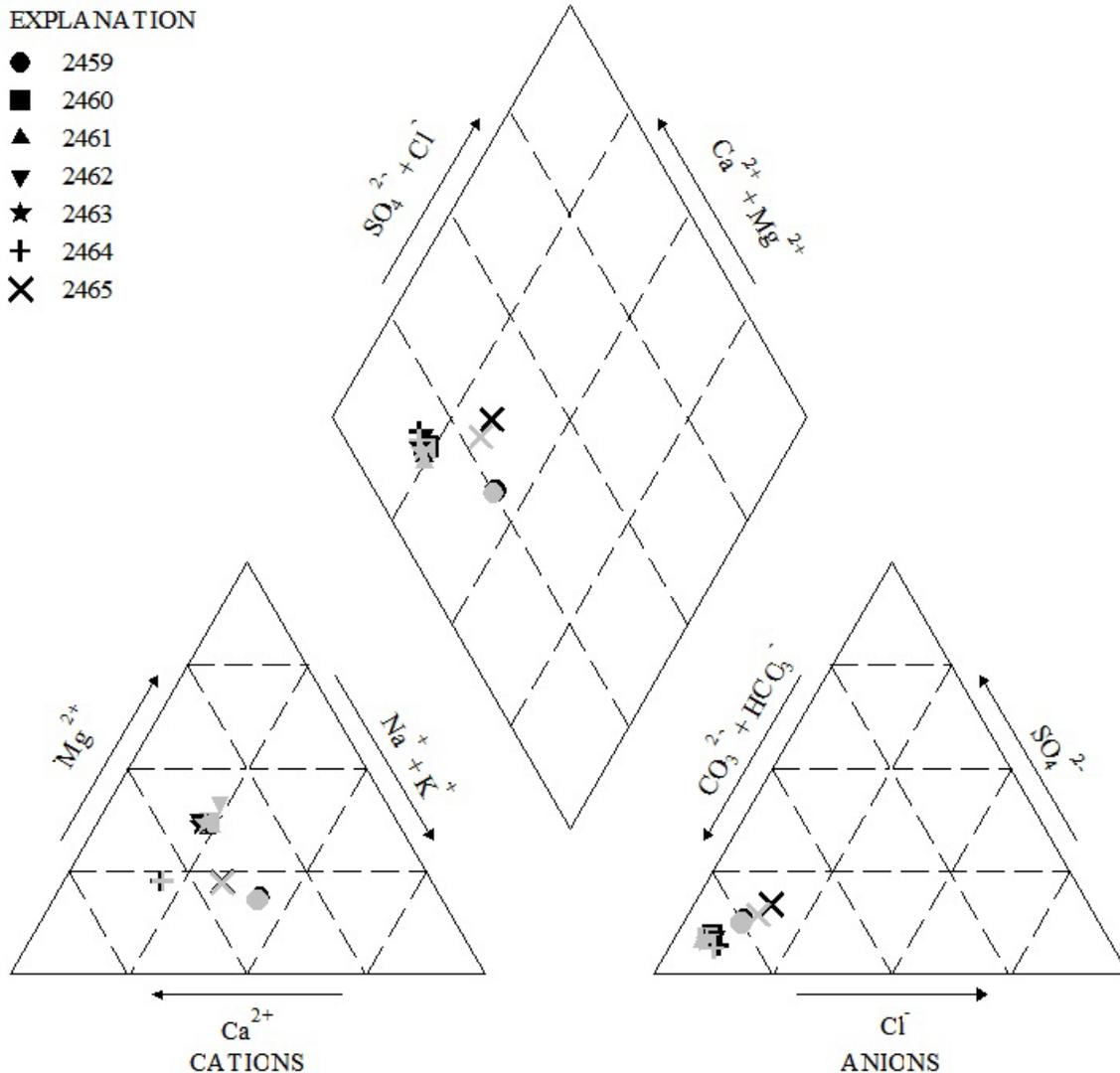


Figure 20. Piper diagram—City of Mountain Home Tracer Test Project 2015. The dark symbols represent samples collected in May; the light symbols represent samples collected in June.

Nitrate Results

All samples for nitrate were below the nitrate MCL of 10 mg/L; five of the seven wells had nitrate concentrations of 2.90 mg/L or less. The highest reported nitrate concentration from either round of sampling was 5.44 mg/L at Well 2459. Well 2465 had a similar nitrate concentration of 5.41 mg/L.

Bacteria Results

TC bacteria are common in the environment (such as soil) and are generally not harmful. *E. coli* bacteria, a type of coliform, are found in animal fecal matter. The presence of *E. coli* in drinking water provides strong evidence that human or animal fecal matter is present; therefore, a greater potential for pathogenic organisms exists. TC and *E. coli* concentrations are reported in the most probable number per 100 milliliters (MPN/100 mL).

In the May 18 sampling round, Well 2459 and Well 2465 had positive detections of TC with concentrations of 42.6 MPN/100 mL and 2,419.6 MPN/100 mL, respectively. Well 2465 also had a positive detection of *E. coli* on May 18, with a concentration of 2.0 MPN/100 mL. Well 2459 was negative for *E. coli* on May 18 (Table 31).

In the June 3 sampling round, Well 2459 and Well 2465 had positive detections of TC with concentrations of >2,419.6 and 435.2 MPN/100 mL, respectively. Well 2459 tested positive for *E. coli* with a concentration of 185.0 MPN/100 mL. Well 2465 was negative for *E. coli* on June 3.

Fluorescein Dye Results

The seven project wells were sampled for fluorescein dye through either discrete water samples or passive samples using charcoal packets. The reported results for the fluorescein samples collected at Well 2459 prior to the dye release as well as all other fluorescein samples collected from the remaining six project wells were below the laboratory detection limit (Table 32). The fluorescein samples collected post-dye release from Well 2459 were all positive for the dye, including the sample collected approximately 2 hours after the dye release. The highest reported fluorescein concentration in a discrete water sample (291.0 µg/L) was detected on May 19, approximately 24 hours post-dye release (Table 32; Figure 21).

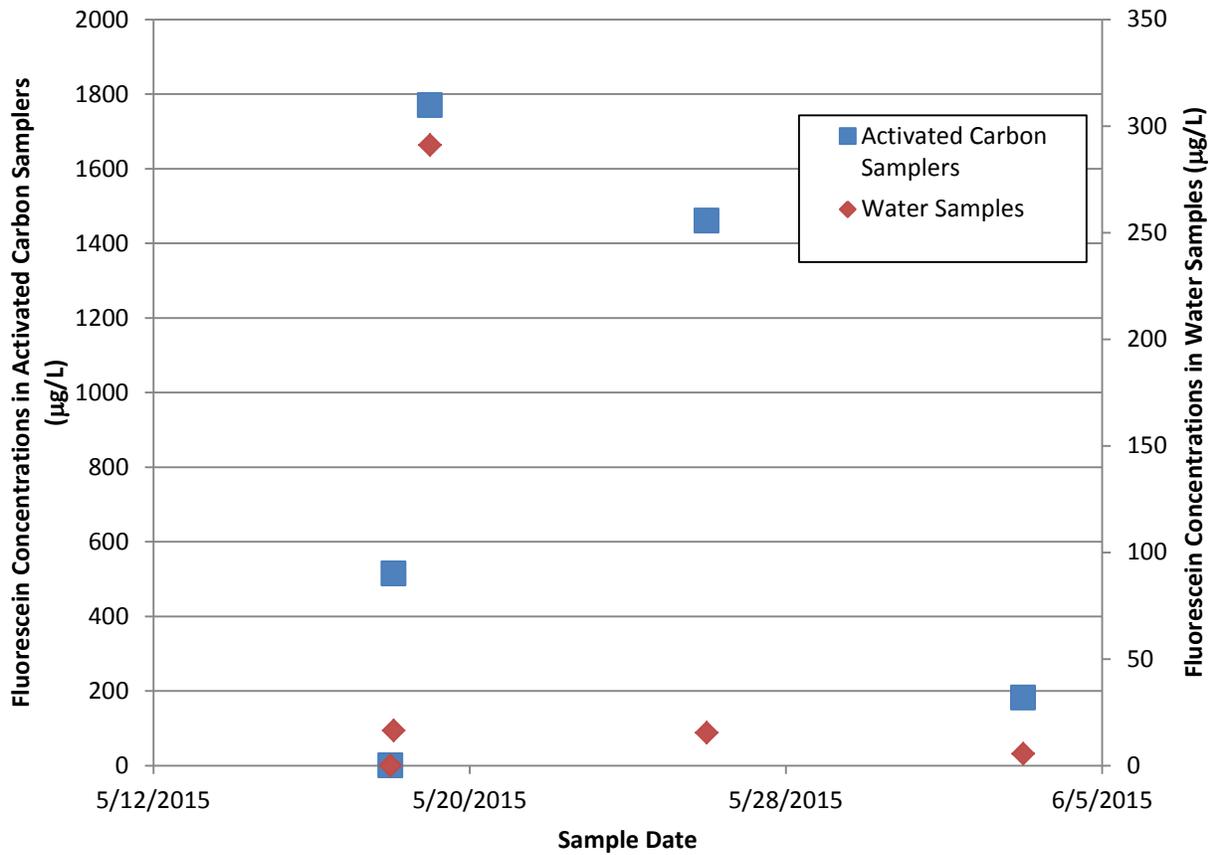


Figure 21. Scatter plot of positive fluorescein detections (both water and charcoal packet samples) from Well 2459—City of Mountain Home Tracer Test Project.

2.1.8.3 Conclusions

In response to a complaint of contaminated ground water, DEQ conducted a ground water dye tracer test to evaluate the potential for a hydraulic connection between a stormwater infiltration basin suspected of impacting ground water quality and a complainant's well (Well 2459). Sample collection for the project confirmed a hydraulic connection between the infiltration basin and the complainant's well (Well 2459) through positive detections of the fluorescein dye tracer. Samples collected on May 18 and June 3 also confirmed the presence of bacteria (both TC and *E. coli*) through positive detections. The nitrate results showed limited nitrate impact within the project area, as samples from five of the seven protect wells had nitrate concentrations of 2.90 mg/L or less; the remaining two wells (2459 and 2465) had slightly elevated concentrations of 5.44 mg/L and 5.41 mg/L, respectively.

Results were communicated with the project participants and public works director for the city of Mountain Home.

2.1.8.4 Recommendations

It was recommended that the city of Mountain Home take appropriate actions to ensure the stormwater infiltration basin, located on S. 5th West Street in Mountain Home, is not contaminating local ground water used by nearby residents for drinking water.

2.1.9 Northeast Star Nitrate Priority Area Ground Water Monitoring Project

2.1.9.1 Purpose and Background

This ground water monitoring project was designed to evaluate the water quality and nitrate concentrations in the Northeast Star NPA in Ada County, northeast of Star, Idaho. In 2008, the Northeast Star NPA ranked as the 8th most impacted NPA in Idaho. In 2014, the Northeast Star NPA ranked as the 9th most impacted NPA in Idaho. During the 2014 NPA delineation and ranking process, the boundaries of the Northeast Star NPA changed. Due to the boundary changes, additional wells were added to the sampling project to measure the nitrate levels in the new portions of the NPA. The 2015 Northeast Star sampling results will be used in the next NPA delineation and ranking process. The primary land use in the Northeast Star NPA is agricultural.

The project area contains two aquifers: a shallow system composed of older terrace gravels, younger terrace gravels, and recent finer-grained alluvial deposits and a deeper system thought to be part of the Tertiary Glens Ferry Formation of the Idaho Group (Howarth 1999; Bahr et al. 2000). The two systems are separated by a characteristic clay layer that ranges in thickness from 10 to 20 feet (Howarth 1999). A review of the available well logs of sampled wells shows that a clay layer is located at various depths throughout the project area, ranging from 18 to 105 feet bgs. This clay, locally identified by well drillers as "blue clay," is often present in various thicknesses and elevations throughout the central and western Boise River valley. The clay forms confining units that can separate shallow aquifers from deeper zones (Petrich and Urban 2004).

The ground water flow direction of the shallow aquifer is to the west toward the Snake River and also to the southwest when influenced by the Boise River or its tributaries (Figure 22).

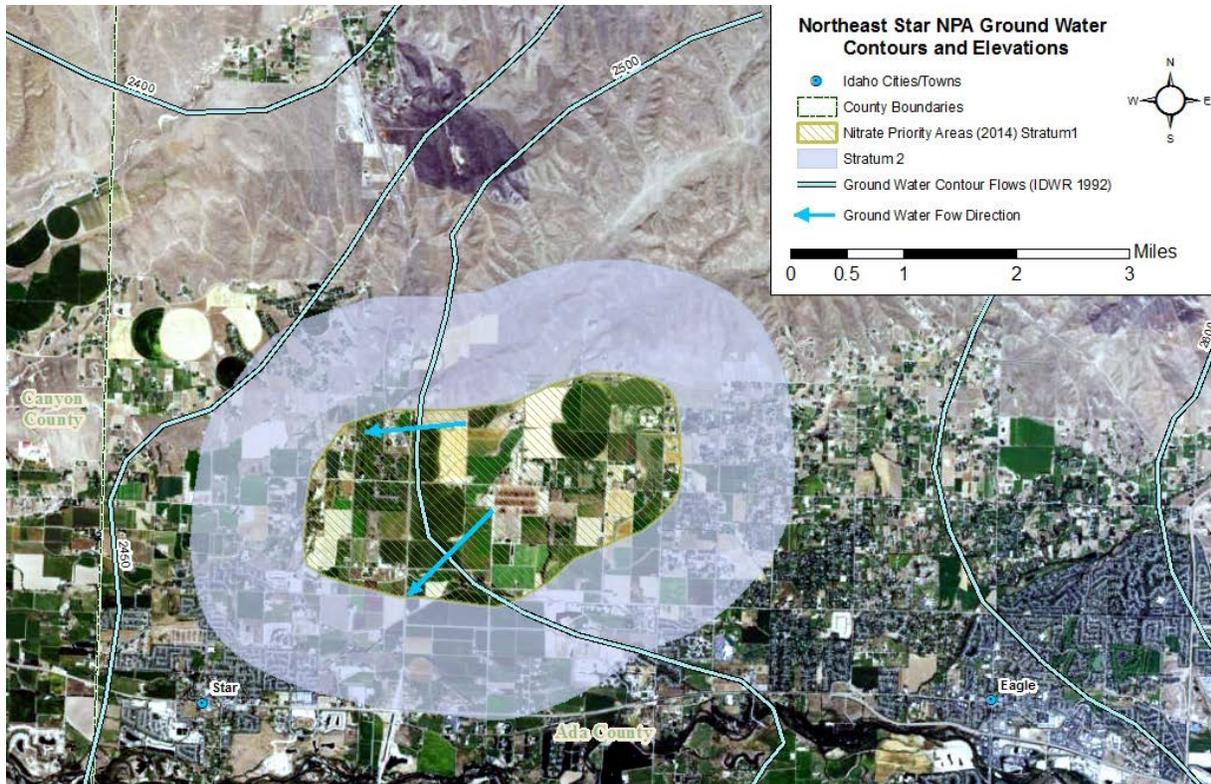


Figure 22. Ground water contours and elevations—Northeast Star Nitrate Priority Area Ground Water Monitoring Project.

The 2015 monitoring project was designed to provide the data necessary for evaluating trends in ground water nitrate concentrations in and around the Northeast Star NPA. Ground water samples were collected from individual private domestic or irrigation wells. Program objectives, design, and well selection processes are identified in the regional ground water monitoring network design (DEQ 2011a).

DEQ collected ground water samples from 18 wells in the Northeast Star NPA in 2010. Of those wells, 4 were previously sampled by either IDWR or ISDA, and 1 of these 4 wells was included in the 2015 project.

Table 33 identifies which wells have been sampled in the past by each agency and which wells were sampled by DEQ in 2015.

Table 33. Project wells identified as sampled by DEQ, ISDA, or IDWR.

DEQ Site ID	Previously Sampled by:	Well Sampled by DEQ in 2015	DEQ Site ID	Previously Sampled by:	Well Sampled by DEQ in 2015
1153	DEQ in 2010		1165	DEQ 1990 & 2010 DEQ/EPA 4/11/96	X
1154	DEQ in 2010		967	DEQ 2010 ISDA Network Well	X
1155	DEQ in 2010	X	499	DEQ 2010 IDWR and ISDA network well	
1156	DEQ in 2010	X	1167	DEQ in 2010	X
1157	DEQ in 2010	X	1168	DEQ in 2010	X
1158	DEQ in 2010	X	1169	DEQ in 2010	X
1159	DEQ in 2010	X	2199		X
1160	DEQ in 2010	X	2218		X
1161	DEQ in 2010		2472		X
1162	DEQ in 2010	X	2474		X
1170	DEQ 2007 & 2010, EPA 6/24/92, DEQ/EPA 3/29/95		2473		X
1163	DEQ – 1990 & 2010 IDWR network well		2475		X
1164	DEQ 2010 IDWR network well				

In 2015, DEQ collected ground water samples from 18 wells, including 12 wells sampled in 2010 and 6 additional domestic and/or irrigation wells. The 6 additional wells were selected using procedures outlined in the QAPP (DEQ 2014b). Program objectives, design, and well selection processes are identified in the regional ground water monitoring network design (DEQ 2011a).

DEQ analyzed the ground water samples for common water quality analytes including nitrate, nitrite, nitrogen isotope, and bacteria (TC and *E. coli*) to assess the ground water quality in the project area.

2.1.9.2 Methods and Results

The Northeast Star NPA is considered a small monitoring area as defined by the regional ground water monitoring network design (DEQ 2011a). When selecting new wells for the 2015 sampling event, cluster sampling was avoided by selecting one well per TRS ¼ section in areas of high well density.

DEQ obtained permission from the well owners to access 18 wells and collect samples for laboratory analysis.

Samples were collected in October 2015 from each well in accordance with the appropriate QAPP (DEQ 2014b) and FSP (DEQ 2015i).

Water quality field parameters (i.e., pH, temperature, specific conductivity, and DO) were measured at each well prior to sample collection (Table 34).

Table 34. Water quality field parameters—Northeast Star Nitrate Priority Area Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	Sample Date	Water Temperature (°C)	pH ^a	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)
967	74	10/20/2015	13.66	<i>6.38</i>	948	3.53
1155	38	10/19/2015	15.49	<i>6.30</i>	293	1.39
1156	110	10/19/2015	14.50	7.02	309	6.12
1157	144	10/19/2015	15.02	7.09	309	6.66
1158	79	10/19/2015	15.22	6.95	319	6.47
1159	123	10/19/2015	14.89	7.21	500	4.37
1160	98	10/19/2015	14.45	7.07	672	5.21
1162	275	10/19/2015	15.69	7.34	160	1.72
1165	60	10/20/2015	14.25	6.66	1,050	3.76
1167	50	10/20/2015	13.32	7.04	504	3.03
1168	60	10/20/2015	14.12	6.88	673	4.28
1169	71	10/20/2015	13.72	6.80	567	4.87
2199	147	10/20/2015	14.10	7.01	419	4.84
2218	119	10/20/2015	13.96	6.97	509	3.62
2472	115	10/19/2015	14.60	7.08	297	6.74
2474	110	10/20/2015	14.98	6.96	525	3.85
2473	105	10/20/2015	13.62	6.96	540	4.30
2475	78	10/19/2015	13.75	7.09	202	2.09

Note: Italicized red numbers indicate EPA's National Secondary Drinking Water Regulation (NSDWR) standard was exceeded. These regulations are applicable for public water systems only but are recommended limits and can be applied to private wells to evaluate water quality.

^a Contaminant with a National Secondary Drinking Water Regulation standard. The NSDWR for pH is 6.5-8.5. NSDWR standards are recommended limits for public water systems but can be applied to private wells to evaluate water quality.

Samples were analyzed for nitrate, nitrite, anions (bromide, chloride, fluoride, sulfate, and orthophosphate), TC, and *E. coli* (Table 35). Wells with a DO less than 2.00 mg/L, as determined by field analysis, were also analyzed for ammonia as required by the FSP. The nutrient and anion analysis was conducted by the UIASL. Bacteria samples were submitted to the IBL.

Nitrogen isotope samples were collected at each sampling location and frozen and stored at DEQ pending nitrate analysis. After DEQ received nitrate analysis results, those nitrogen isotope samples from wells with nitrate concentrations greater than 5 mg/L were sent to the University of Arizona Environmental Isotope Geosciences Laboratory in Tucson for nitrogen isotope analysis.

Table 35. Nutrient, bacteria, nitrogen isotope, and anion results—Northeast Star Nitrate Priority Area Ground Water Monitoring Project.

DEQ Site ID	Sample Date	Nutrient Concentrations				Bacteria ^b		Anions				
		Ammonia	Nitrate ^a	Nitrite ^a	$\delta^{15}\text{N}$ (‰)	Total Coliform	<i>E. coli</i>	Bromide	Chloride ^c	Fluoride ^a	Sulfate ^c	Ortho-phosphate
		(mg/L)				(MPN/100 mL)	(mg/L)					
<i>Primary or Secondary Standard:</i>	NA	10	1	NA	1 cfu/100 mL	<1 cfu/100 mL	NA	250	4	250	NA	
967	10/20/2015	—	44	<0.050	8.0	<1	<1	<0.20	45	0.29	65	<0.50
1155	10/19/2015	<0.1	3.4	<0.050	—	178.5	<1	<0.20	11	0.32	13	<0.50
1156	10/19/2015	—	2.6	<0.050	—	<1	<1	<0.20	4.3	0.29	12	<0.50
1157	10/19/2015	—	2.7	<0.050	—	<1	<1	<0.20	3.4	0.24	8.2	<0.50
1158	10/19/2015	—	2.9	<0.050	—	<1	<1	<0.20	3.8	0.23	7.7	<0.50
1159	10/19/2015	—	5.4	<0.050	5.4	<1	<1	<0.20	6.5	0.20	18	<0.50
1160	10/19/2015	—	16	<0.050	4.8	<1	<1	<0.20	18	0.26	18	<0.50
1162	10/19/2015	<0.1	<0.050	<0.050	—	<1	<1	<0.20	0.95	0.48	5.7	<0.50
1165	10/20/2015	—	37	<0.050	9.7	44.1	<1	<0.20	54	0.34	68	<0.50
1167	10/20/2015	—	2.5	<0.050	—	1	<1	<0.20	5.3	0.38	9.1	<0.50
1168	10/20/2015	—	3.4	<0.050	—	<1	<1	<0.20	5.2	0.33	10	<0.50
1169	10/20/2015	—	5.2	<0.050	5.0	9.8	<1	<0.20	8.9	0.24	17	<0.50
2199	10/20/2015	—	2.0	<0.050	—	<1	<1	<0.20	3.6	0.28	18	<0.50
2218	10/20/2015	—	2.5	<0.050	—	<1	<1	<0.20	3.4	0.33	15	<0.50
2472	10/19/2015	—	1.7	<0.050	—	<1	<1	<0.20	2.0	0.17	5.7	<0.50
2474	10/20/2015	—	2.7	<0.050	—	<1	<1	<0.20	5.7	0.36	21	<0.50
2473	10/20/2015	—	2.4	<0.050	—	<1	<1	<0.20	3.5	0.29	15	<0.50
2475	10/19/2015	—	0.080	<0.050	—	<1	<1	<0.20	1.6	0.55	9.0	<0.50

Notes: Bolded red numbers indicate EPA's National Primary Drinking Water Regulation (NPDWR) standard, expressed as a maximum contaminant level (MCL), was reached or exceeded. These regulations are applicable for public water systems only but are recommended limits and can be applied to private wells to evaluate water quality.

^a Contaminant with a National Primary Drinking Water Regulation standard.

^b Total coliform and *E. coli* standards are from the Idaho Ground Water Quality Rule (IDAPA 58.01.11.200). An exceedance of the primary ground water quality standard for total coliform (indicated by gray shaded numbers) is not a violation of these rules. Total coliform is not a health threat in itself; it is used to indicate whether other potentially harmful bacteria may be present. Although the standards are given in cfu/100 mL, analytical results provided in MPN/100 mL are acceptable for comparison to the standard.

^c Contaminant with a National Secondary Drinking Water Regulation standard.

Nitrate Results

The reported nitrate concentrations ranged from <0.050 mg/L to 44 mg/L; 5 of the 18 wells sampled, (967, 1159, 1160, 1165, and 1169) had nitrate concentration of 5 mg/L or greater. The nitrate MCL of 10 mg/L was exceeded in 3 samples (967, 1160, and 1165). The spatial distribution of nitrate concentrations is shown in Figure 23.

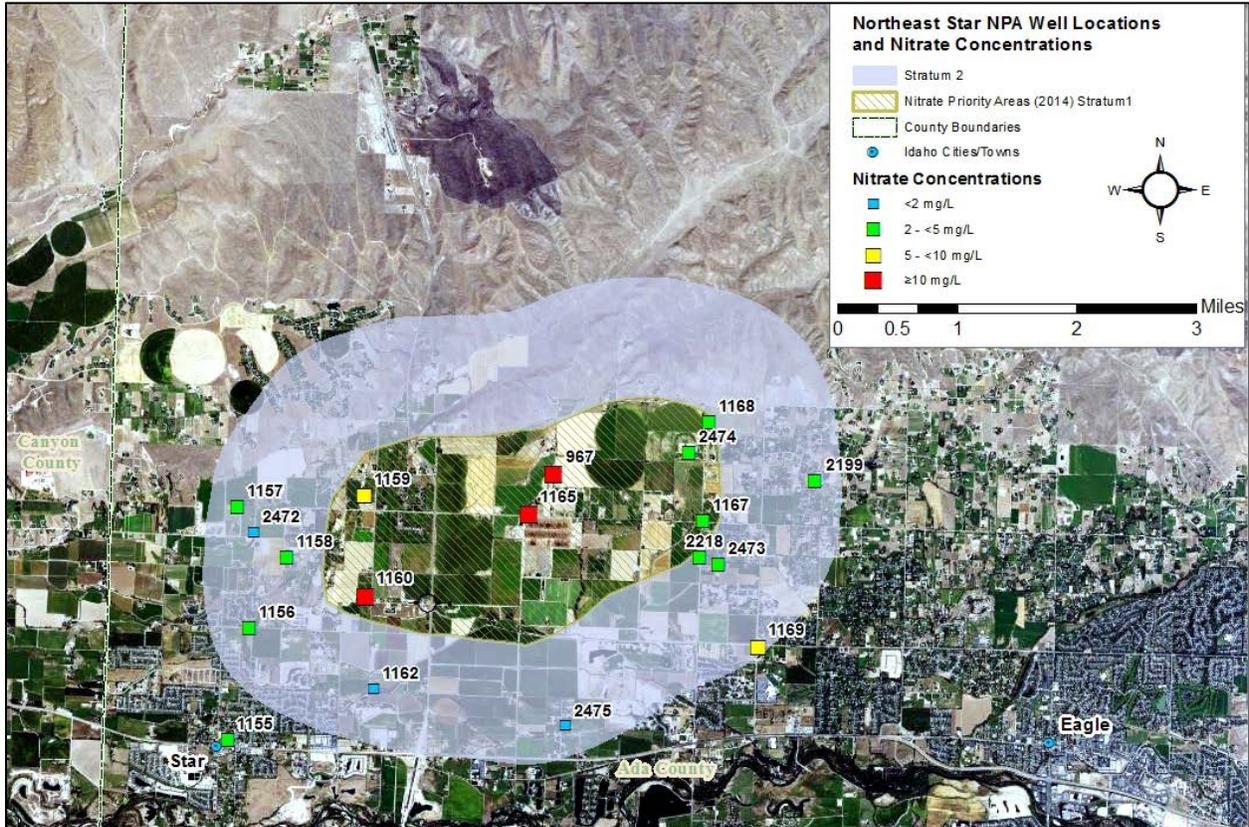


Figure 23. Private domestic drinking water and irrigation well sample locations and nitrate concentrations—Northeast Star Nitrate Priority Area Ground Water Monitoring Project.

Bacteria Results

The reported TC bacteria concentrations ranged from <1 MPN/100 mL to 178.5 MPN/100 mL; 4 of the 18 wells (1155, 1165, 1167, and 1169) were positive for TC (Table 35). All wells were negative for *E. coli*.

Nitrogen Isotope Results

Nitrogen isotope ratios, denoted as $\delta^{15}\text{N}$, can be helpful in determining the potential sources of nitrate in the ground water. Nitrogen isotope ratios were determined for the 5 samples with nitrate concentrations greater than or equal to 5 mg/L (Table 35). Nitrogen from human or animal waste and fertilizer sources has distinguishable $\delta^{15}\text{N}$ signatures. Typical $\delta^{15}\text{N}$ values for various nitrogen sources are listed in Table 3.

The $\delta^{15}\text{N}$ results from this project ranged from 4.8‰ to 9.7‰. Of the 5 wells analyzed, 4 (967, 1159, 1160, and 1169) had $\delta^{15}\text{N}$ values of 4‰ through 9‰, suggesting the source of nitrate in the ground water is most likely organic nitrogen in the soil or a mixed nitrogen source (Seiler 1996). Only Well 1165 had a $\delta^{15}\text{N}$ value greater than 9‰, suggesting the source of nitrate in the ground water is most likely animal or human waste (Seiler 1996).

Ammonia Results

Ammonia samples were collected from the two wells (Well 1155 and Well 1162) with a DO field measurement of less than 2.00 mg/L. The results of both samples were below the detection limit for the analytical method (Table 35).

Chloride Results

Reported chloride concentrations ranged from 0.95 mg/L to 54 mg/L. EPA has set the NSDWR standard for chloride at 250 mg/L, based on aesthetic effects. All reported chloride concentrations were below this standard (Table 35).

Fluoride Results

Reported fluoride concentrations ranged from 0.17 mg/L to 0.55 mg/L. All reported fluoride concentrations were below the MCL of 4.0 mg/L (Table 35).

Sulfate Results

Reported sulfate concentrations ranged from 5.7 mg/L to 68 mg/L. EPA has set the NSDWR standard for sulfate at 250 mg/L, based on aesthetic effects. All reported sulfate concentrations were below this standard (Table 35).

Comparison of 2010 and 2015 Samples

Of the 20 wells sampled during the 2010 Northeast Star NPA sampling event, 12 were resampled in 2015. Results from both sampled events are presented in Table 36. When the sample results for 2010 and 2015 are compared, 9 of the 12 wells had an increase in nitrate concentration; 7 of the 9 increases were 0.5 mg/L or more. Wells 967, 1159, 1160, 1165, and 1169 showed the greatest increase. Wells 1160 and 1165 had samples that nearly doubled in nitrate concentration between 2010 and 2015. The increase in concentration at Well 1160 resulted in an exceedance of the MCL in 2015.

Table 36. Comparison of 2010 and 2015 nutrient, bacteria, nitrogen isotope, and anion results—2015 Northeast Star Nitrate Priority Area Ground Water Monitoring Project.

DEQ Site ID	Sample Date	Nutrient Concentrations				Bacteria ^b		Anions				
		Ammonia	Nitrate ^a	Nitrite ^a	$\delta^{15}\text{N}$ (‰)	Total Coliform	<i>E. coli</i>	Bromide	Chloride ^c	Fluoride ^a	Sulfate ^c	Ortho-phosphate
		(mg/L)				(MPN/100 mL)		(mg/L)				
<i>Primary or Secondary Standard:</i>		NA	10	1	NA	1	<1	NA	250	4	250	NA
967	10/26/2010	0.17	40	<0.05	8.1	<1	<1	<0.1	50	<0.15	53	0.13
	10/20/2015	—	44	<0.050	8.0	<1	<1	<0.20	45	0.29	65	<0.50
1155	10/25/2010	0.3	3.3	<0.05	—	<1	<1	<0.1	8.4	0.21	11	<0.1
	10/19/2015	<0.1	3.4	<0.050	—	178.5	<1	<0.20	11	0.32	13	<0.50
1156	10/26/2010	0.51	2.2	<0.05	—	<1	<1	<0.1	3.4	0.26	9.4	<0.1
	10/19/2015	—	2.6	<0.050	—	<1	<1	<0.20	4.3	0.29	12	<0.50
1157	10/25/2010	<0.1	3.8	<0.05	—	<1	<1	<0.1	4.6	0.19	12	0.19
	10/19/2015	—	2.7	<0.050	—	<1	<1	<0.20	3.4	0.24	8.2	<0.50
1158	10/25/2010	0.24	1.7	<0.05	—	<1	<1	<0.1	2.8	0.28	6.5	0.20
	10/19/2015	—	2.9	<0.050	—	<1	<1	<0.20	3.8	0.23	7.7	<0.50
1159	10/25/2010	<0.1	3.2	<0.05	—	<1	<1	<0.1	5.3	0.23	16	<0.1
	10/19/2015	—	5.4	<0.050	5.4	<1	<1	<0.20	6.5	0.20	18	<0.50
1160	10/25/2010	0.49	8.9	<0.05	4.4	1	<1	<0.1	8.3	0.24	14	<0.1
	10/19/2015	—	16	<0.050	4.8	<1	<1	<0.20	18	0.26	18	<0.50

DEQ Site ID	Sample Date	Nutrient Concentrations				Bacteria ^b		Anions				
		Ammonia	Nitrate ^a	Nitrite ^a	$\delta^{15}\text{N}$ (‰)	Total Coliform	<i>E. coli</i>	Bromide	Chloride ^c	Fluoride ^a	Sulfate ^c	Ortho-phosphate
<i>Primary or Secondary Standard:</i>		NA	10	1	NA	1	<1	NA	250	4	250	NA
1162	10/25/2010	0.21	<0.05	<0.05	—	<1	<1	<0.1	0.83	0.42	5.3	<0.1
	10/19/2015	<0.1	<0.050	<0.050	—	<1	<1	<0.20	0.95	0.48	5.7	<0.50
1165	10/26/2010	0.36	19	<0.05	8.2	<1	<1	<0.1	29	<0.15	34	<0.1
	10/20/2015	—	37	<0.050	9.7	44.1	<1	<0.20	54	0.34	68	<0.50
1167	10/28/2010	0.28	3.0	<0.05	—	<1	<1	<0.1	5.6	0.32	9.8	<0.1
	10/20/2015	—	2.5	<0.050	—	1	<1	<0.20	5.3	0.38	9.1	<0.50
1168	10/26/2010	0.13	2.9	<0.05	—	19.9	<1	<0.1	7.1	0.29	11	<0.1
	10/20/2015	—	3.4	<0.050	—	<1	<1	<0.20	5.2	0.33	10	<0.50
1169	10/26/2010	0.22	2.9	<0.05	—	<1	<1	<0.1	7.4	0.38	11	<0.1
	10/20/2015	—	5.2	<0.050	5.0	9.8	<1	<0.20	8.9	0.24	17	<0.50

Notes: Bolded red numbers indicate EPA's National Primary Drinking Water Regulation (NPDWR) standard, expressed as a maximum contaminant level (MCL), was reached or exceeded. These regulations are applicable for public water systems only but are recommended limits and can be applied to private wells to evaluate water quality. (—) = data are unavailable or were not analyzed.

^a Contaminant with a National Primary Drinking Water Regulation standard.

^b Total coliform and *E. coli* standards are from the Idaho Ground Water Quality Rule (IDAPA 58.01.11.200). An exceedance of the primary ground water quality standard for total coliform (indicated by gray shaded numbers) is not a violation of these rules. Total coliform is not a health threat in itself; it is used to indicate whether other potentially harmful bacteria may be present. Although the standards are given in cfu/100 mL, analytical results provided in MPN/100 mL are acceptable for comparison to the standard.

^c Contaminant with a National Secondary Drinking Water Regulation standard.

Table 37. A Comparison of Samples taken in 2010 and 2015 in the Northeast Star NPA—Northeast Star Nitrate Priority Area Project

DEQ Site ID	Nitrate Concentrations (mg/L)		Change in Concentration
	2010	2015	
967	40	44	+4
1155	3.3	3.4	+0.1
1156	2.2	2.6	+0.4
1157	3.8	2.7	-1.1
1158	1.7	2.9	+1.2
1159	3.2	5.4	+2.2
1160	8.9	16	+7.1
1162	<0.05	<0.05	0
1165	19	37	+18
1167	3.0	2.5	-0.5
1168	2.9	3.4	+0.5
1169	2.9	5.2	+2.3

2.1.9.3 Conclusions

The primary land use in the Northeast Star NPA is agricultural, including cropland, pasture, and animal feeding operations.

The criterion for an NPA is at least 25% of the wells sampled within the area meet or exceed 5 mg/L nitrate. This value is half the MCL of 10 mg/L. In this project, 5 of the 18 wells sampled in 2015 (28%) had nitrate values ≥ 5 mg/L. The nitrate MCL of 10 mg/L was exceeded in 3 of these samples (967, 1160, and 1165).

The 3 wells with nitrate concentrations above the MCL appear to be located along the same ground water flow line to the southwest. The most upgradient well (967) has the highest nitrate concentration of 44 mg/L. The middle well (1165) has a nitrate concentration of 37 mg/L, and the southernmost well has a nitrate concentration of 16 mg/L.

The source of nitrogen impacting Well 1165 is likely an animal or human waste nitrogen source due to a $\delta^{15}\text{N}$ value greater than 9‰ (Seiler 1996). A 62-acre cattle feedlot located 130 feet south of Well 1165 is the largest waste source of nitrogen near the well.

The other 4 wells with nitrate above 5 mg/L had $\delta^{15}\text{N}$ results that suggest a nitrogen source of either organic nitrogen in the soil or a mixture of fertilizer and waste sources. These signature values are typical for an agricultural area.

The nitrate sources near Wells 967 and 1160 include fertilized cropland, manure from pastureland, fertilized residential lawns, and possibly waste from septic tanks. In addition, a golf course located north of Well 1160 could be a contributing source of nitrogen.

Wells 1159 and 1169 had $\delta^{15}\text{N}$ values of 5.4 and 5.0‰, respectively, which is consistent with isotopic signatures from organic nitrogen in the soil or mixed sources (Seiler 1996). Wells 1159 and 1169 are close to several potential sources of nitrogen, including residential activities (irrigated lawns, septic tanks) and agriculture fields (sod farm parcels). Well 1159 is located close to and downgradient from a golf course, which could be a potential source of nitrogen.

2.1.9.4 Recommendations

DEQ recommends that property owners with private domestic drinking water wells sample their well, prior to any water treatment system and as close to the well as possible, on an annual basis. Central District Health Department can provide Ada County property owners with information and guidance.

In addition, property owners may benefit from education on the use of commercial fertilizers and pesticides on their lawns and gardens and education on proper maintenance of their wells and septic systems.

DEQ has assisted Ada County in developing and implementing a ground water quality improvement and drinking water source protection plan. This plan includes information for private well owners and agricultural operators aimed at reducing source water contamination, including activities to reduce nitrate contamination.

2.1.10 City of Payette Gas Field Ground Water Monitoring Project

2.1.10.1 Purpose and Background

Production quantities of natural gas have been discovered in several counties in southwest Idaho, including Payette County. Recent interest in this resource has led to the establishment of two gas fields in Payette County: the Hamilton Field, which underlies the area surrounding the town of New Plymouth, and the Willow Field, which underlies the foothills northeast of New Plymouth. In Idaho, the environmental effects of gas field development on ground water are unknown. Gas field development includes, but is not limited to, well drilling and drilling-related activities and treatment/enhancement of wells to increase gas production.

In 2013, the City of Payette requested sampling of their municipal wells for a baseline study of ground water quality prior to gas field development. Payette is located in a general down-gradient ground water flow direction from gas wells in the Hamilton and Willow Fields. The 2013 City of Payette Gas Field Ground Water Monitoring Project was established and designed to provide baseline ground water quality data for eight municipal wells operated by the City of Payette. At the time of the 2013 ground water sampling (September 2013), 11 of 12 permitted wells had been drilled. The 2013 baseline project is summarized in the 2013 ground water quality monitoring project summary report (DEQ 2015j).

The 2015 City of Payette Gas Field Ground Water Monitoring Project was designed to collect follow-up ground water quality data to assist the City of Payette in its effort to continue evaluating potential impacts to ground water from gas field development and determine if drilling additional gas wells and production activity from the 6 operating wells has affected the quality of the city's drinking water. At the time of this report, a total of 17 gas wells have been drilled in the two gas fields, 6 of which are in production.

The city of Payette is located in southwest Idaho, adjacent to the Payette River and approximately 1 mile east of the Snake River. The confluence of the Payette and Snake Rivers is approximately 1 mile northwest of Payette. The town is located on the relatively flat floodplains of the Snake and Payette Rivers. Land use in the area surrounding Payette is generally agricultural.

The city wells sampled for the project are completed at depths ranging from 125 feet to 270 feet bgs. The IDWR well drillers reports for the wells suggest the subsurface in the immediate area around Payette consists of interbedded layers of gravel, sand, silt, and clay from the surface to a depth of at least 270 feet. Based on the reports, aquifers consisting of coarser-grained material (sand and gravel) supply ground water to the municipal wells. The aquifers are generally at depths ranging from approximately 130 to 270 feet bgs. The general regional ground water flow direction in Payette County is southwest toward the Snake River and locally toward the Payette River. Figure 24 shows ground water elevation contours (IDWR 1992) and the estimated ground water flow directions in the Payette area.

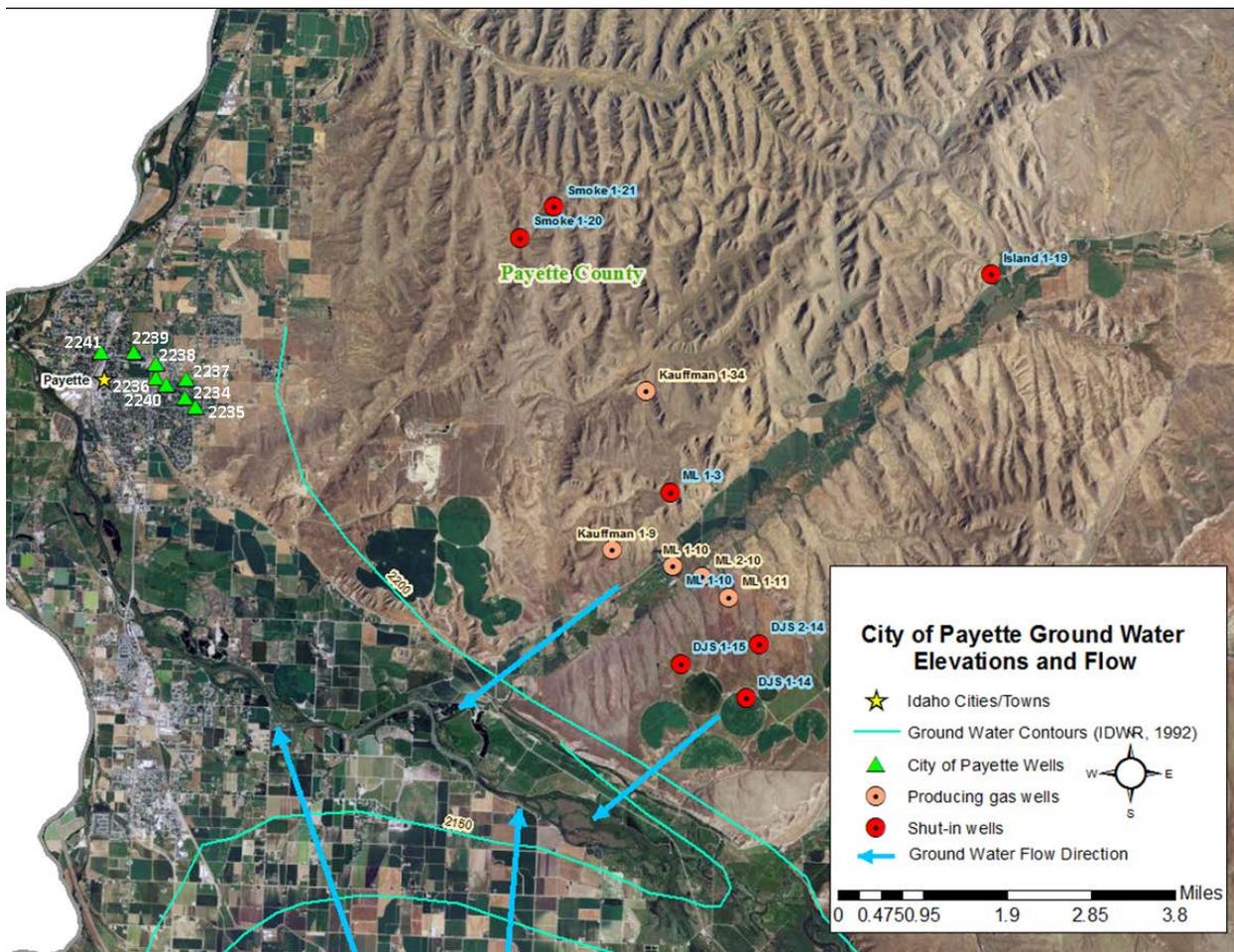


Figure 24. City of Payette ground water elevations and ground water flow direction—City of Payette Gas Field Ground Water Monitoring Project.

Methods and Results

The City of Payette requested DEQ collect samples from the 8 active city of Payette PWS wells. All 8 PWS wells and the Willow Field gas wells are shown in Figure 24.

On November 16, 2015, DEQ collected water samples from the 8 wells using procedures outlined in the QAPP (DEQ 2015b) and FSP (DEQ 2015k). Water quality field parameters (pH, temperature, specific conductivity, and DO) were measured at each well prior to sample collection (Table 38). Samples collected from the City of Payette PWS wells were collected prior to water treatment.

The water samples were submitted to three analytical laboratories for analysis using procedures outlined in the FSP. The UIASL in Moscow, Idaho, analyzed the samples for common ions (bromide, calcium, chloride, fluoride, magnesium, orthophosphate, sodium, and sulfate) (Table 39); nutrients (nitrate and nitrite) (Table 38); TDS and alkalinity (Table 40); and metals (arsenic, barium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, molybdenum, nickel, potassium, selenium, uranium, vanadium, and zinc) (Table 41, Table 42). Dissolved methane analysis was conducted by Accutest Laboratories in Wheat Ridge, Colorado (Table 43). Anatek Labs, Inc., in Moscow, Idaho, analyzed samples for benzene, toluene, ethylbenzene, and xylenes (m+p-xylene and O-xylene) (BTEX) and TPH (Table 43).

Table 38. Water quality field parameters—City of Payette Gas Field Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	Sample Date	Water Temperature (°C)	pH ^a	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)
2234	198	11/16/2015	15.29	6.56	804	7.71
2235	194	11/16/2015	15.82	6.51	877	4.93
2236	270	11/16/2015	16.52	6.70	528	7.75
2237	228	11/16/2015	15.62	6.64	1,060	9.55
2238	213	11/16/2015	16.36	6.86	458	6.26
2239	125	11/16/2015	15.26	<i>6.30</i>	677	5.75
2240	230	11/16/2015	16.11	6.84	676	10.59
2241	210	11/16/2015	15.39	<i>6.35</i>	650	8.70

Note: Italicized red numbers indicate EPA's National Secondary Drinking Water Regulation (NSDWR) standard was exceeded. These regulations are applicable for public water systems only but are recommended limits and can be applied to private wells to evaluate water quality.

^a Contaminant with a National Secondary Drinking Water Regulation standard. The NSDWR for pH is 6.5-8.5. NSDWR standards are recommended limits for public water systems but can be applied to private wells to evaluate water quality.

Table 39. Common ion results—City of Payette Gas Field Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	Sample Date	Common Ions (mg/L)								Nutrients (mg/L)		
			Calcium	Magnesium	Potassium	Sodium	Fluoride ^a	Chloride ^b	Bromide	Ortho-phosphate	Sulfate ^b	Nitrite ^a	Nitrate ^a
Primary or Secondary Standard:			NA	NA	NA	NA	4	250	NA	NA	250	1	10
2234	198	11/16/2015	65	19	5.7	69	0.40	24	<0.50	0.15	35	<0.05	1.9
2235	194	11/16/2015	64	23	6.5	73	0.49	25	<0.50	0.51	74	<0.05	<0.1
2236	270	11/16/2015	41	16	3.0	40	0.23	10	<0.50	0.36	36	<0.05	<0.1
2237	228	11/16/2015	95	36	5.4	94	0.50	67	<0.50	0.40	160	<0.05	<0.1
2238	213	11/16/2015	39	15	2.6	28	0.29	8.9	<0.50	1.1	33	<0.05	<0.1
2239	125	11/16/2015	64	24	6.7	34	0.23	12	<0.50	0.040	38	<0.05	0.20
2240	230	11/16/2015	53	20	4.5	60	<0.15	12	<0.50	0.068	39	<0.05	<0.1
2241	210	11/16/2015	64	24	6.7	34	0.19	12	<0.10	<0.006	40	<0.05	<0.1

^a Contaminant with a National Primary Drinking Water Regulation standard.

^b Contaminant with a National Secondary Drinking Water Regulation standard.

Table 40. Total dissolved solids—City of Payette Gas Field Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	Sample Date	Total Dissolved Solids ^a (mg/L)	Alkalinity (as CaCO ₃) (mg/L)
Primary or Secondary Standard:			500	NA
2234	198	11/16/2015	480	350
2235	194	11/16/2015	<i>510</i>	330
2236	270	11/16/2015	310	210
2237	228	11/16/2015	<i>700</i>	340
2238	213	11/16/2015	200	190
2239	125	11/16/2015	370	290
2240	230	11/16/2015	400	310
2241	210	11/16/2015	380	280

^a Contaminant with a National Secondary Drinking Water Regulation (NSDWR) standard. Italicized red numbers indicate EPA's NSDWR standard was exceeded.

Table 41. Uranium and other metals results—City of Payette Gas Field Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	Sample Date	Arsenic ^a	Cadmium ^a	Chromium ^a	Lead ^a (µg/L)	Nickel	Selenium ^a	Uranium ^a
Primary or Secondary Standard:			10	5	100	15	NA	50	30
2234	198	11/16/2015	14	<0.1	1.4	<0.1	<2.5	1.0	4.7
2235	194	11/16/2015	18	<0.1	<0.5	0.20	<2.5	<0.1	1.1
2236	270	11/16/2015	0.42	0.11	<0.5	<0.1	<2.5	<0.1	<0.25
2237	228	11/16/2015	3.6	<0.1	<0.5	0.28	<2.5	0.50	<0.25
2238	213	11/16/2015	2.2	0.12	<0.5	<0.1	<2.5	<0.1	<0.25
2239	125	11/16/2015	1.8	0.55	<0.5	<0.1	<2.5	<0.1	2.4
2240	230	11/16/2015	2.4	<0.1	<0.5	<0.1	<2.5	0.12	<0.25
2241	210	11/16/2015	1.4	0.10	<0.5	<0.1	<2.5	0.15	<0.25

Notes: Bolded red numbers indicate EPA's National Primary Drinking Water Regulation (NPDWR) standard, expressed as a maximum contaminant level (MCL), was exceeded. These regulations are applicable for public water systems only, but are recommended limits and can be applied to private wells to evaluate water quality.

^a Contaminant with a National Primary Drinking Water Regulation standard.

^b Contaminant with a National Secondary Drinking Water Regulation standard.

Table 42. Additional metals results—City of Payette Gas Field Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	Sample Date	Barium ^a	Boron	Cobalt	Copper ^b	Iron ^c	Manganese ^c	Molybdenum	Vanadium	Zinc ^c
Primary or Secondary Standard:			2	NA	NA	1.3	0.3	0.05	NA	NA	5
2234	198	11/16/2015	0.03	<0.5	<0.01	<0.02	0.34	0.08	<0.25	<0.02	<0.02
2235	194	11/16/2015	0.04	<0.5	<0.01	<0.02	0.75	0.30	<0.25	<0.02	<0.02
2236	270	11/16/2015	<0.02	<0.5	<0.01	<0.02	0.11	0.09	<0.25	<0.02	<0.02
2237	228	11/16/2015	0.22	<0.5	<0.01	<0.02	0.63	0.36	<0.25	<0.02	<0.02
2238	213	11/16/2015	<0.02	<0.5	<0.01	<0.02	0.20	0.15	<0.25	<0.02	<0.02
2239	125	11/16/2015	<0.02	<0.5	<0.01	<0.02	0.30	0.39	<0.25	<0.02	<0.02
2240	230	11/16/2015	<0.02	<0.5	<0.01	<0.02	0.16	0.22	<0.25	<0.02	<0.02
2241	210	11/16/2015	<0.02	<0.5	<0.01	<0.02	0.30	0.39	<0.25	<0.02	<0.02

Notes: Italicized red numbers indicate EPA's National Secondary Drinking Water Regulation (NSDWR) standard was reached or exceeded. These regulations are applicable for public water systems only but are recommended limits and can be applied to private wells to evaluate water quality.

^a Contaminant with a National Primary Drinking Water Regulation standard.

^b EPA established a treatment technique rather than an MCL for copper. If more than 10% of tap water samples exceed the copper action level of 1.3 mg/L, water systems must take additional steps to reduce corrosiveness.

^c Contaminant with a National Secondary Drinking Water Regulation standard.

Table 43. BTEX, TPH, and methane results—City of Payette Gas Field Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	Sample Date	Benzene ^a	Toluene ^a	Ethylbenzene ^a	m+p-xylene ^a	O-xylene ^a	TPH			Methane ^c (µg/L)
								Gasoline Range	Lube Oil Range	Diesel Range	
			(µg/L)					(mg/L)			
Primary or Secondary Standard:			5	1000	700	10,000^b		NA	NA	NA	NA
2234	198	11/16/2015	<0.50	<0.50	<0.50	<1.00	<0.50	<0.10	<0.50	<0.10	0.84
2235	194	11/16/2015	<0.50	<0.50	<0.50	<1.00	<0.50	<0.10	<0.50	<0.10	17.9
2236	270	11/16/2015	<0.50	<0.50	<0.50	<1.00	<0.50	<0.10	<0.50	<0.10	4.40
2237	228	11/16/2015	<0.50	<0.50	<0.50	<1.00	<0.50	<0.10	<0.50	<0.10	3.70
2238	213	11/16/2015	<0.50	<0.50	<0.50	<1.00	<0.50	<0.10	<0.50	<0.10	0.50
2239	125	11/16/2015	<0.50	<0.50	<0.50	<1.00	<0.50	<0.10	<0.50	0.127	1.50
		02/01/2016	—	—	—	—	—	—	—	<0.10	—
2240	230	11/16/2015	<0.50	<0.50	<0.50	<1.00	<0.50	<0.10	<0.50	<0.10	1.80
2241	210	11/16/2015	<0.50	<0.50	<0.50	<1.00	<0.50	<0.10	<0.50	<0.10	125

^a Contaminant with a National Primary Drinking Water Regulation standard.

^b MCL for xylenes (total).

^c The US Department of the Interior Office of Surface Mining advises well owners with dissolved methane levels greater than 28 mg/L (28,000 µg/L) to immediately remove any potential ignition sources and vent the gas away from any confined spaces (Eltschlager et al. 2001).

Arsenic Results

All 8 samples had positive detections of arsenic (Table 41). The arsenic concentrations ranged from 0.42 µg/L to 18 µg/L; 2 wells (2234 and 2235) exceeded the arsenic MCL of 10 µg/L. Elevated arsenic values have been identified in this area by various studies (Baldwin and Wicherski 1994; Neely 2000; Mitchell 2004). Elevated arsenic values were also found in this area when samples were collected by DEQ for the Lower Payette NPA in 2011 (DEQ 2013a), and for the City of Payette in 2013 (DEQ 2015j). These exceedances may be due to naturally occurring arsenic in the granitic sediments found in the lower Payette River valley (Neely 2000).

The 2013 arsenic results were similar to the 2015 detections. Samples from Wells 2234 and 2235 also exceeded the arsenic MCL in 2013 with concentrations of 16 µg/L and 17 µg/L, respectively.

Cadmium Results

Of the 8 well sampled, 4 (2236, 2238, 2239, and 2241) tested positive for cadmium in levels ranging from 0.10 to 0.55 µg/L (Table 41). None of the 4 wells exceeded the MCL for cadmium of 5 µg/L. Cadmium was absent or below reporting limit for all wells during the 2013 sampling event.

Chromium Results

Chromium was only detected in Well 2234 (1.4 µg/L) (Table 41). This well had a chromium detection in 2013. The detections were below the MCL of 100 µg/L in both the 2013 and 2015 sampling.

Lead Results

Lead was detected in 2 wells (2235 and 2237) during the 2015 sampling event at concentrations below the MCL of 15 µg/L (Table 41). Lead concentrations in Wells 2235 and 2237 were 0.20 and 0.28 µg/L, respectively. Lead was present in concentrations below the MCL in all wells during the 2013 sampling event.

Selenium Results

Selenium was detected in 4 of the 8 wells (2234, 2237, 2240, and 2241) at concentrations ranging from 0.12 to 1.0 µg/L (Table 41), all below the MCL of 50 µg/L.

In 2013, Well 2234 tested positive for selenium in levels that did not exceed the MCL. Selenium was either absent or below the reporting limit in the remaining wells.

Uranium Results

The uranium concentrations ranged from less than the reporting limit (<0.25 µg/L) to 4.7 µg/L (Table 41); 3 of the 8 wells (2234, 2235, and 2239) had reportable detections of uranium. No wells exceeded the uranium MCL of 30 µg/L. Uranium was detected at similar concentrations in the same 3 wells in 2013.

Iron Results

Iron was detected in all 8 wells; 5 wells (2234, 2235, 2237, 2239, and 2241) had concentrations that met or exceeded the NSDWR standard for iron in drinking water of 0.3 µg/L. Iron concentrations ranged from 0.11 to 0.75 µg/L. In 2013, iron was detected at similar concentrations; however, only 2 wells (2235 and 2237) had iron detections above the NSDWR standard.

Total Dissolved Solids (TDS) Results

The TDS results ranged from 200 mg/L to 700 mg/L (Table 40). Wells 2235 and 2237 exceeded the NSDWR standard of 500 mg/L with concentrations of 510 and 700, respectively. The 2015 results were consistent with 2013 results; however, 3 wells (2234, 2235, and 2237) exceeded the NSDWR standard in 2013.

Manganese Results

All 8 samples had detections of manganese exceeding the NSDWR standard of 0.05 mg/L during the 2015 sampling event; concentrations ranged from 0.083 mg/L to 0.39 mg/L (Table 42). The range of detected concentrations was similar to concentrations reported in 2013. In the 2013 study, 7 of the 8 wells had manganese concentrations above the NSDWR standard.

Hydrocarbon Results

All 8 wells were sampled for the following hydrocarbon constituents: benzene, ethylbenzene, xylene (m+p- and o-), toluene, TPH compounds (gasoline range, lubricant oil range, and diesel range organic compounds), and dissolved methane.

Diesel range organic compounds were detected in Well 2239 at a concentration of 0.127 mg/L. A follow-up sample was taken on February 1, 2016. Diesel range organic compounds were not detected in the follow-up sample (Table 43).

Dissolved methane was detected in all 8 wells; concentrations ranged from 0.50 µg/L to 125 µg/L (Table 43). Currently there is no MCL for dissolved methane. The hazard with methane in water is when dissolved methane moves from ground water into the atmosphere, where it can potentially ignite, or if it accumulates in a confined space where it can explode.

Dissolved methane concentrations in 2015 were similar to concentrations recorded in 2013, with the exception of Well 2235, which had an increase in concentration from 4.6 µg/L in 2013 to 17.9 µg/L in 2015.

2.1.10.2 Conclusions

The 2015 City of Payette Gas Field Ground Water Monitoring Project was designed to provide ground water quality data for the city's PWS wells to assist the city in determining whether gas field development has affected ground water quality at its PWS wells.

Ground water samples from 2 of the wells (2234 and 2235) contained concentrations of arsenic in excess of the MCL of 10 µg/L; however, the water samples were taken prior to treatment. The

city of Payette has treatment in place to ensure the water they serve to customers does not exceed the MCLs.

Dissolved methane was detected in all 8 wells at concentrations ranging from 0.50 µg/L to 125 µg/L. The suggested action level for methane is 28 mg/L (or 28,000 µg/L); none of the 8 wells had concentrations approaching the action level.

Diesel (range compounds) was detected in Well 2239 during the November 2015 sampling event. Follow-up diesel testing occurred in February 2016 and was negative.

2.1.10.3 Recommendations

No additional ground water quality monitoring appears to be warranted unless oil and gas production moves closer to the city of Payette.

2.1.11 Sand Hollow Creek Follow-Up Ground Water Monitoring Project

2.1.11.1 Purpose and Background

In response to the sample results of the 2013 Sand Hollow Creek monitoring project, the purpose of this project was to collect additional samples from Well 2232 for nitrate and bacteria analysis in an effort to determine if bacteria are present and whether trends in nitrate data exist.

The 2013 Sand Hollow Creek monitoring project was conducted in response to a complaint DEQ received on September 3, 2013, concerning possible bacteria and nitrate contamination of wells in the vicinity of a dairy operation (Sage Dairy) and a farming operation (Rim Fire Ranch). Both Sage Dairy and Rim Fire Ranch are located in the Sand Hollow Creek drainage within the 2014 Emmett North Bench NPA (Figure 25).

Seven of the eight project wells sampled in 2013 contained nitrate concentrations below the nitrate MCL of 10 mg/L (some below detectable concentrations). The sample from Well 2232 exceeded the nitrate MCL with a concentration of 19.0 mg/L. The nitrogen isotope value was 9.1‰, suggesting that the nitrate in the ground water originated from animal or human waste (Table 3). Two of the eight project wells tested positive for TC; however, Well 2232 did not. No *E. coli* was detected during the 2013 monitoring efforts. The 2013 results are summarized in the *Summary Report for the Idaho Department of Environmental Quality Ground Water Quality Monitoring Projects—2013* (DEQ 2015j).

Well 2232 was resampled in 2014 as follow up to the 2013 monitoring efforts. The results from the 2014 sampling project are summarized in the 2014 summary report (DEQ 2016).

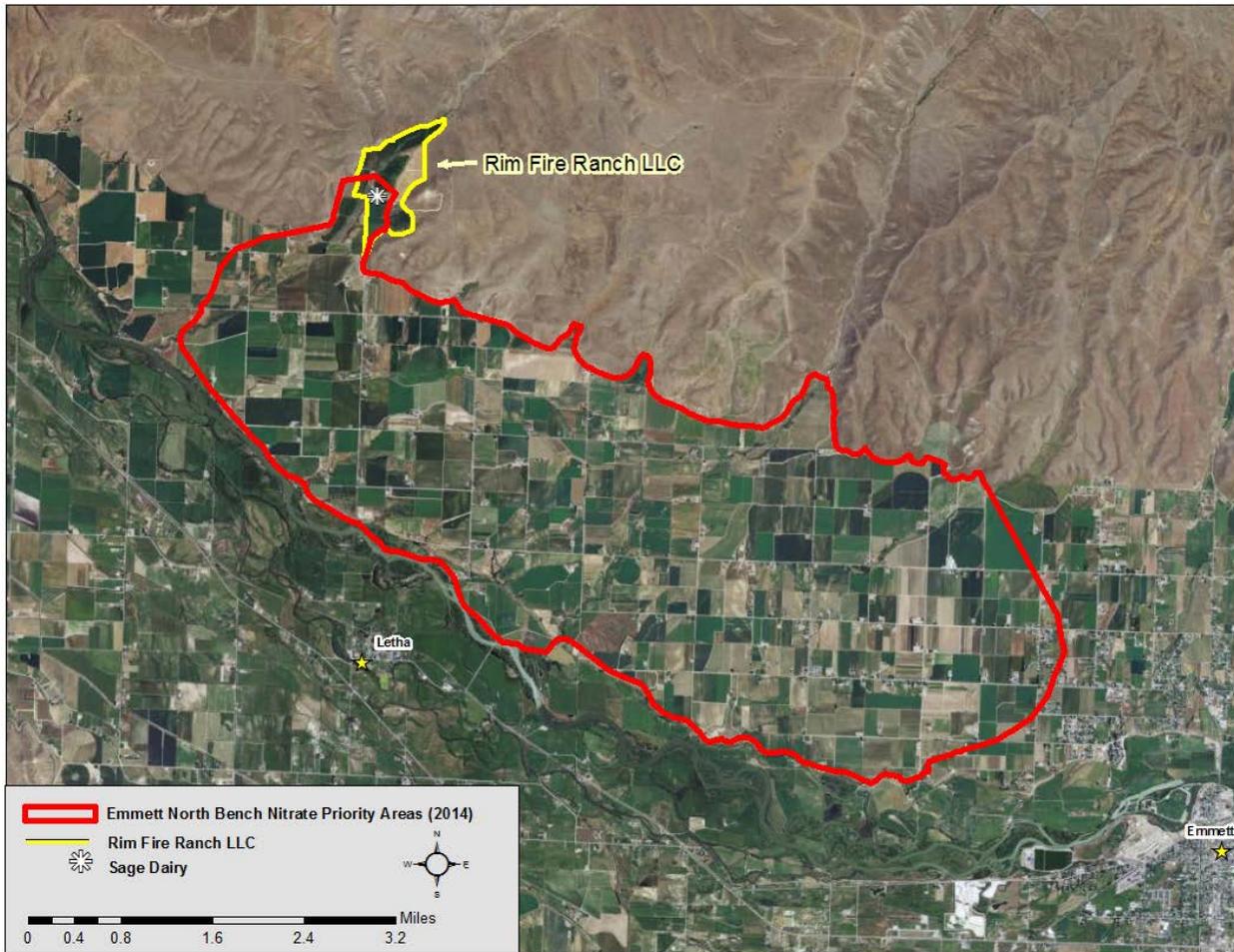


Figure 25. Location of Sage Dairy within the Emmett North Bench Nitrate Priority Area on the Rim Fire Ranch LLC property.

The ISDA Dairy Bureau collects ground water samples for nitrate analysis at dairy production wells during annual facility inspections. When a sample has a nitrate concentration that exceeds the MCL of 10 mg/L for nitrate, ISDA provides the information to DEQ. The ISDA Dairy Bureau samples from the Sage Dairy site production well show nitrate concentrations above the MCL since 2000. The ISDA data indicate a declining trend from 17.10 mg/L in 2000 to 11.60 mg/L in 2013. However, the nitrate concentration rose again to 13.10 mg/L in 2014 before decreasing to 10.0 mg/L in 2015 (Table 44, Figure 26). Sage Dairy began operations at this facility location in 2012.

ISDA also collects isotope samples every 5 years from dairy production wells with previous nitrate concentrations greater than 5 mg/L. Nitrogen isotope ratios ($\delta^{15}\text{N}$) can be helpful in determining sources of nitrate in the ground water, as nitrogen from human or animal waste and fertilizer sources has distinguishable $\delta^{15}\text{N}$ signatures. The ISDA samples collected for nitrogen isotope analysis in 2000, 2005, and 2010 all had $\delta^{15}\text{N}$ signatures above 9‰, suggesting that animal or human waste is contributing nitrogen to the ground water supplying water to the dairy production well (Table 44).

Table 44. ISDA Dairy Bureau nitrate concentration and nitrogen isotope data—Sage Dairy site production well.

Sample Date	Nitrate Concentration (mg/L)	$\delta^{15}\text{N}$ (‰)
05/15/2000	17.10	9.54
03/19/2002	18.90	NS
02/14/2003	17.00	NS
02/24/2004	17.90	NS
03/01/2005	17.00	NS
06/22/2005	NS	10.24
05/03/2007	14.40	NS
08/21/2008	14.10	NS
04/14/2009	11.70	NS
07/20/2010	12.10	NS
08/23/2010	NS	9.36
11/08/2012 ^a	11.60	NS
10/16/2013	11.60	NS
10/14/2014	13.10	NS
04/09/2015	10.80	NS
10/09/2015	10.00	NS

Notes: Bolded red numbers indicate EPA's National Primary Drinking Water Regulation standard, expressed as a maximum contaminant level (MCL), was reached or exceeded. The MCL for nitrate is 10 mg/L. NS = not sampled.

^a Sage Dairy began operating at this facility location.

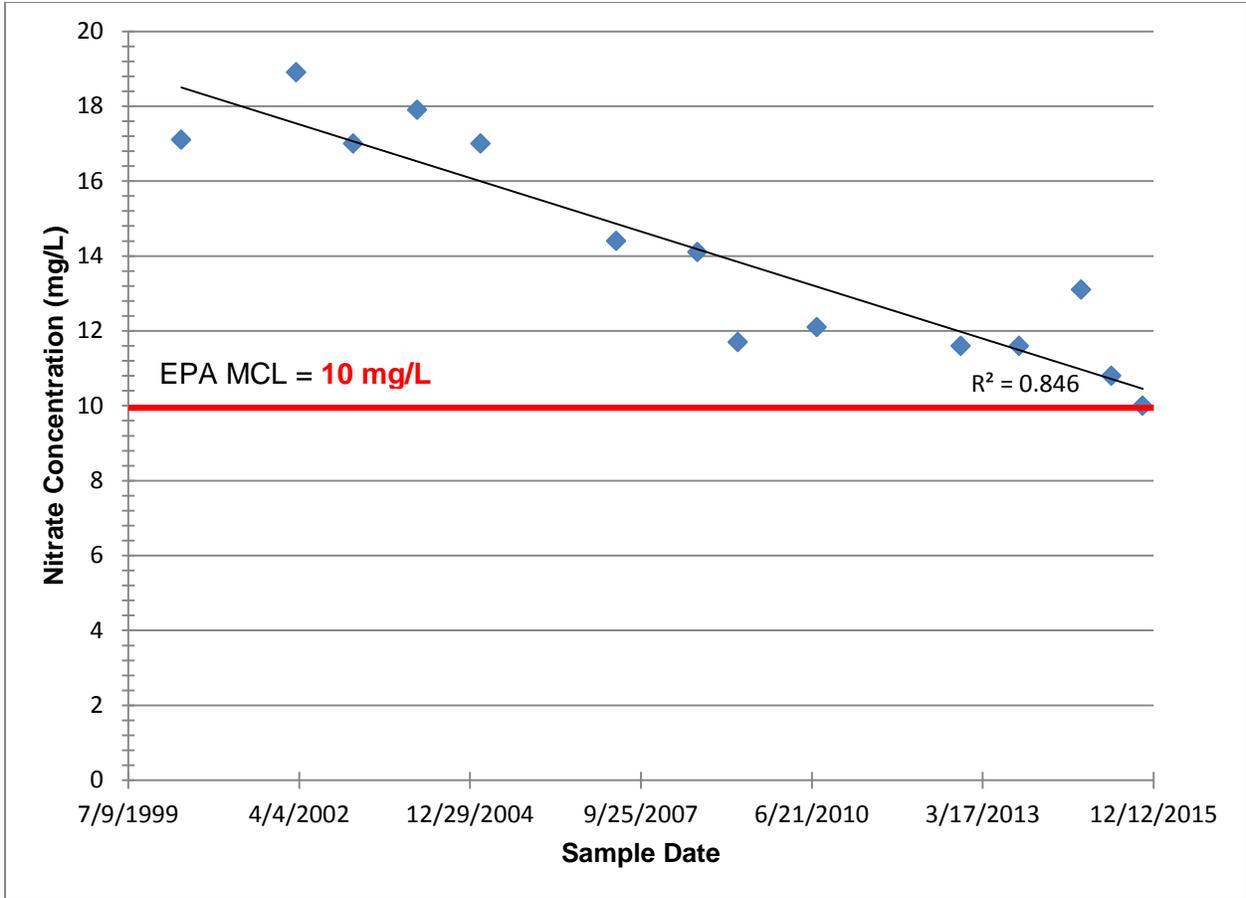


Figure 26. ISDA Dairy Bureau nitrate concentrations—Sage Dairy site production well.

Well drillers logs from wells located within and surrounding the project area indicate the lithology consists of interbedded clay, sand, and gravel. The depth to ground water shown on well drillers logs for private, domestic wells located to the south and southwest of Well 2232 ranges from approximately 70 to 110 feet bgs. Ground water occurs under both confined and unconfined conditions. Ground water is estimated to flow in a southwesterly direction in the project area as shown in Figure 27. Based on regional ground water flow information from IDWR and local topography, Well 2232 is believed to be located downgradient from the Rim Fire Ranch property and Sage Dairy (Figure 27). Site-specific hydrogeological information was not available at the time of this report.

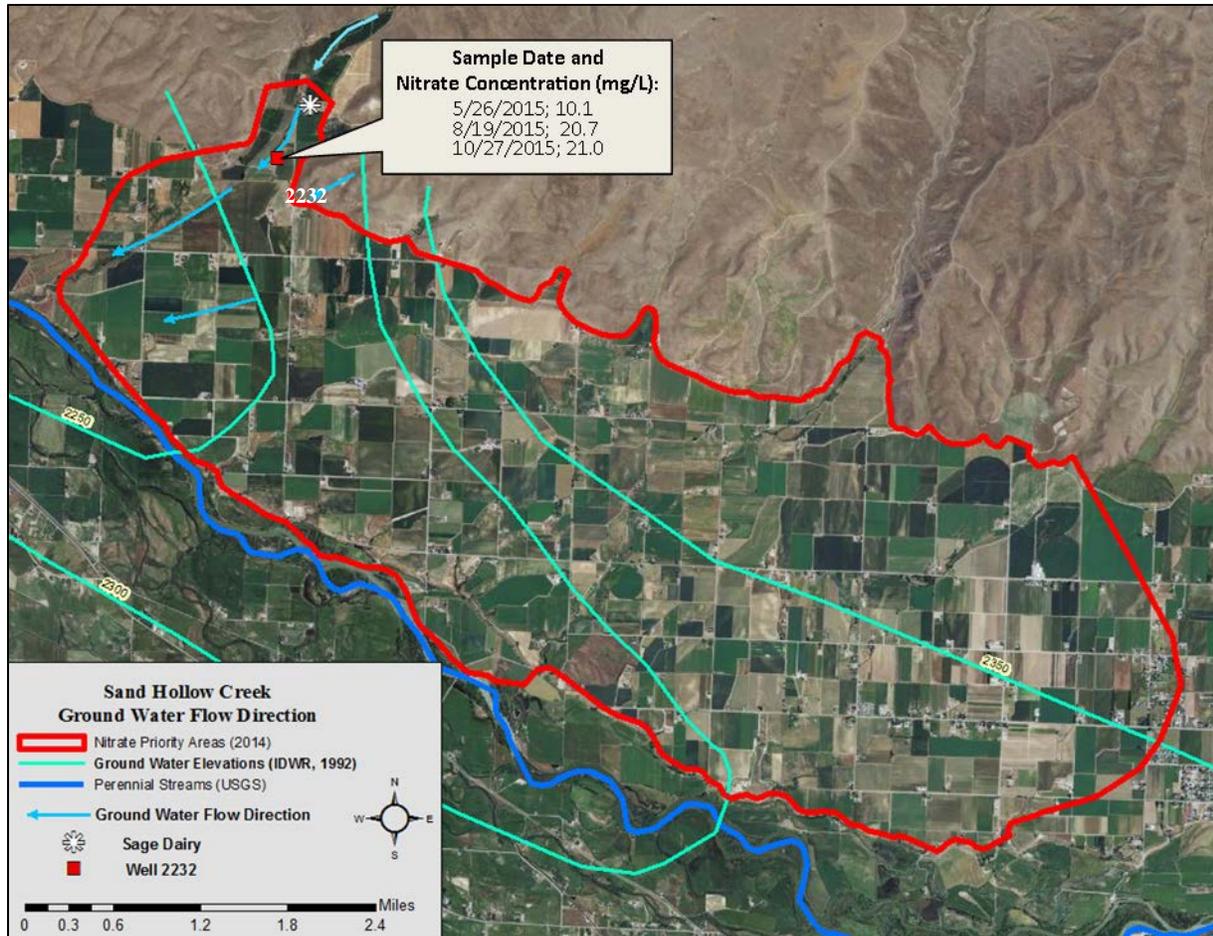


Figure 27. Sample location—Sand Hollow Creek Follow-Up Ground Water Monitoring Project.

2.1.11.2 Methods and Results

On May 26, 2015, DEQ sampled Well 2232 for nitrite, nitrate, nitrogen isotope, and bacteria (TC and *E. coli*). Follow-up sampling for the same analytes was conducted on August 19, 2015, and October 27, 2015. Samples were collected on each sampling date in accordance with the QAPP (DEQ 2012) and the FSP (DEQ 2015).

Water quality field parameters (pH, temperature, specific conductivity, and DO) were measured prior to sample collection (Table 45). The May 26 field parameter measurements are inconsistent with the August and October measurements, as well as measurements recorded in 2013 and 2014; however, the field meter was calibrated without incident prior to use. The reason for the differences in the field parameter measurements is unknown.

Table 45. Water quality field parameters—Sand Hollow Creek Follow-Up Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	Sample Date	Water Temperature (°C)	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	pH ^a
2232	—	05/26/2015	20.39	4,500	9.15	<i>3.71</i>
2232	—	08/19/2015	14.54	812	9.51	6.64
2232	—	10/27/2015	14.26	847	7.82	<i>6.44</i>

Note: Italicized red numbers indicate EPA's National Secondary Drinking Water Regulation (NSDWR) standard was exceeded. These regulations are applicable for public water systems only but are recommended limits and can be applied to private wells to evaluate water quality.

^a Contaminant with a National Secondary Drinking Water Regulation standard. The NSDWR for pH is 6.5–8.5. NSDWR standards are recommended limits for public water systems and are used with private wells to evaluate water quality.

All three rounds of samples were submitted to the IBL in Boise, Idaho, for analysis (Table 46).

Nitrogen isotope samples were collected on May 26, August 19, and October 27 and frozen and stored at DEQ pending nitrate analysis. After DEQ received nitrate analysis results, the nitrogen isotope samples were sent to the University of Arizona Environmental Isotope Geosciences Laboratory in Tucson for nitrogen isotope analysis (Table 46).

Table 46. Nutrient and bacteria results—Sand Hollow Creek Follow-Up Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	Sample Date	Nutrient Concentrations			Bacteria ^b	
			Nitrite ^a (mg/L)	Nitrate ^a (mg/L)	δ ¹⁵ N (‰)	Total Coliform (MPN/100 mL)	<i>E. coli</i> (MPN/100 mL)
Standard:			1	10	NA	1 cfu/100 mL	<1 cfu/100 mL
2232	—	05/26/2015	<0.030	10.1	6.0	4.1	<1
2232	—	08/19/2015	<0.030	20.7	9.2	<1	<1
2232	—	10/27/2015	<0.030	21.0	8.3	<1	<1

Notes: Bolded red numbers indicate the EPA National Primary Drinking Water Regulation standard, expressed as a maximum contaminant level (MCL), was reached or exceeded. These regulations are applicable for public water systems only and are used to evaluate water quality in private wells.

^a Contaminant with a National Primary Drinking Water Regulation standard.

^b Total coliform and *E. coli* standards are from the Idaho Ground Water Quality Rule (IDAPA 58.01.11.200). An exceedance of the primary ground water quality standard for total coliform (indicated by gray shaded numbers) is not a violation of these rules. Total coliform is not a health threat in itself; it is used to indicate whether other potentially harmful bacteria may be present. Although the standards are given in cfu/100 mL, analytical results provided in MPN/100 mL are acceptable for comparison to the standard.

Nitrate Results

All 3 samples collected in 2015 had a reported nitrate concentration above the nitrate MCL of 10 mg/L, with the highest concentration occurring in October at 21.0 mg/L (Table 46). The 2015 nitrate concentrations are plotted with the 2013 and 2014 concentrations in Figure 28 for comparison.

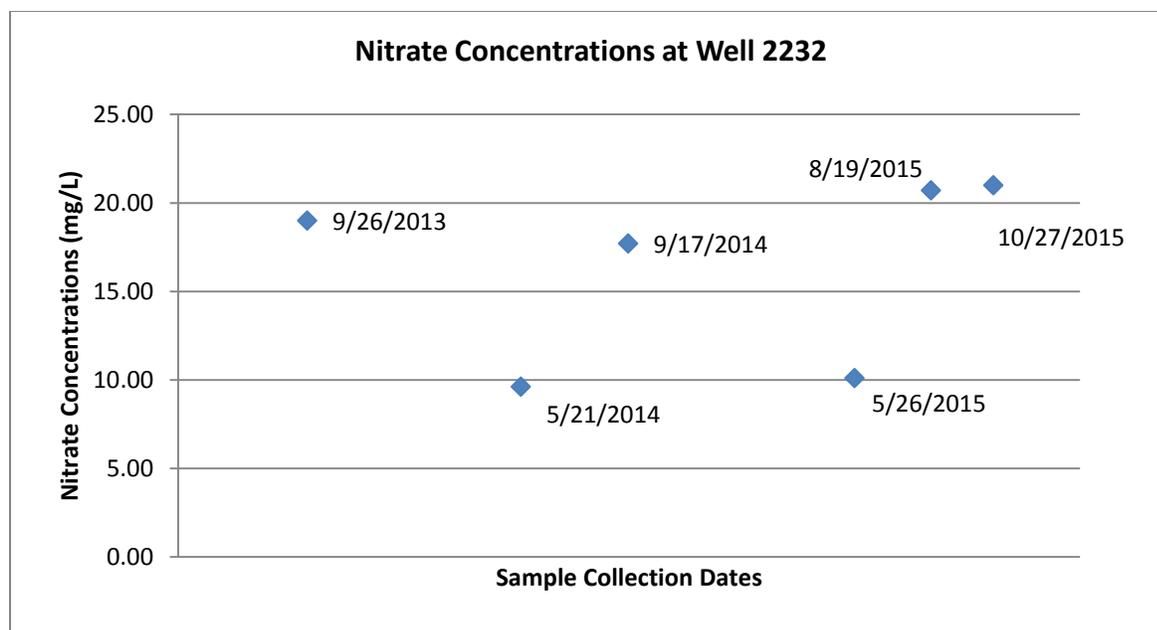


Figure 28. Nitrate concentrations at Well 2232, 2013–2015—Sand Hollow Creek Follow-Up Ground Water Monitoring Project.

Based on the initial data presented in Figure 28, it appears there may be a seasonal component to the nitrate concentration at Well 2232. The two spring samples (collected in May) are lower and consistent with each other, while the fall samples (collected in August, September, and October) are higher and relatively consistent with each other.

Nitrite Results

No samples contained nitrites above the laboratory reportable detection limit of 0.030 mg/L.

Nitrogen Isotope Results

Nitrogen isotope analysis was completed for all three rounds of sampling (Table 46). In August and October, Well 2232 had higher $\delta^{15}\text{N}$ ratios of 9.2‰ and 8.3‰, respectively, suggesting the source of nitrogen is from human or animal waste, organic nitrogen in soil, or a mixed nitrogen source (Table 3). The isotopic signature of the May sample (6.0‰) suggested organic nitrogen in soil or a mixed source of nitrogen.

Bacteria Results

TC bacteria are a group of bacteria common in the environment (such as soil) and are generally not harmful to humans. *E. coli* bacteria, a type of coliform, are found in human and animal fecal matter. The presence of *E. coli* in drinking water provides strong evidence that human or animal fecal matter is present; therefore, a greater potential for pathogenic organisms exists.

The only positive detection of TC was from the May 26 sample (4.1 MPN/100 mL). All three samples were negative for *E. coli*.

2.1.11.3 Conclusions

The 2015 sampling of Well 2232 was conducted in May, August, and October. The sample collected in May had a nitrate concentration of 10.1 mg/L, which is similar to the May 2014 sample result of 9.62 mg/L. The sample collected in August 2015 had a nitrate concentration of 20.7 mg/L, more than double the nitrate concentration in the May 2015 sample. The sample collected in October 2015 had a nitrate concentration of 21.0 mg/L, which is higher than all previous samples. Both the August and October 2015 results were similar to the September 2013 and 2014 results.

The 2014 and 2015 nitrate results showed significant variability between the spring (May) and fall (September–October) samples, suggesting a potential seasonality of the nitrate concentrations.

Well 2232 was sampled for nitrogen isotopes in May, August, and October 2015. The 2015 $\delta^{15}\text{N}$ ratios ranged from 6.0‰ (May) to 9.2‰ (August). Both 2014 $\delta^{15}\text{N}$ results were lower than the September 2013 result of 9.1‰; however, the August 2015 ratio was similar at 9.2‰. The range of $\delta^{15}\text{N}$ ratios from September 2013 through October 2015 suggests there may also be variability in nitrogen sources.

TC was detected in the May 2015 sample at a concentration of 4.1 MPN/100 mL. All three 2015 bacteria samples were negative for *E. coli*.

2.1.11.4 Recommendations

Additional ground water sampling and analyses will be conducted to monitor changes in ground water quality and further evaluate the ground water chemistry. DEQ may collect seasonal samples from Well 2232 in 2016 in an attempt to better define the seasonal variability in the nitrate and bacteria concentrations.

2.2 Idaho Falls Region

Two ground water quality monitoring projects were conducted in the Idaho Falls region in 2015 and 2016 using public funds.

2.2.1 Mud Lake Subarea Ground Water Monitoring Project

2.2.1.1 Purpose and Background

The DEQ Idaho Falls region has been divided into three subareas (Teton Basin/Ashton, Eastern Snake River Plain, and Mud Lake) based on land use and hydrogeologic boundaries to help identify impacts or changes to ambient ground water quality (Figure 29). The process for identifying the regional subareas is described in *Regional Ground Water Monitoring Network Design, Idaho Falls Regional Office* (DEQ 2013d). Definitions for the specific subareas are summarized in *Idaho Falls Regional Office Ambient Ground Water Monitoring Plan Development: Defining Subareas* (DEQ 2013c). Sampling for the Mud Lake subarea was completed in calendar year 2015 and is summarized below. Sampling for the Teton Basin/Ashton

subarea and the Eastern Snake River Plain subarea was completed in calendar years 2013 and 2014, respectively.

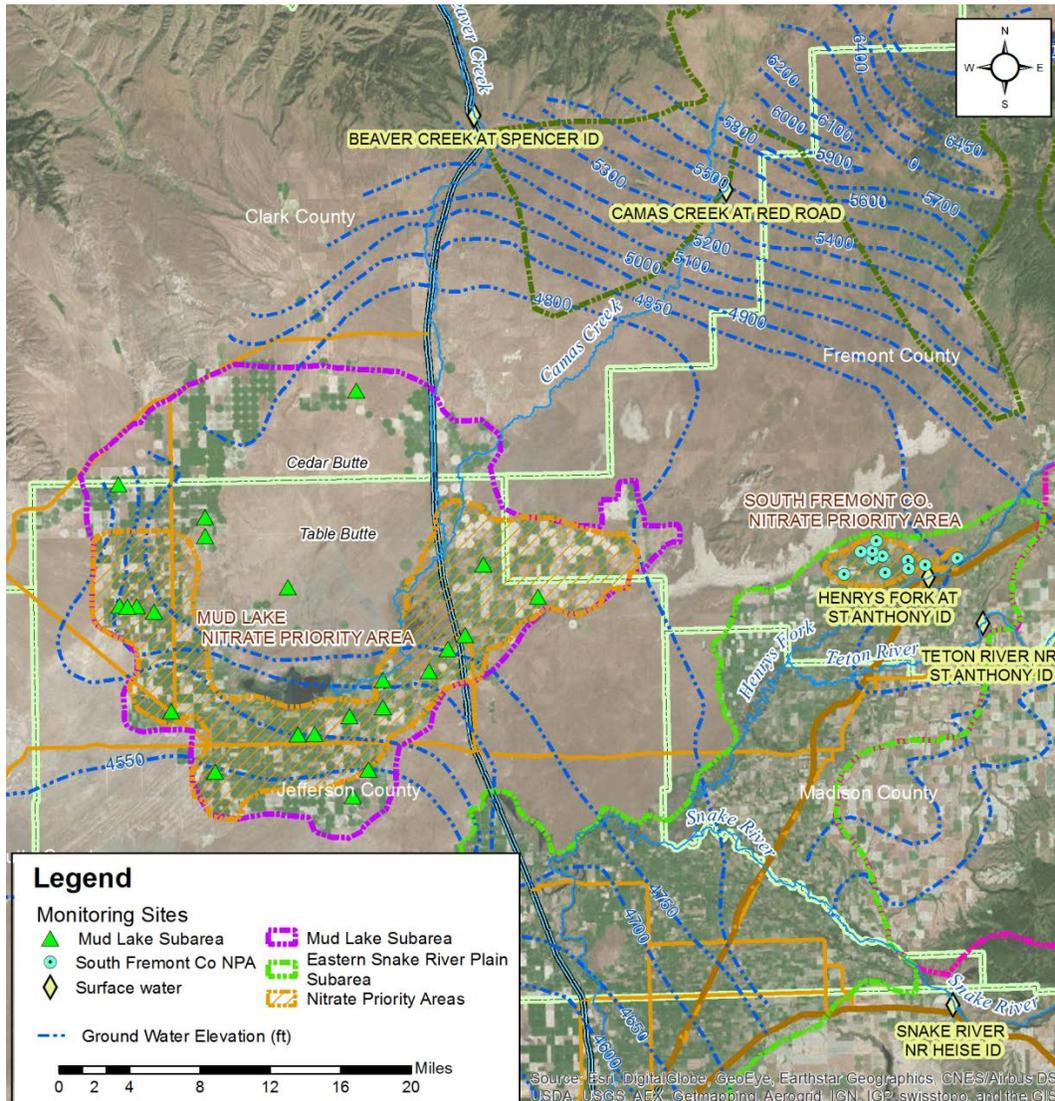


Figure 29. Monitoring sites, Idaho Falls Regional Office.

The Mud Lake subarea covers 525 square miles of eastern Idaho, including the Mud Lake-Terreton Basin and the relatively low lands surrounding the Table Butte/Cedar Butte complex of Jefferson and Clark Counties (Figure 30). The Mud Lake subarea is within the Eastern Snake River Plain (ESRP) aquifer. The regional geology for the ESRP aquifer is dominated by basalts, interbedded sediments, and rhyolites. The shallower subsurface is dominated by lake deposits and sandy, wind-blown sediments, intercalated with basalt and other volcanic deposits. The lake sediments are sufficiently continuous and of lower permeability to support a local aquifer perched above the regional ESRP aquifer. Lake sediments and basalts are intercalated with sediments from the Beaver, Camas, and Birch Creek and other smaller drainages. Apart from shallower, perched conditions near Mud Lake, transmissivity and aquifer thickness are again greatest toward the center of the ESRP and tend to decrease toward the margins. The ESRP aquifer tends to respond as unconfined toward the center and as confined toward the margins,

reflecting the larger proportion of sediments (Stearns et al. 1939; Spinizola 1994). Major sources of recharge are downward percolation of precipitation and snowmelt, runoff from the surrounding uplands, streamflow losses from drainages to the north of the region, and direct infiltration of surface water diverted for irrigation (Graham and Campbell 1981).

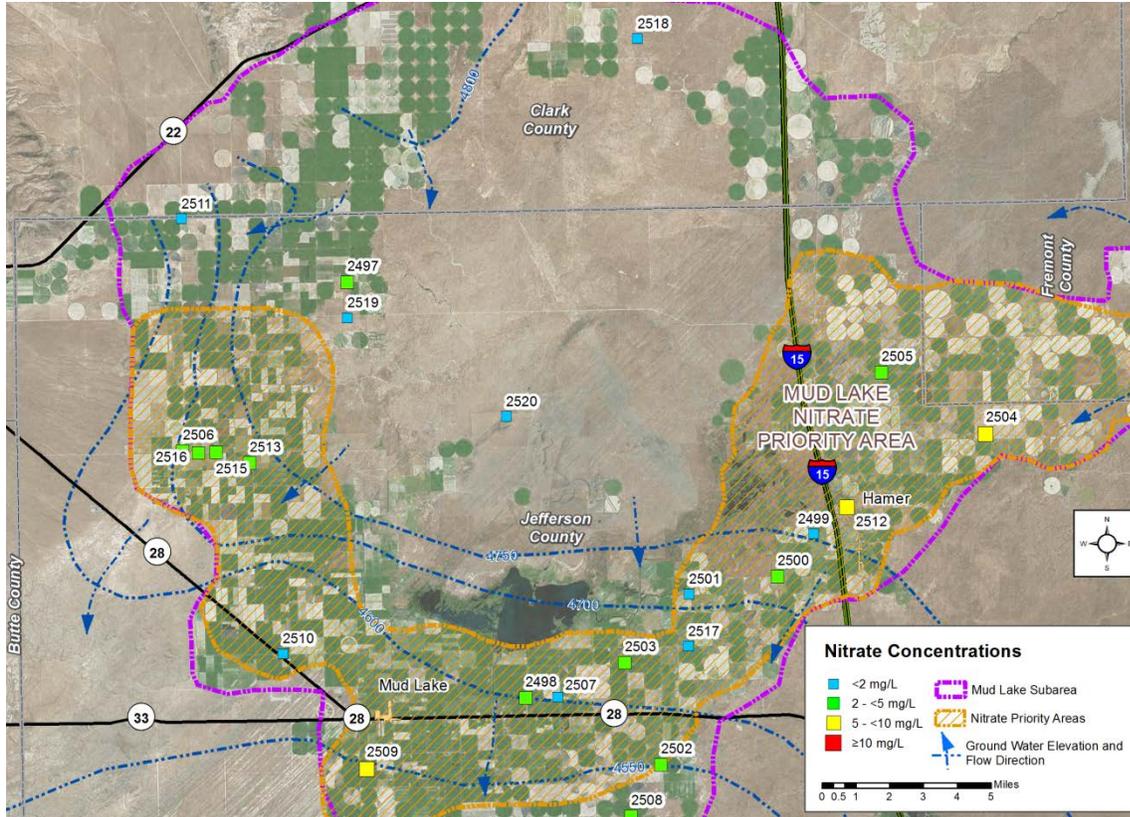


Figure 30. Mud Lake regional subarea nitrite plus nitrate concentrations and ground water flow direction—Mud Lake Subarea Regional Ground Water Quality Monitoring Project.

2.2.1.2 Methods and Results

Sample locations were selected from domestic and livestock wells with available well logs. Selection favored more recent wells with complete information concerning well construction, well-bore seals, and lithologic descriptions suggesting that ground water sampled would represent the shallowest aquifer zone. The number of sample sites needed to adequately represent the area of interest was based on a statistical process (Steinhorst unpublished), with the specific data used to determine the number of sample sites needed detailed in *Idaho Falls Regional Office Ambient Ground Water Monitoring Plan Development: Defining Subareas* (DEQ 2013c). A goal of 20 to 25 sample sites was established. Potential sample sites (wells) were selected from randomly identified and ordered 1-mile sections completely within the 525 square-mile study area. Sections that included IDWR or ISDA monitoring wells were excluded. A total of 23 wells were sampled in 2015 and 2016. Results from these randomly selected wells can statistically represent the subarea and can be combined with results from other sampling networks to make inferences concerning the subarea.

Samples were also collected at 5 surface water locations to characterize the potential recharge to the ESRP aquifer in the vicinity of both the Mud Lake subarea and the South Fremont County NPA. Sample results from regional monitoring of the Eastern Snake River Plain subarea (DEQ 2016), suggested that recharge from tributary basins for the ESRP aquifer could be characterized by water quality observed for surface water. The 5 surface water sites, sampled late in the fall at a time when baseflow is dominant, are surrogates for ground water underflow from these primary contributing basins: Beaver Creek at Spencer, Camas Creek at Red Road, Henrys Fork at Saint Anthony, Teton River at Saint Anthony, and Snake River at Heise.

The surface water sites were sampled at the US Geological Survey (USGS) stream gages (Figure 29). Henrys Fork, Teton River, and Snake River sites are active monitoring sites for the USGS; the Beaver Creek and Camas Creek sites have been discontinued. Data from all 5 locations were included in Wood and Low (1988) to characterize ESRP aquifer recharge for the USGS Snake River Plain Regional Aquifer System Analysis program completed in the 1990s (Sun and Johnson 1994).

The 23 project wells and 5 surface water locations were sampled during November and December 2015 and March and June 2016 following the appropriate QAPP (DEQ 2011c) and FSP (DEQ 2015n).

Water quality field parameters (pH, temperature, specific conductance, and DO) were measured at each site prior to sample collection (Table 47).

Table 47. Water quality field parameters—Mud Lake Subarea Ground Water Monitoring Project.

DEQ Site ID	Sample Date	Water Temperature (°C)	Specific Conductivity (µS/cm)	pH ^a	Dissolved Oxygen (mg/L)
2497	11/17/15	9.4	517	7.47	6.75
2498	11/17/15	10.64	419	7.93	6.21
2499	11/24/15	9.33	257	7.78	4.98
2500	11/24/15	9.33	257	7.78	4.98
2501	11/24/15	11.2	297	7.73	5.74
2502	11/24/15	10.46	338	7.38	8.42
2503	11/24/15	10.97	418	7.54	6.9
2504	12/02/15	12.08	365	7.78	9.21
2505	12/02/15	14.27	298	7.90	7.99
2506	12/02/15	9.06	785	7.27	8.35
2507	12/02/15	9.96	327	7.95	7.75
2508	12/09/15	11.52	314	7.44	10.82
2509	12/09/15	9.96	626	7.51	8.13
2510	12/09/15	11.29	405	7.79	0.62
2511	12/09/15	11.19	414	7.55	12.38
2512	03/30/16	9.43	328	7.49	6.68
2513	03/30/16	8.29	1001	7.16	3.81
2515	03/30/16	9.74	829	7.05	7.54
2516	03/30/16	9.47	791	7.03	7.54
2517	03/30/16	8.41	327	7.62	4.33
2518	06/01/16	12.31	328	7.75	7.79
2519	06/01/16	11.25	340	7.51	2.95
2520	06/01/16	13.6	237	7.77	8.68
Beaver Creek at Spencer (13113000)	11/17/15	0.1	409	8.06	9.74
Camas Creek at Red Road (13108900)	11/16/15	0.63	157	7.96	9.69
Henrys Fork at St Anthony (13050500)	11/16/15	2.73	143	8.22	9.33
Snake River near Heise (13037500)	11/16/15	5.31	476	7.99	7.79
Teton River near St Anthony (13055000)	11/16/15	3.34	307	8.34	8.92

^a Contaminant with a National Secondary Drinking Water Regulation standard. The NSDWR for pH is 6.5-8.5. NSDWR standards are recommended limits for public water systems and are used with private wells to evaluate water quality.

Samples were analyzed by IBL in Boise for common ions (calcium, sodium, magnesium, potassium, chloride, fluoride, and sulfate), arsenic, total alkalinity, nitrite plus nitrate (nitrate), and ammonia. Samples for bacteria (TC and *E. coli*) were analyzed by IAS Environmental in Pocatello.

After receiving the major ion chemistry and nutrient results, samples for stable isotope analysis were submitted to Northern Arizona University–Colorado Plateau Stable Isotope Laboratory (NAU CPSIL) for stable isotopes of nitrogen and oxygen in nitrate ($\delta^{15}\text{N}_{\text{nitrate}}$, $\delta^{18}\text{O}_{\text{nitrate}}$) and

University for Arizona for stable isotopes of oxygen and hydrogen in water ($\delta^{18}\text{O}$ and $\delta^2\text{H}$). Increased sample volume (500 mL–1L) was submitted to NAU CPSIL for analysis of nitrogen isotopes in ammonium ($\delta^{15}\text{N}_{\text{NH}_4}$). Analyses for $\delta^{15}\text{N}_{\text{NH}_4}$ were not complete by the time of publication. Results will be incorporated in an upcoming, more detailed analysis of monitoring results.

Samples were submitted to the University of Idaho–Center for Advanced Energy Studies laboratory in Idaho Falls for total organic carbon, bromide, and trace elements (boron, lithium, strontium), and uranium. Samples were also submitted to Idaho State University Environmental Monitoring Laboratory for environmental-level tritium analyses to assist in determining the age of recharge. Results from the tritium analyses are not yet available and will be included in upcoming publications.

Nitrate Results

Nitrate concentrations for the Mud Lake subarea ranged from less than 0.010 mg/L to 6.1 mg/L (Well 2504), with a mean and median of 2.8 and 2.4 mg/L, respectively (Table 48). The spatial distribution of nitrate concentrations is presented in Figure 30.

Table 48. Nutrient and bacteria results—Mud Lake Subarea Regional Ground Water Quality Monitoring Project.

DEQ Site ID	Well Depth (feet)	Casing Depth (feet)	Sample Date	Nutrient Concentrations		Bacteria ^b	
				Nitrite plus Nitrate ^a	Ammonia	Total Coliform	<i>E. coli</i>
				(mg/L)		(MPN/100 mL)	
<i>Standard:</i>				10	NA	1 cfu/100 mL	<1 cfu/100 mL
2497	75	68	11/17/2015	2.8	<0.010	<1.0	<1.0
2498	280	128	11/17/2015	3.1	0.021	<1.0	<1.0
2499	223	195	11/24/2015	1.2	0.018	<1.0	<1.0
2500	75	26	11/24/2015	2.4	0.012	<1.0	<1.0
2501	205	198	11/24/2015	1.4	0.036	<1.0	<1.0
2502	365	334	11/24/2015	2.4	<0.010	1	<1.0
2503	300	175	11/24/2015	2.4	<0.010	<1.0	<1.0
2504	292	195	12/02/2015	6.1	<0.010	<1.0	<1.0
2505	185	18	12/02/2015	3.4	<0.010	<1.0	<1.0
2506	400	280	12/02/2015	4.8	<0.010	8.6	<1.0
2507	300	300	12/02/2015	1.9	<0.010	<1.0	<1.0
2508	360	—	12/09/2015	3.3	<0.010	<1.0	<1.0
2509	335	335	12/09/2015	5.2	<0.010	<1.0	<1.0
2510	260	180	12/09/2015	0.72	0.21	<1.0	<1.0
2511	405	320	12/09/2015	1.5	0.017	<1.0	<1.0
2512	92	60	03/30/2016	5	0.013	<1.0	<1.0
2513	162	112	03/30/2016	4.8	0.011	<1.0	<1.0
2515	253	78	03/30/2016	3.8	<0.010	<1.0	<1.0
2516	300	45	03/30/2016	4.5	<0.010	<1.0	<1.0
2517	220	174	03/30/2016	1.2	<0.010	<1.0	<1.0
2518	220	160	06/01/2016	0.74	<0.010	<1.0	<1.0
2519	180	173	06/01/2016	0.25	<0.010	<1.0	<1.0
2520	195	180	06/01/2016	1.5	<0.010	<1.0	<1.0
Beaver Creek at Spencer (13113000)			11/17/2015	<0.010	0.056	435.2	209.8
Camas Creek at Red Road (13108900)			11/16/2015	<0.010	<0.010	275.2	22.8
Henrys Fork at St Anthony (13050500)			11/16/2015	0.16	<0.010	517.2	34.5
Snake River near Heise (13037500)			11/16/2015	0.058	0.043	209.8	61.3
Teton River near St Anthony (13055000)			11/16/2015	0.84	0.016	249.5	20.3

Notes: Bolded red numbers indicate either an EPA National Primary Drinking Water Regulation (NPDWR) standard, expressed as a maximum contaminant level (MCL), or an Idaho Ground Water Quality Rule (IDAPA 58.01.11.200) standard was reached or exceeded. These regulations are applicable for public water systems only but are used to evaluate water quality in private wells.

^a Contaminant with a National Primary Drinking Water Regulation standard.

^b Total coliform and *E. coli* standards are from the Idaho Ground Water Quality Rule (IDAPA 58.01.11.200). An exceedance of the primary ground water quality standard for total coliform (indicated by gray shaded cells) is not a violation of these rules. Total coliform is not a health threat in itself; it is used to indicate whether other potentially harmful bacteria may be present. Although the standards are given in cfu/100 mL, analytical results provided in MPN/100 mL are acceptable for comparison to the standard.

Ammonia Results

Ammonia was reported above the reporting limit of 0.010 mg/L for samples from 8 of 23 wells. Reportable concentrations ranged from 0.011 mg/L to 0.21 mg/L. Detections for ammonia were very small compared to nitrate (<1–3% of total nitrogen) for all but one well (Well 2510). Well 2510 had concentrations for ammonia and nitrate of 0.21 mg/L and 0.72 mg/L, respectively. Well 2510 is characterized by relatively low sulfate compared to chloride (a ratio of less than 1)—typically associated with a waste-related nitrate source—and a high $\delta^{15}\text{N}_{\text{nitrate}}$ (23.2‰), suggesting that chemical (isotope fractionation) or biological processes (denitrification or other nitrogen-cycle processes) may be impacting the isotopic and chemical signature of ground water at this site. For most wells, the proportion of ammonia to nitrate was very low (<1–3%). Sites with very low nitrite plus nitrate levels (<1 mg/L) tended to have a greater proportion of N in the sample as ammonia, and also low sulfate/chloride ratios. The general chemistry and isotopic results are presented later in this summary.

Bacteria Results

TC bacteria are a group of bacteria common in the environment (such as soil) and are generally not harmful. *E. coli* bacteria (a type of coliform bacteria) are found in animal fecal matter. The presence of *E. coli* in ground water provides strong evidence that human or animal fecal waste is present and a greater potential for pathogenic organisms exists. Bacterial analyses aid in identifying potential impacts or influences at the wellhead or sample point. TC was detected in 2 wells; Wells 2502 and 2506 had TC concentrations of 1 and 8.6 MPN/100 mL, respectively (Table 48). All 5 surface water locations had positive detections of TC and *E. coli*. The surface water concentrations of TC ranged from 209.8 to 517.2 MPN/100 mL; the *E. coli* concentrations ranged from 20.3 to 209.8 MPN/100 mL. All 23 wells were negative for *E. coli*.

General Ground Water Chemistry

Common ion chemistry provides a picture of the overall relative character of ground water, including mixing from different sources and changes in ground water chemistry from processes such as dissolution of the aquifer matrix, infiltration, and impacts from contamination sources. Major ion chemistry along with field parameters can also provide clues to ongoing chemical processes and indications of the favored chemical forms for nitrogen in ground water (Table 49).

Table 49. Common ion results—Mud Lake Subarea Regional Ground Water Quality Monitoring Project.

DEQ Site ID	Well Depth (feet)	Casing Depth (feet)	Sample Date	Major Ion Concentrations							
				Calcium	Magnesium	Sodium	Potassium	Chloride ^a	Fluoride ^b	Sulfate ^a	Alkalinity (as CaCO ₃)
				(mg/L)							
<i>Standard:</i>				<i>NA</i>	<i>NA</i>	<i>NA</i>	<i>NA</i>	<i>250</i>	<i>4</i>	<i>250</i>	<i>NA</i>
2497	75	68	11/17/2015	77	19	29	3.7	10.2	0.275	12.8	292
2498	280	128	11/17/2015	47	17	19	3.6	51.5	0.403	16.7	131
2499	223	195	11/24/2015	32	9.4	13	2.7	7.05	0.828	8.87	125
2500	75	26	11/24/2015	38	10	15	2.7	9.36	0.684	12.3	139
2501	205	198	11/24/2015	40	11	12	2.6	8.51	0.406	11	144
2502	365	334	11/24/2015	42	12	18	2.8	16.1	0.611	17.4	146
2503	300	175	11/24/2015	52	15	22	3.5	24.6	0.374	16.5	184
2504	292	195	12/02/2015	39	13	21	3.1	12.8	0.905	31.6	125
2505	185	18	12/02/2015	35	11	14	2.7	7.81	0.849	17.8	124
2506	400	280	12/02/2015	86	25	60	6.1	50.6	0.244	46.3	328
2507	300	300	12/02/2015	39	12	14	3	21.3	0.409	12.9	132
2508	360	—	12/09/2015	36	11	17	2.9	11.4	0.928	16.2	128
2509	335	335	12/09/2015	58	15	59	8	42.8	0.222	30.5	243
2510	260	180	12/09/2015	28	11	44	7.3	27.6	0.574	20.6	172
2511	405	320	12/09/2015	55	15	12	3.2	28.1	0.403	26.8	160
2512	92	60	03/30/2016	35	11	16	2.9	8.71	0.82	18	122
2513	162	112	03/30/2016	88	27	94	6	65.9	<0.20	101	334
2515	253	78	03/30/2016	84	24	68	5.7	30.9	<0.20	36.6	372
2516	300	45	03/30/2016	84	24	57	5.4	31.2	<0.20	37.7	348
2517	220	174	03/30/2016	39	11	13	2.7	8.96	0.314	10.7	150
2518	220	160	06/01/2016	41	12	11	2.5	10	0.26	10.3	161
2519	180	173	06/01/2016	42	11	14	3.7	9.01	0.378	24.3	155
2520	195	180	06/01/2016	26	8.9	11	2.3	7.24	0.479	8.16	107
Beaver Creek at Spencer (13113000)			11/17/2015	65	16	10	1.5	13.2	0.203	8.89	231
Camas Creek at Red Road (13108900)			11/16/2015	23	6.1	5	2.4	1.84	0.259	2.58	92

DEQ Site ID	Well Depth (feet)	Casing Depth (feet)	Sample Date	Major Ion Concentrations							
				Calcium	Magnesium	Sodium	Potassium	Chloride ^a	Fluoride ^b	Sulfate ^a	Alkalinity (as CaCO ₃)
				(mg/L)							
Standard:				NA	NA	NA	NA	250	4	250	NA
Henry's Fork at St Anthony (13050500)			11/16/2015	11	3.1	19	2.5	6.78	2.42	3.21	65
Snake River near Heise (13037500)			11/16/2015	66	18	20	2.9	26.2	0.378	66.4	178
Teton River near St Anthony (13055000)			11/16/2015	49	15	4.4	1.4	4.19	0.237	10.4	174

Note: (—) = data are unavailable or were not analyzed.

^a Contaminant with a National Secondary Drinking Water Regulation standard.

^b Contaminant with a National Primary Drinking Water Regulation standard.

Based on the common ion results, the ground water in the Mud Lake subarea is primarily a calcium-bicarbonate water with generally low, but increasing, relative proportions of chloride and sulfate primarily with the direction of ground water flow (Table 49, Figure 31). The Piper trilinear water chemistry plot (Piper diagram) can help to identify major trends in ground water chemistry. While there is a small distinction between proportions of calcium (Ca), magnesium (Mg), and sodium plus potassium (Na+K) for the Mud Lake subarea and the South Fremont County NPA (discussed in section 2.2.2), the variation can likely be explained due to mixing of surface water recharging the ground water; Beaver and Camas Creek represent one endpoint with Henrys Fork of the Snake River representing the other. The cation chemistry of the Teton and Snake Rivers is similar to Beaver and Camas Creeks but is not within the direction of regional ground water flow and thus cannot represent endpoints for the study area.

The variations in anion chemistry can be explained as a combination of the primary recharge sources and other, potentially anthropogenic sources. The proportions of anions for the representative surface water sources are essentially the same, with the exclusion of the Snake River at Heise. The proportional addition of sulfate and chloride can be an indication of an additional source impacting ground water for those wells with higher sulfate and chloride. The data generally show higher chloride and sulfate concentrations in the western and south-central portions of the Mud Lake subarea, which are regionally hydraulically downgradient from multiple potential surface water recharge sources: natural recharge represented by Camas Creek, Beaver Creek, and potentially from the Henrys Fork of the Snake River. Ground water chemistry also may be influenced by playa deposits within the Mud Lake basin and inputs from anthropogenic sources. Water chemistry from the Teton and Snake River will aid in a follow-up analysis examining the compilation of regional monitoring data for potential nitrate source signatures.

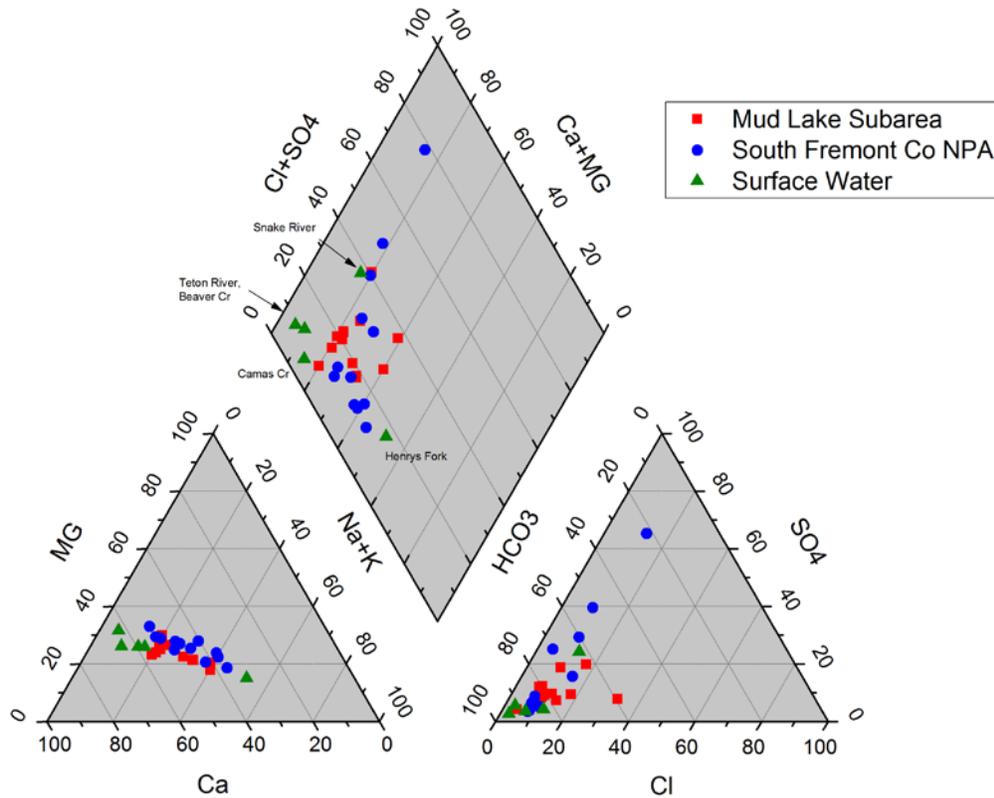


Figure 31. Piper diagram—Mud Lake Subarea Ground Water Quality Monitoring Project.

Relative concentrations of major ions can provide clues to the potential sources of nitrates to ground water. Figure 32 presents the relationship of chloride to sulfate for the Mud Lake Subarea and for the South Fremont County NPA (discussed in section 2.2.2). General chemistry presented in Figure 31 suggests that variations in anion chemistry can be due to a combination of the general chemistry of the primary recharge sources, hydrogeology, and other potential sources associated with land use. Regional monitoring in the ESRP aquifer has shown that most sites will plot in a linear pattern over a relatively small range of concentrations. This pattern reflects a relative concentration of the ions in ground water due to continued dissolution of the aquifer or by concentration of recharge water. Sites plotting above or below this “regional chloride-sulfate line” can point to additional sources of these anions, potentially related to land use, such as waste disposal, or other processes impacting ground water. Mud Lake subarea sites that plot the farthest from this line—Wells 2498, 2506, 2509, and 2513—all have nitrite plus nitrate concentrations that exceed accepted background levels, with values ranging from 3.1 to 5.2 mg/L. Other groupings that plot off this “regional background” include sites with higher nitrite plus nitrate (Wells 2504 [6.1 mg/L] and 2516 [4.5 mg/L]).

The chloride-sulfate relationship for surface water sites that represent the primary sources of ground water recharge (with the exception of Snake River at Heise) appears to provide a lower bound for chloride and sulfate concentrations for wells in the Mud Lake subarea (Figure 32).

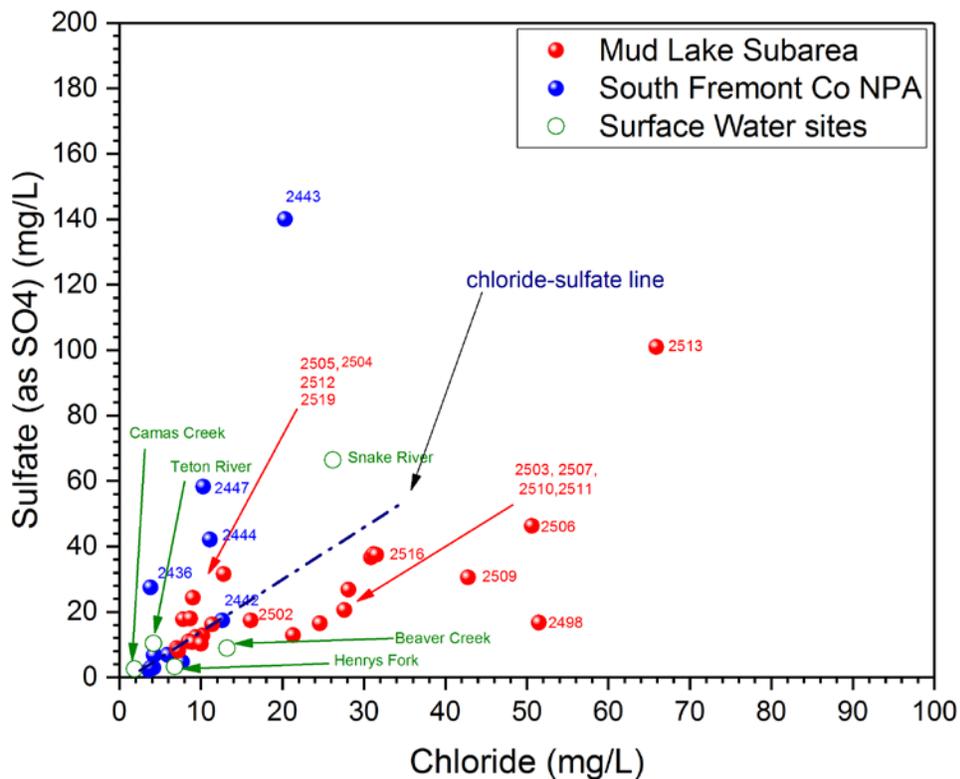


Figure 32. Comparison of chloride versus sulfate concentrations—Mud Lake Subarea Ground Water Quality Monitoring Project 2015.

This chloride-sulfate relationship can provide a basis for distinguishing between sources for some sites (Suen 2008), with a common observation of a higher sulfate/chloride ratio reflecting an influence from sulfate-based fertilizers and a lower ratio (often less than 1) generally reflecting a waste-related impact. Such interpretations must be supported by additional monitoring data and with an understanding of the local hydrogeology.

Figure 33 presents the relationship of sulfate/chloride to nitrate for Idaho Falls regional monitoring. Samples from the Mud Lake subarea sites all have sulfate/chloride ratios less than 3 and are more tightly grouped than the data from the South Fremont NPA sites. One modest outlier is Well 2519, which plots adjacent to Snake River and Teton River samples.

The surface water sites plot with a range of sulfate/chloride ratios from about 0.5 to 2.5 with Beaver Creek (0.47) and Henrys Fork (0.67) with lower ratios, Camas Creek with intermediate ratios (1.4) and the Teton and Snake River sites (2.5, 2.5) with higher ratios.

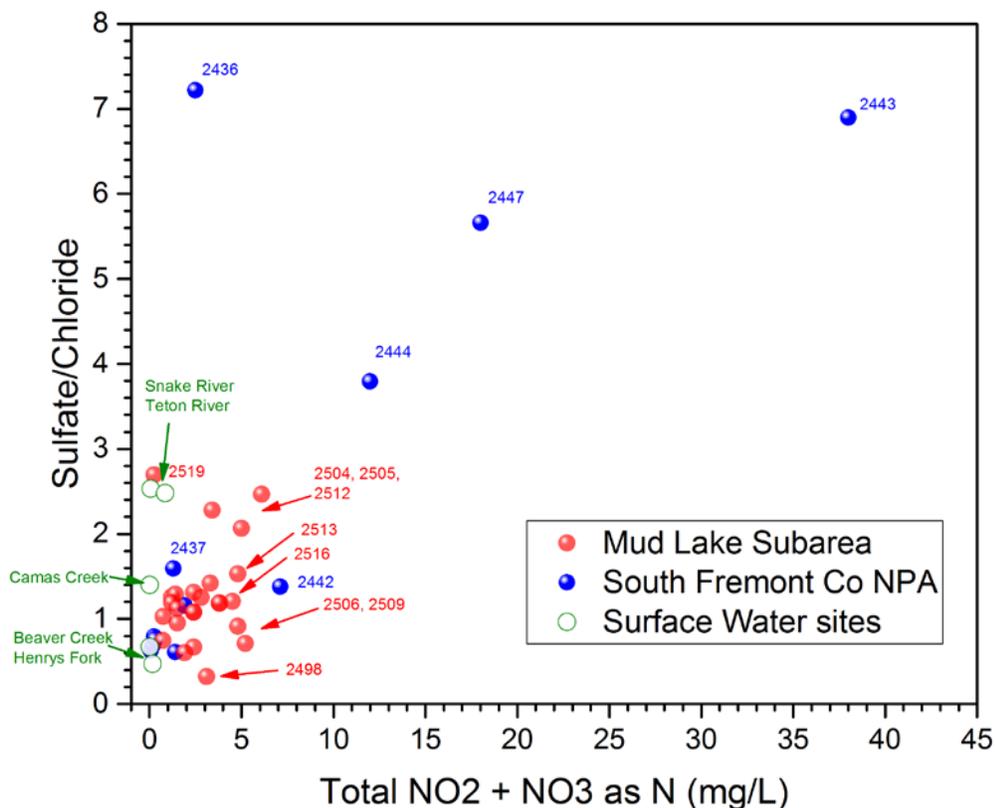


Figure 33. Nitrite plus nitrate versus sulfate/chloride (in mg/L)—Idaho Falls Regional Office monitoring projects.

Stable Isotope Results

Stable isotope results can also aid in understanding the possible ongoing thermodynamic or biochemical processes within the system. Results for stable isotope analyses are presented in Table 50. The $\delta^{15}\text{N}_{\text{nitrate}}$ values for the wells sampled ranged from 2.45‰ to 23.2‰. A total of 8 wells had isotope values $<4\text{‰}$, suggesting an inorganic, possible commercial fertilizer source; 13 wells had isotope values between 4‰ and 9‰, suggesting a possible mixed source or organic soil nitrogen source; and 2 wells had isotope values greater than 9‰, suggesting a possible waste source. While general ranges of $\delta^{15}\text{N}$ values for categorizing isotopic signatures are presented (Table 3), secondary processes including microbial-facilitated nitrogen cycling and mixing from multiple sources can alter the observed $\delta^{15}\text{N}$ value. Supporting evidence such as the sulfate/chloride ratio and the $\delta^{15}\text{N}$ value for the nitrogen in nitrate ($\delta^{15}\text{N}_{\text{nitrate}}$) along with the $\delta^{18}\text{O}_{\text{nitrate}}$ can be extremely valuable in understanding the “nitrogen history” for the sample.

Figure 34 presents stable isotope measurements of $\delta^{15}\text{N}_{\text{nitrate}}$ compared to sulfate/chloride ratios. The isotopic ratio for ^{15}N in ground water is a product of the combination of nitrate sources and fractionation due to nitrogen cycle processes. Distinctions in sulfate/chloride ratios have been identified for wells sampled, and comparison of those ratios with $\delta^{15}\text{N}_{\text{nitrate}}$ can aid in interpreting potential nitrate sources. Most steps in the nitrogen cycle in the subsurface are facilitated by microbes and can result in isotope fractionation (changes in the observed stable isotope ratio).

Two groupings of Mud Lake subarea sites plot in the range typically attributed to inorganic nitrogen sources ($\delta^{15}\text{N}_{\text{nitrate}} < 4\text{‰}$). Group A wells (2504, 2505, 2512) are all in the Hamer area and share similar sulfate/chloride and $\delta^{15}\text{N}_{\text{nitrate}}$ ratios and similar nitrate values suggesting a similar potential nitrate source. Group B wells (2497, 2501, 2502, 2508, and 2520) are distributed across the sample area with a range of nitrite plus nitrate values suggesting a range of potential sources for the signatures observed. Three other Mud Lake wells (2519, 2498, and 2510) plot distinctively in Figure 34. The combination of sulfate/chloride and $\delta^{15}\text{N}_{\text{nitrate}}$ ratio for 2498 suggests a potential waste influence. The relatively high sulfate/chloride ratio for well 2519 and the $\delta^{15}\text{N}_{\text{nitrate}}$ suggest a mixed inorganic and organic source that may include an impact from fertilizers. A combination of factors for Well 2510—low nitrite plus nitrate (0.72 mg/L) and similar concentration of ammonia (0.21 mg/L), the high $\delta^{15}\text{N}_{\text{nitrate}}$ (23.2 ‰), and anoxic conditions ($\text{DO} < 1 \text{ mg/L}$)—suggest additional chemical and/or biological processes such as denitrification are impacting the ground water at this site. Knowing the $\delta^{15}\text{N}$ value for ammonia in the sample might provide further understanding of nitrogen cycle or chemical processes for this site.

Table 50. Stable isotope analytical results—Mud Lake Subarea Regional Monitoring Project.

DEQ Site ID	Sample Date	NAU CPSIL ^a		University of Arizona	
		$\delta^{15}\text{N}_{\text{nitrate}}$ (‰ Air)	$\delta^{18}\text{O}_{\text{nitrate}}$ (‰ VSMOW)	$\delta^{18}\text{O}$ (‰ VSMOW)	$\delta^2\text{H}$ (‰ VSMOW)
2497	11/17/2015	3.41	-4.90	-17.5	-130.1
2498	11/17/2015	9.91	-2.22	-17.7	-131.7
2499	11/24/2015	4.40	-7.37	-18.1	-133.4
2500	11/24/2015	4.51	-4.26	-18.1	-132.3
2501	11/24/2015	3.88	-5.29	-17.7	-131.4
2502	11/24/2015	3.99	-6.42	-17.8	-132.8
2503	11/24/2015	4.58	-4.78	-17.5	-131.0
2504	12/02/2015	2.87	-3.61	-17.2	-128.9
2505	12/02/2015	2.45	-4.99	-17.7	-130.9
2506	12/02/2015	5.76	-8.52	-17.3	-130.2
2507	12/02/2015	5.68	-5.44	-17.8	-131.7
2508	12/09/2015	3.79	-4.33	-17.5	-130.2
2509	12/09/2015	5.99	-3.55	-15.5	-121.1
2510	12/09/2015	23.2	2.72	-17.5	-131.8
2511	12/09/2015	5.73	-6.47	-17.7	-131.0
2512	03/30/2016	2.68	-4.25	-17.6	-129.3
2513	03/30/2016	5.22	-4.34	-17.1	-126.0
2515	03/30/2016	5.55	-5.63	-17.2	-128.8
2516	03/30/2016	5.18	-5.87	-17.3	-127.6
2517	03/30/2016	4.90	-4.29	-17.6	-128.8
2518	06/01/2016	5.57	-4.80	-17.4	-126.5
2519	06/01/2016	6.24	-6.03	-17.6	-129.0
2520	06/01/2016	3.59	-5.12	-17.9	-130.3
Beaver Creek at Spencer (13113000)	11/17/2015	-6.22	9.20	-16.7	-123.8
Camas Creek at Red Road (13108900)	11/16/2015	b	b	-17.2	-125.8
Henrys Fork at St Anthony (13050500)	11/16/2015	4.68	-3.46	-17.7	-127.4
Snake River near Heise (13037500)	11/16/2015	4.37	-7.25	-17.3	-126.6
Teton River near St Anthony (13055000)	11/16/2015	5.65	-3.7	-17.9	-129.8

Note: Stable isotope analytical results are presented as delta values (δ) reported as parts per thousand (identified as per mill or ‰) compared to a standard. For $\delta^{15}\text{N}$ and $\delta^{15}\text{N}_{\text{nitrate}}$, delta values represent the measured ratio $^{15}\text{N}/^{14}\text{N}$ for the sample compared to $^{15}\text{N}/^{14}\text{N}$ for air.

^a Northern Arizona University Colorado Plateau Stable Isotope Laboratory.

^b Insufficient nitrate in sample for analysis.

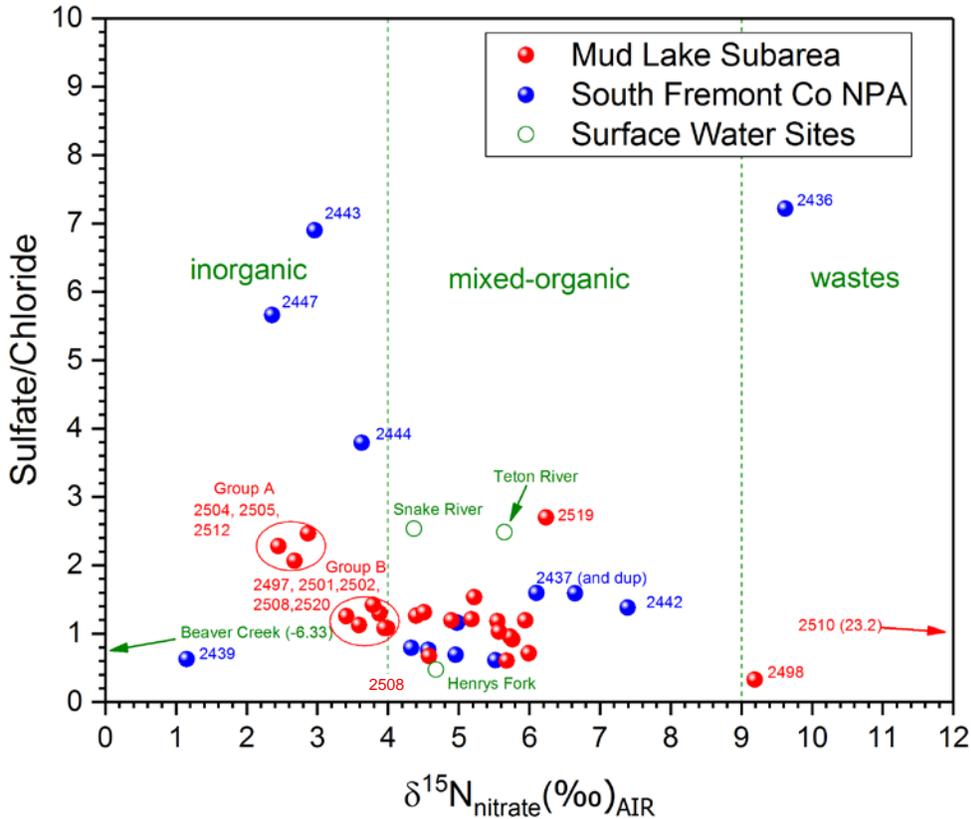


Figure 34. $\delta^{15}\text{N}_{\text{nitrate}}$ versus sulfate/chloride — Idaho Falls Regional Office monitoring projects 2015.

Surface water samples from Beaver Creek, Snake River at Heise, the Teton River, and Henrys Fork at St. Anthony provided sufficient nitrogen for $\delta^{15}\text{N}_{\text{nitrate}}$ analysis. Values for Snake River, Henrys Fork, and the Teton River are within the range for an organic or mixed source. The sample for Camas Creek at Red Road, with <0.010 mg/L nitrate, provided less than the required 0.07 mg/L N needed for a sample to be prepared. The sample for Beaver Creek, while also reported as less than the reporting limit (< 0.010) did provide sufficient N for an analysis. The $\delta^{15}\text{N}_{\text{nitrate}}$ value, -6.33‰ reflects a value in the range acceptable for N from precipitation.

Kendall (1998) discusses the use of $\delta^{15}\text{N}_{\text{nitrate}}$ and $\delta^{18}\text{O}_{\text{nitrate}}$ to aid in tracing sources and nitrogen cycling in the environment. This dual-isotope method can help explain the ongoing microbial-facilitated processes and aid in understanding portions of the nitrogen cycle where $\delta^{15}\text{N}$ signatures are not sufficiently distinct. Figure 35 plots $\delta^{15}\text{N}_{\text{nitrate}}$ versus $\delta^{18}\text{O}_{\text{nitrate}}$. Also included are typical ranges for $\delta^{15}\text{N}_{\text{nitrate}}$ versus $\delta^{18}\text{O}_{\text{nitrate}}$ for various sources (Kendall et al. 2007). As nitrogen in the form of ammonia undergoes nitrification, oxygen from the air and from soil or irrigation water is added; the typical ratio is one $\delta^{18}\text{O}$ from air (usually $\delta^{18}\text{O} = 23\text{‰}$) and two from the soil water, either precipitation or irrigation water ($\delta^{18}\text{O} \sim -17\text{‰}$), from Table 50 and Figure 35, yielding an expected $\delta^{18}\text{O}$ value of ~ -4 or -5‰ (Kendall 1998).

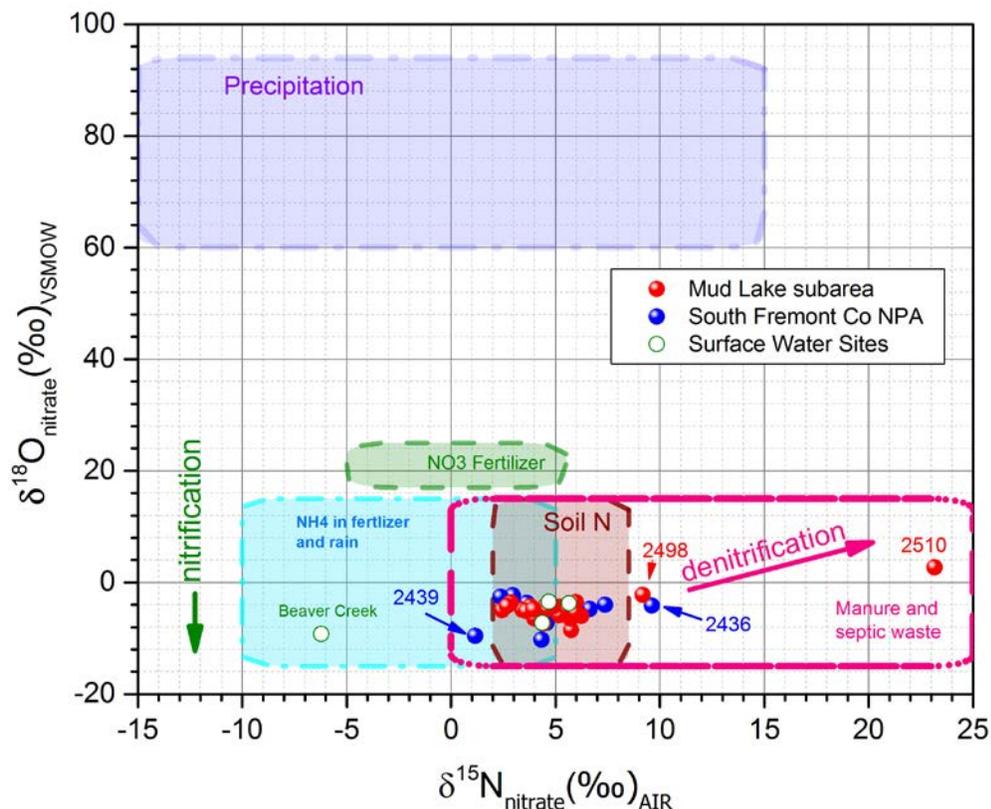


Figure 35. $\delta^{15}\text{N}_{\text{nitrate}}$ versus $\delta^{18}\text{O}_{\text{nitrate}}$ —Idaho Falls Regional Office monitoring projects 2015. Ranges for typical nitrate sources are from Kendall et al. 2007.

Results for most of the sites plot in a similar range; however, there are several noteworthy exceptions. Mud Lake subarea wells 2498 and 2510 plot in the typical waste range based on $\delta^{15}\text{N}_{\text{nitrate}}$ and both have a low relative sulfate. The $\delta^{15}\text{N}_{\text{nitrate}}$ value for 2498 (9.91) plots in the typical waste range. The $\delta^{15}\text{N}_{\text{nitrate}}$ for 2510 (23.2)—with the additional factors of similar values for nitrite plus nitrate and ammonia that are both very low—suggests that while it may have a waste signature, the isotopic fractionation resulting in the high $\delta^{15}\text{N}_{\text{nitrate}}$ value may indicate other processes altering the source signature. With the very low DO identified at the time of sampling, denitrification may be occurring. However, more information is needed to confirm that hypothesis. Beaver Creek plots in the expected range for ammonia in fertilizer and rain (Kendall 1998), consistent with the detection of ammonia in the sample and the assumed ambient sulfate /chloride ratio.

Stable isotopes of oxygen and hydrogen in ground water can help identify the likely source and timing of recharge. Results for $\delta^{18}\text{O}$ and $\delta^2\text{H}$ (deuterium) for water are reported relative to Vienna Standard Mean Ocean Water (VSMOW). Results for $\delta^{18}\text{O}$ versus $\delta^2\text{H}$ for the Mud Lake subarea are presented in Figure 36. The figure also includes for comparison the global meteoric water line (GMWL) from Craig (1961), a local meteoric water line (LMWL) based on regional precipitation, and a compilation of ground water $\delta^{18}\text{O}$ versus $\delta^2\text{H}$ for the ESRP aquifer from Cecil et al. (2005).

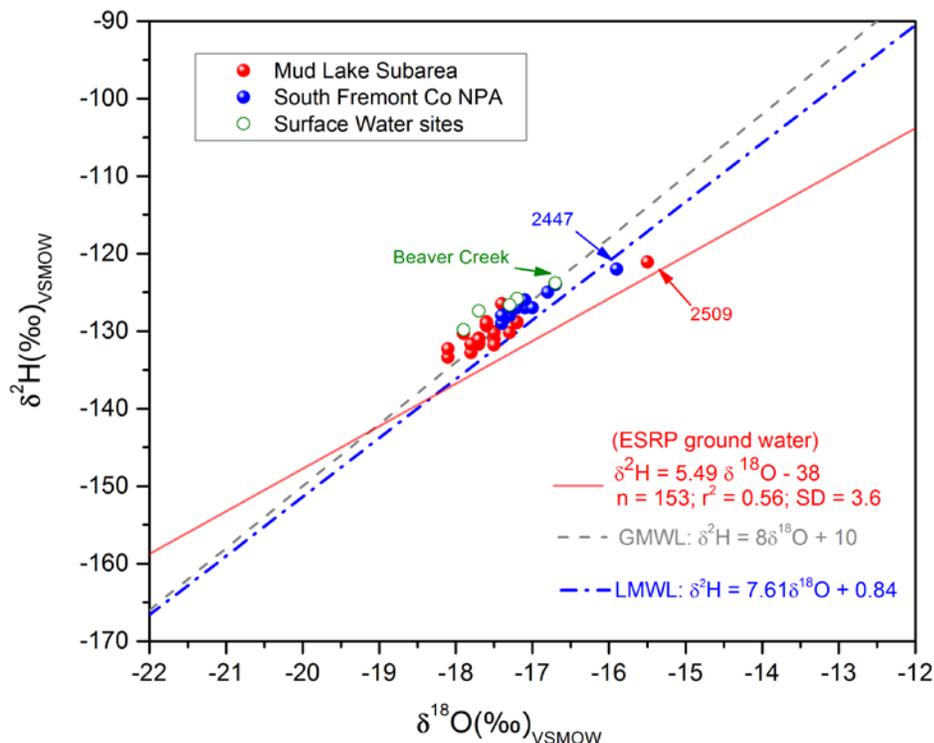


Figure 36. Stable oxygen and deuterium ($\delta^{18}\text{O}$ versus $\delta^2\text{H}$)—Idaho Falls Regional Office monitoring projects.

Most of the sites plot along the GMWL or LMWL. Well 2509 plots parallel the ESRP ground water line, indicative of evaporation, potentially related to irrigation. Well 2509, with high nitrite plus nitrate, but an organic or mixed signature from $\delta^{15}\text{N}_{\text{nitrate}}$ and lower relative sulfate, suggests a combination of factors and sources may be influencing nitrate concentrations. The Beaver Creek result plots directly on the meteoric water line. Combined with the nitrite plus nitrate and ammonia relationship and the sulfate/chloride ratios, this result suggests that this site largely reflects a natural precipitation source for N.

Characteristic Ratios and Trace Elements

Relative concentrations of trace elements in ground water can provide additional support to distinguish between potential sources of nitrate. Ratios of chloride to bromide and the relative concentration of boron have been used as indicators by Katz et al. (2011) and Davis et al. (1998). University of Idaho-Center for Advanced Energy Studies analyzed additional parameters and trace elements. Bromide, boron, strontium, and uranium were detected for samples from all 23 wells (Table 51). Lithium was detected in 21 of the 23 wells. Bromide, strontium and uranium were detected in all 5 surface water sites, while boron and lithium were detected in 3 and 2 surface water sites, respectively. All uranium concentrations were below the MCL of 30 $\mu\text{g/L}$. Along with total organic carbon, further analysis of trace elements will be included in a more in-depth treatment of results from regional monitoring to be published later.

Samples from all 23 wells and 5 surface water sites were analyzed for arsenic. Arsenic was detected in 13 of 23 wells, with a median value of 2.3 $\mu\text{g/L}$ and a maximum of 8.5 $\mu\text{g/L}$.

Table 51. Total Inorganic Carbon, Arsenic, Bromide, and trace element results—Mud Lake Subarea Regional Monitoring Project.

DEQ Site ID	Sample Date	Total Inorganic Carbon (mg/L)	Arsenic ^a (µg/L)	Bromide (µg/L)	Boron (µg/L)	Lithium (µg/L)	Strontium (µg/L)	Uranium, Total ^a (µg/L)
<i>Standard</i>		<i>NA</i>	<i>10</i>	<i>NA</i>	<i>NA</i>	<i>NA</i>	<i>NA</i>	<i>30</i>
2497	11/17/2015	<0.50	<2.0	32.6	27	<10	321	5.09
2498	11/17/2015	<0.5	4.4	88.5	21.7	13.7	235	1.76
2499	11/24/2015	<0.5	<2.0	19.1	37.5	25.1	92.7	1.58
2500	11/24/2015	<0.5	<2.0	22.1	19	11.6	111	1.9
2501	11/24/2015	<0.5	2.4	22.3	10.8	<10	123	1.57
2502	11/24/2015	<0.5	<2.0	34.5	24.7	10.9	135	2.17
2503	11/24/2015	<0.5	2.6	54.8	24.5	17.4	200	2.65
2504	12/02/2015	0.555	<2.0	35.6	45	16.5	116	1.89
2505	12/02/2015	<0.5	<2.0	24.3	30.6	13	94.6	1.77
2506	12/02/2015	1.14	5.5	116	94.7	50.8	378	5.88
2507	12/02/2015	<0.5	3.6	50	19.4	13	159	1.72
2508	12/09/2015	<0.5	<2.0	34.1	56.5	29	96.9	1.88
2509	12/09/2015	0.705	<2.0	99.2	57.4	22.9	262	3.44
2510	12/09/2015	<0.5	5.5	69.8	32	33.7	116	0.981
2511	12/09/2015	<0.5	<2.0	68.2	27.2	12.3	249	2.61
2512	03/30/2016	<0.5	2.0	26.2	44.8	24.2	97	1.58
2513	03/30/2016	1.24	5.7	163	112	27.7	349	5.52
2515	03/30/2016	0.943	4.4	82.8	92	20	351	5.21
2516	03/30/2016	0.974	4.5	98.5	88.2	26.5	338	5.14
2517	03/30/2016	<0.5	2.8	24.8	20.8	13.5	137	1.63
2518	06/01/2016	<0.5	<2.0	33.4	27.9	6.02*	172	1.5
2519	06/01/2016	<0.5	8.5	31.5	28.9	20.5	158	1.1
2520	06/01/2016	<0.5	2.3	22.5	14.6	10.6	111	0.982
Beaver Creek at Spencer (13113000)	11/17/2015	2.98	<2.0	22.9	15.7	<10	282	0.97
Camas Creek at Red Road (13108900)	11/16/2015	2.98	<2.0	11.5	<10	<10	94.3	0.242
Henrys Fork at St Anthony (13050500)	11/16/2015	0.661	5.2	25.1	97.4	63.4	24	0.73
Snake River near Heise (13037500)	11/16/2015	0.869	2.4	21.7	41	27.8	394	0.693
Teton River near St Anthony (13055000)	11/16/2015	0.813	<2.0	18.1	<10	<10	85.3	1.97

^a Contaminant with a National Primary Drinking Water Regulation standard.

*The laboratory reporting limit for this sample was 5 µg/L.

2.2.1.3 Conclusions

The objectives of this regional monitoring study are to identify areas of vulnerable or degraded water quality, collect data to aid in determining potential sources of degradation to direct and prioritize ground water protection efforts based on potential sources, and evaluate the effectiveness of management practices used to reduce nitrate impacts. The goal of this summary was to present preliminary results for the third of three regional monitoring subareas for the DEQ Idaho Falls region.

Nitrate concentrations exceeded 2 mg/L for 14 of 23 wells within the Mud Lake subarea. Nitrate concentrations of 5 mg/L or greater were detected in 3 wells, all within the Mud Lake NPA. Ammonia was detected at 8 Mud Lake wells.

Major ion chemistry, presented with a Piper diagram, suggests that the variation in common ions may be explained as primarily a mixture of recharge from source areas (Beaver Creek, Camas Creek, and the Henrys Fork of the Snake River) and the addition of sulfate and chloride from other sources including playa deposits within the Mud Lake basin, as well as inputs from anthropogenic sources. A relatively small but general increase of both chloride and sulfate along the regional ground water flow paths was observed. Some wells with a lower sulfate relative to chloride shared characteristics of Beaver Creek and Henrys Fork recharge, suggesting that in some cases this low relative sulfate proportion reflects natural water chemistry that has not been impacted by anthropogenic land uses.

Two wells plotted with $\delta^{15}\text{N}_{\text{nitrate}}$ values indicative of a waste source ($>9\text{‰}$) and returned relatively low sulfate concentrations compared to chloride typically associated with waste sources. The $\delta^{15}\text{N}_{\text{nitrate}}$ value for Well 2510 (23.2 ‰) is higher than commonly observed, which may suggest that a combination of chemical and biological processes, including denitrification, may be impacting the nitrate signature for this site. The overall signature for Beaver Creek likely represents a natural precipitation source. Furthermore, a combination of very low nitrate with a corresponding ammonia concentration may be a signature of natural nitrogen from precipitation.

2.2.1.4 Recommendations

Major ion chemistry, chloride, sulfate, and stable isotopes should be considered for sampling to identify potential nitrate sources. Assessment of the potential sources of nitrate observed should consider a combination of factors and characterize the potential sources of recharge as well as nitrate sources.

Further support for nitrate source evaluation may come from trace elements or other indicators. Conclusions from this analysis should refine suggested analytes and guidance for interpreting monitoring results for evaluating potential nitrate sources to ground water across Idaho.

2.2.2 South Fremont County Nitrate Priority Area Potential Nitrate Source Evaluation Monitoring Project

2.2.2.1 Purpose and Background

This ground water monitoring project was designed to evaluate the water quality and nitrate concentrations in the South Fremont County (SFC) NPA. The SFC NPA, ranked 26 in the 2014 NPA priority list, encompasses approximately 12 square miles and is located north of St. Anthony in Fremont County (Figure 37).

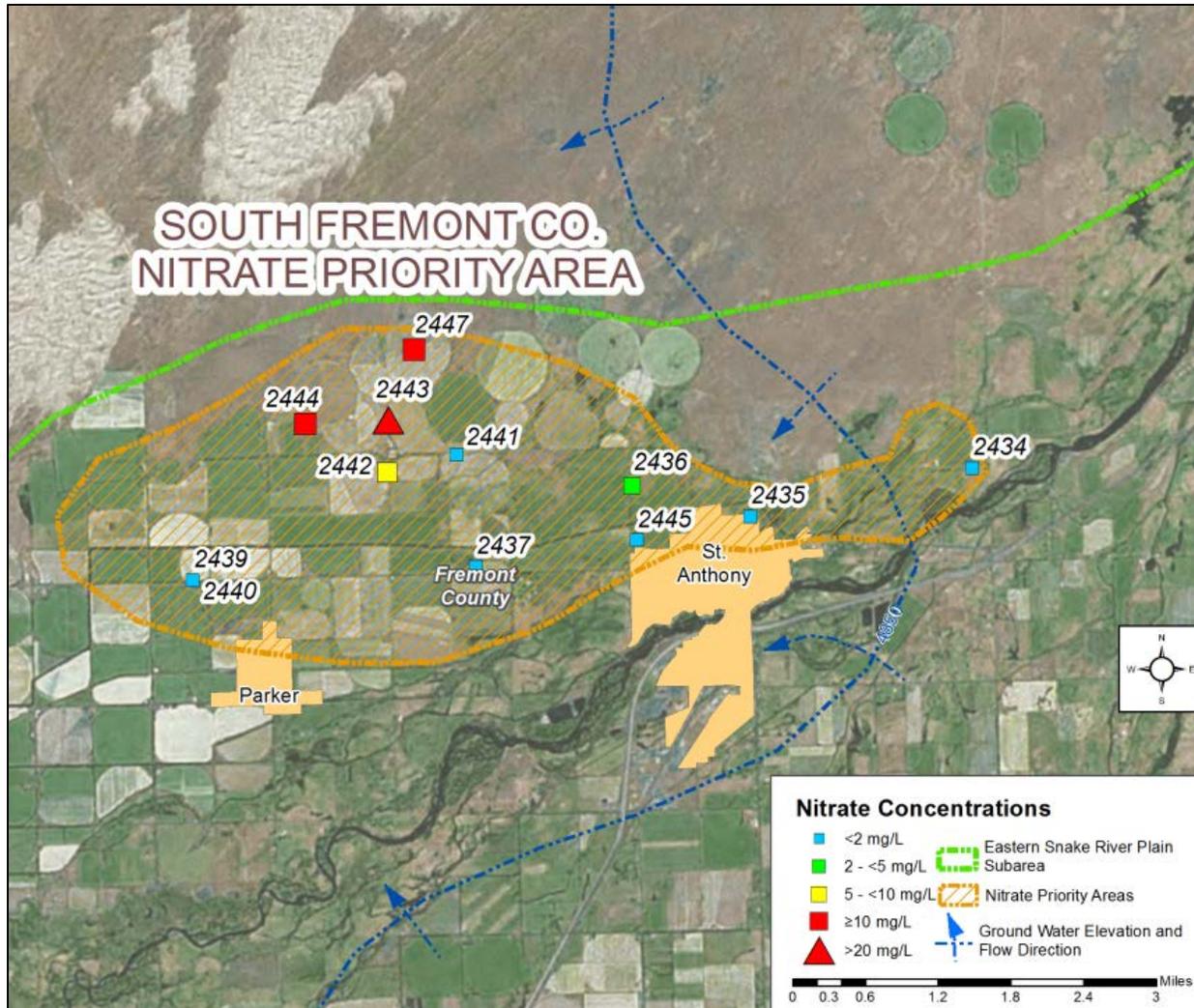


Figure 37. Well locations and nitrite plus nitrate concentrations—South Fremont County Nitrate Priority Area Ground Water Monitoring Project 2015.

Geology of the aquifers sampled in the SFC NPA is similar to the Mud Lake subarea, with intercalated sediments and basalt of the ESRP aquifer. The wind-blown deposits and sediments from the Henrys Fork of the Snake River tend to be sandy and more permeable than the Mud Lake sediments to the west. The ESRP aquifer tends to respond as unconfined toward the center and as confined toward the margins, reflecting the larger proportion of sediments (Stearns et al. 1939; Spinizola 1994). Major sources of recharge are downward percolation of precipitation and snowmelt, runoff from the surrounding uplands, streamflow losses from drainages to the north of the region and the Henrys Fork River, and direct infiltration of surface water diverted for irrigation (Graham and Campbell 1981). Ground water flow direction with the project area is to the southwest. The primary land use within the NPA is irrigated agriculture.

2.2.2.2 Methods and Results

The DEQ Idaho Falls Office used a local, biased monitoring approach for selecting sampling sites for the SFC NPA ground water quality monitoring project. Site selection is designed to achieve the following monitoring goals: identify areas with degraded ground water quality;

determine potential sources of nitrate to ground water; develop management strategies based on monitoring results and land usage; and evaluate the effectiveness of BMPs used to reduce nitrate impacts to ground water. The general monitoring approach and quality assurance context is described in the appropriate QAPP (DEQ 2011c), with details specific to this sampling provided in the FSP (DEQ 2015o).

During the 2014 NPA delineation and ranking, the SFC NPA was defined by a relatively small number of sample sites and encompasses a correspondingly small area of 12 square miles. The intent of this sampling was to enhance the available data by selecting wells not sampled previously that would provide nitrate results in areas with few or no data points and to resample sites with both high and lower historical nitrate levels for additional analytes to aid in evaluating potential sources of nitrate.

Potential sites included those with elevated nitrate from previous sampling by IDWR or ISDA monitoring and from domestic wells identified from available well logs cataloged by IDWR. Permissions from well owners were received for a total of 12 wells. Two wells (2439 and 2440) were available at one location: the domestic well and a nearby sand point well used for irrigation. Of the 12 wells, 3 had been previously sampled; 2 wells (2443 and 2447) were previously sampled as part of IDWR monitoring efforts and 1 well (2439) was previously sampled by ISDA as part of a regional monitoring project. Wells sampled in 2015 as part of the SFC NPA monitoring project are included in Figure 37.

Samples were collected in June and August 2015 from each well in accordance with the above referenced QAPP and FSP.

Water quality field parameters (pH, temperature, specific conductivity, and DO) were measured at each well prior to sample collection (Table 52).

Table 52. Water quality field parameters—South Fremont County Nitrate Priority Area Ground Water Monitoring Project.

DEQ Site ID	Sample Date	Water Temperature (°C)	Specific Conductivity (µS/cm)	pH ^a	Dissolved Oxygen (mg/L)
2434	6/4/2015	11.97	257	7.47	6.63
2435	6/4/2015	9.97	132	7.14	4.84
2436	6/4/2015	9.86	228	6.89	3.93
2437	6/4/2015	10.63	156	6.80	4.03
2439	6/4/2015	14.19	118	7.17	0.87
2440	6/4/2015	9.00	116	7.00	4.57
2441	6/17/2015	13.43	199	7.29	5.92
2442	6/17/2015	12.98	255	6.48	8.02
2443	6/17/2015	10.82	632	6.62	7.77
2444	6/17/2015	13.83	337	7.18	6.43
2445	6/17/2015	11.25	125	7.29	4.91
2447	8/11/2015	11.13	424	7.03	6.00

Note: Italicized red numbers indicate EPA's National Secondary Drinking Water Regulation (NSDWR) standard was exceeded. These regulations are applicable for public water systems only but are recommended limits and can be applied to private wells to evaluate water quality.

^a Contaminant with a National Secondary Drinking Water Regulation standard. The NSDWR for pH is 6.5-8.5. NSDWR standards are recommended limits for public water systems and are used with private wells to evaluate water quality.

Samples were analyzed by IBL in Boise for common ions (calcium, sodium, magnesium, potassium, chloride, fluoride, and sulfate), arsenic (for one well based on DO concentration <1.0 mg/L), total alkalinity, and nutrients (nitrite plus nitrate and ammonia). Samples for bacteria (TC and *E. coli*) were analyzed by IAS Environmental in Pocatello. Samples for nitrogen isotopes were collected at each sampling location, frozen, and stored at DEQ pending common ion chemistry and nitrate analysis. After receiving the common ion chemistry and nutrient results, samples for stable isotope analysis were submitted to NAU CPSIL for stable isotopes of nitrogen and oxygen in nitrate ($\delta^{15}\text{N}_{\text{nitrate}}$, $\delta^{18}\text{O}_{\text{nitrate}}$). Samples were also submitted to the University for Arizona for stable isotopes of oxygen and hydrogen in water ($\delta^{18}\text{O}$ and $\delta^2\text{H}$). Selected samples (Well 2435 and Well 2437) were also analyzed by University for Arizona for total $\delta^{15}\text{N}$ based on their greater ammonia concentration. Samples were submitted to the University of Idaho—Center for Advanced Energy Studies laboratory in Idaho Falls for total organic carbon, bromide, and trace elements (boron, lithium, strontium, and uranium). Samples were also submitted to Idaho State University Environmental Monitoring Laboratory for environmental-level tritium analyses. Results for tritium analyses are not yet available and will be included in upcoming publications.

General Ground Water Chemistry

Common ion chemistry provides a picture of the overall relative character of ground water, including mixing from different sources and changes in ground water chemistry from processes such as dissolution of the aquifer matrix, infiltration, and impacts from contamination sources. Common ion chemistry along with field parameters can also provide clues to ongoing chemical processes and indications of the favored chemical forms for nitrogen in ground water. Common

ion chemistry can also evolve with increasing nitrite plus nitrate concentration where the nitrite plus nitrate source also includes a significant proportion of other anions.

The Piper trilinear water chemistry plot (Piper diagram) for ground water within the SFC NPA shows primarily a calcium-bicarbonate type water with generally low but increasing relative proportions of chloride and sulfate with increasing nitrite plus nitrate, as indicated by symbols reflecting nitrite plus nitrate concentrations (Figure 38). Higher sulfate concentrations and the accompanying greater proportion of sulfate compared to bicarbonate (HCO_3) in ground water for SFC NPA samples provides a clear signature for elevated nitrates in the study area (Table 53). With increasing nitrite plus nitrate is an increase in the proportion of calcium and magnesium in the ground water. For the SFC NPA monitoring, due to the proximity to and dominance by the Henrys Fork of the Snake River, the cation trend may indicate a correlation between the BMP of applying lime (often limestone, CaCO_3 , and dolomite [Ca , MgCO_3]) to control the soil acidification that can occur related to the use of ammonium sulfate for a primary fertilizer. These findings suggest a mixing between Henrys Fork-dominated recharge and recharge with a signature reflecting local BMPs.

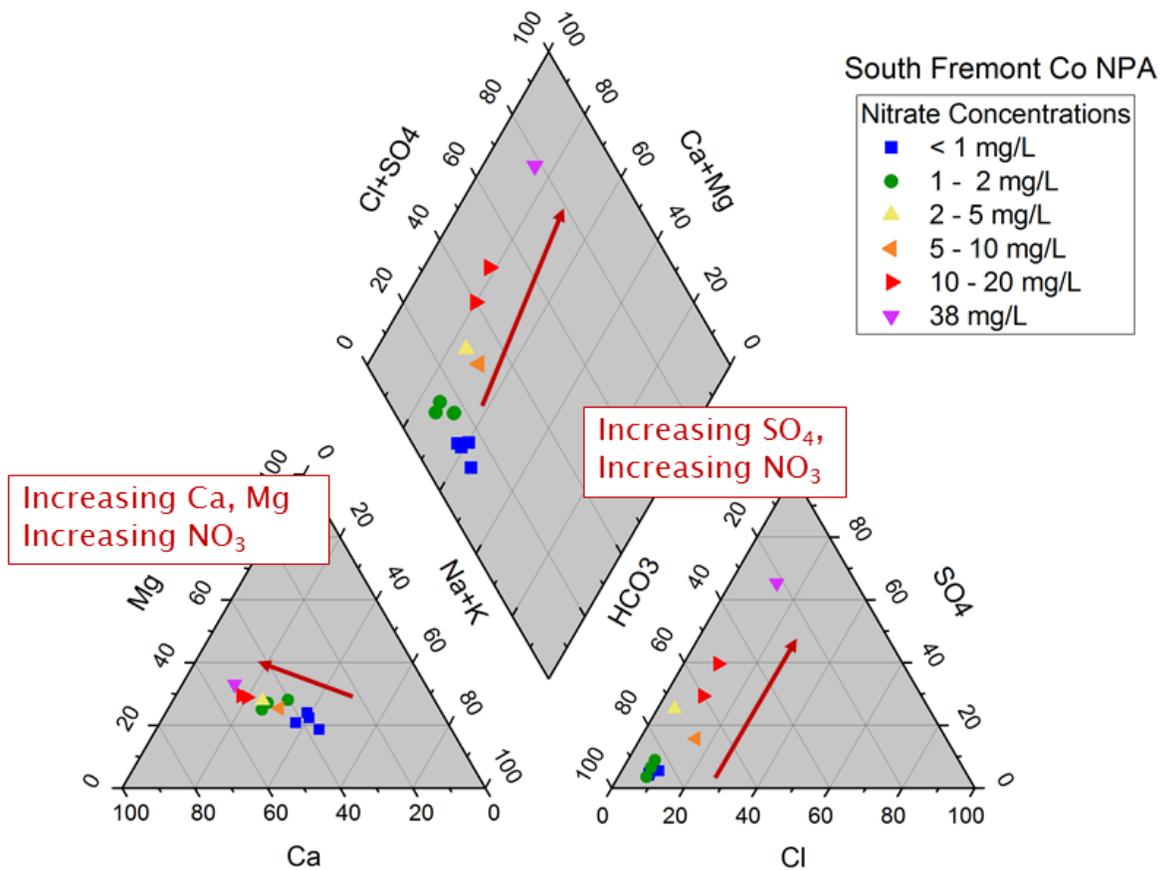


Figure 38. Piper diagram—South Fremont County NPA Ground Water Quality Monitoring Project 2015.

Table 53. Common ion, nutrient, and bacteria results—South Fremont County Nitrate Priority Area Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	Casing Depth (feet)	Sample Date	Common Ion Concentrations (mg/L)								Nutrient Concentrations		Bacteria ^c	
				Calcium	Magnesium	Sodium	Potassium	Chloride ^a	Fluoride ^b	Sulfate ^a	Alkalinity (as CaCO ₃)	Nitrite plus Nitrate ^b	Ammonia	Total Coliform	<i>E. coli</i>
				(mg/L)								(MPN/100 mL)		1 cfu/100 mL ^c	<1 cfu/100 mL ^c
Primary or Secondary Standard:				NA	NA	NA	NA	250	4	250	NA	10	NA	1 cfu/100 mL^c	<1 cfu/100 mL^c
2434	280	225	6/4/15	28	9.9	17	2.3	7.7	1.3	4.71	122	1.4	—	4.1	<1.0
2435	53	20	6/4/15	11	4.3	12	2.2	4.04	1.73	3.19	61	0.25	0.042	<1.0	<1.0
2436	48	5	6/4/15	25	8.9	13	3.3	3.81	1.07	27.5	80	2.5	<0.010	1	<1.0
2437	80	28	6/4/15	15	6.3	12	2.5	4.26	1.64	6.78	67	1.3	0.041	<1.0	<1.0
2439	—	—	6/4/15	10	3.1	13	2	3.64	1.63	2.29	54	0.073	0.015	<1.0	<1.0
2440	—	—	6/4/15	9.9	3.6	11	2.2	4.2	1.88	2.9	48	0.2	0.008 ^d	—	—
2441	200	178	6/17/15	24	7.4	13	2.7	5.92	1.26	6.87	94	1.9	<0.010	<1.0	<1.0
2442	175	128	6/17/15	26	9.1	16	8.1	12.6	1.25	17.4	80	7.1	0.035	<1.0	<1.0
2443	113	110	6/17/15	76	29	20	6.7	20.3	0.416	140	49	38	0.025	<1.0	<1.0
2444	195	195	6/17/15	41	14	16	3.7	11.1	0.931	42.1	90	12	0.029	<1.0	<1.0
2445	104	104	6/17/15	13	3.9	12	2.3	3.84	1.74	2.92	59	0.29	0.029	<1.0	<1.0
2447	165	19	8/11/15	47	16	16	4.3	10.3	0.718	58.3	78	18	0.015	57.3	<1.0

^a Contaminant with a National Secondary Drinking Water Regulation standard.

^b Contaminant with a National Primary Drinking Water Regulation standard.

^c Total coliform and *E. coli* standards are from the Idaho Ground Water Quality Rule (IDAPA 58.01.11.200). An exceedance of the primary ground water quality standard for total coliform (indicated by gray shaded cells) is not a violation of these rules. Total coliform is not a health threat in itself; it is used to indicate whether other potentially harmful bacteria may be present. Although the standards are given in cfu/100 mL, analytical results provided in MPN/100 mL are acceptable for comparison to the standard

^d Result was qualified as an estimated value; above the detection level but less than the minimum reportable level

The relationship of chloride to sulfate for the SFC NPA is included in Figure 39. Wells completed in a distinct aquifer may plot in a linear pattern relating chloride to sulfate characteristic for a given region along a ground water flow path. This relationship likely reflects dissolution from a relatively consistent aquifer matrix or a consistent recharge source. In this case, the increase in dissolved chloride and sulfate should be proportional at a ratio representative of the hydrologic conditions; wells with data plotting above that line indicate a relative increase in sulfate, and wells plotting below that line indicate a relative increase in chloride, each from different sources. Suen (2008) related this higher relative sulfate concentration to ammonium-sulfate based fertilizers in Fresno and Tulare Counties, California.

The SFC NPA wells plotting outside this regional background sulfate/chloride relationship include the 3 wells with the highest nitrite plus nitrate concentrations (Well 2443 [38 mg/L], Well 2447 [18 mg/L], and Well 2444, [12 mg/L]), which were all above the MCL for nitrate. The well with the fourth highest nitrite plus nitrate level (Well 2442 [7.1 mg/L]) plots along that same regional chloride/sulfate line but at a higher concentration for both chloride and sulfate. Well 2436 (which had a nitrite plus nitrate concentration of 2.5 mg/L) also plots above this regional background relationship, indicative of higher relative sulfate and anthropogenic impact.

The relationship of sulfate/chloride concentration to nitrite plus nitrate concentration is shown in Figure 40. The 3 wells with the highest nitrite plus nitrate concentrations (Well 2443, Well 2447, and Well 2444) have some of the highest sulfate/chloride ratios, suggesting an association between nitrite plus nitrate concentrations and sulfate/chloride ratios. Wells with lower nitrite plus nitrate concentrations (Wells 2442 and 2437) tend to have lower sulfate/chloride ratios. Well 2436 is an anomaly with a sulfate/chloride ratio > 7 but a relatively low nitrite plus nitrate concentration on 2.5 mg/L.

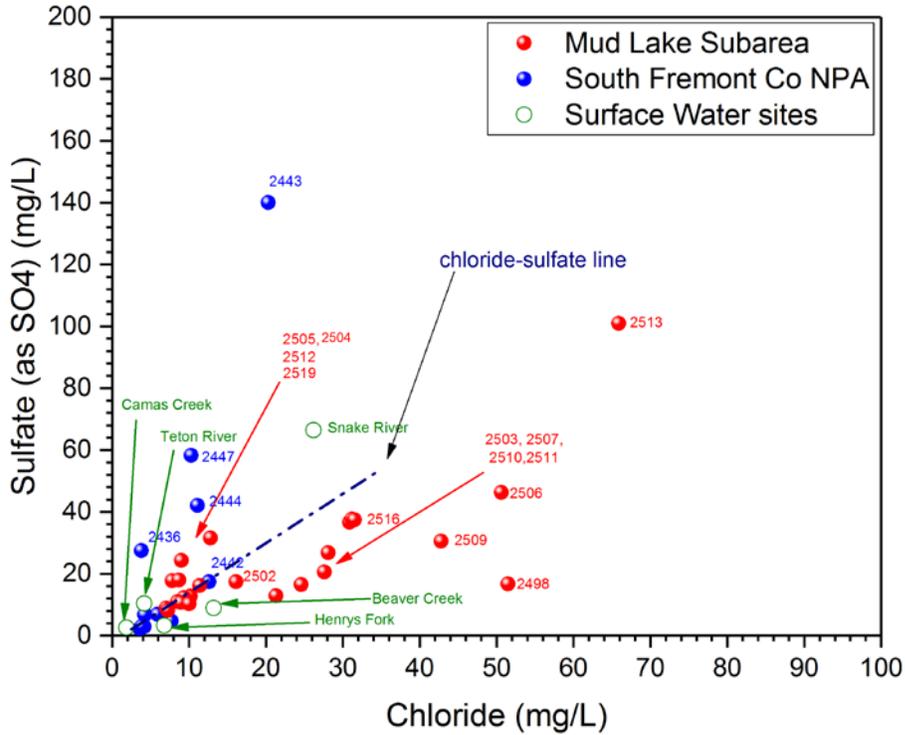


Figure 39. Comparison of chloride versus sulfate concentrations—South Fremont County NPA Ground Water Monitoring Project.

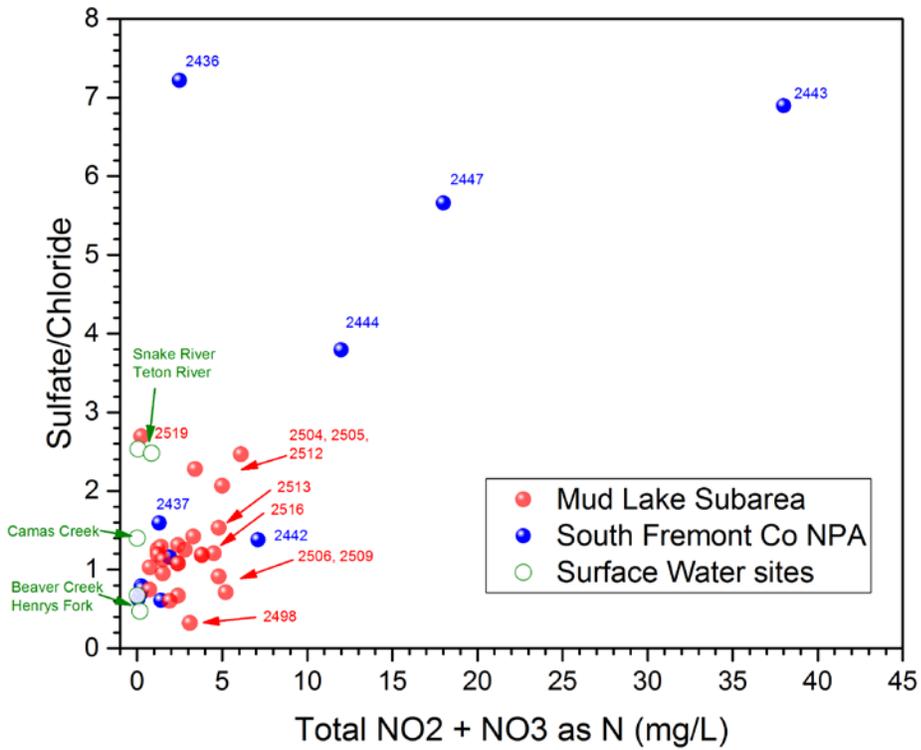


Figure 40. Nitrite plus nitrate versus sulfate/chloride (in mg/L)—South Fremont County NPA Ground Water Quality Monitoring Project.

Nitrite plus Nitrate Results

Nitrite plus nitrate concentrations for the SFC NPA ranged from 0.073 mg/L to 38 mg/L (Table 53). Of the 3 sites previously sampled by other agencies (Wells 2439, 2443, and 2447), 2 wells—2443 (4.86 mg/L in 2001) and 2447 (35 mg/L in 2010)—showed an increase in concentration with this most recent sampling.

Ammonia Results

Ammonia was reported for 9 of the 11 samples collected for the SFC NPA, with concentrations ranging from 0.008 to 0.042 mg/L (Table 53). For most sites, the proportion of ammonia to nitrite plus nitrate was very low (<1–3%). Sites with very low nitrite plus nitrate levels (>1 mg/L) tended to have a greater proportion of N in the sample as ammonia and also tended to have low sulfate/chloride ratios.

Bacteria Results

Bacterial analyses aid in identifying potential impacts or influences at the wellhead or sample point. TC bacteria was identified in 3 wells (2434, 2436, and 2447) at levels ranging from 1 to 57.3 MPN/100 mL (Table 53). TC bacteria are common in soils and when detected are usually present in the well piping instead of the aquifer. The presence of *E. coli* is considered indicative of contamination from a nearby source of human or animal wastes. All 11 wells sampled were negative for *E. coli*.

Stable Isotope Results

Stable isotope analysis can aid in understanding the possible ongoing thermodynamic or biochemical processes within the hydrogeological system. Results for all stable isotope analysis are presented in Table 54.

The $\delta^{15}\text{N}_{\text{nitrate}}$ values for the wells sampled ranged from 1.15‰ to 9.62‰. A total of 4 wells had isotope values <4‰, suggesting an inorganic, possible commercial fertilizer source; 7 wells had isotope values between 4‰ and 9‰, suggesting a possible mixed source or organic soil nitrogen source; and 1 well had an isotope value greater than 9‰, suggesting a possible waste source. While general ranges of $\delta^{15}\text{N}$ values for categorizing isotopic signatures are presented (Table 3), secondary processes including microbial-facilitated nitrogen cycling and mixing from multiple sources can alter the observed $\delta^{15}\text{N}$ value. Supporting evidence such as the sulfate/chloride ratio and the $\delta^{15}\text{N}$ value for the nitrogen in nitrate ($\delta^{15}\text{N}_{\text{nitrate}}$) along with the $\delta^{18}\text{O}_{\text{nitrate}}$ can be extremely valuable in understanding the “nitrogen history” for the sample.

Samples from Wells 2435 and 2437 were sent to the University of Arizona for $\delta^{15}\text{N}$ analysis to aid in understanding the practical difference between analytical method used by the Colorado Plateau Stable Isotope Lab and the University of Arizona. A similar comparison was included with the report for the Eastern Snake River Plain subarea (DEQ 2016), where it was observed that differences between $\delta^{15}\text{N}$ and $\delta^{15}\text{N}_{\text{nitrate}}$ tended to be greater where ammonia was a greater proportion of N in the sample. The two samples compared here yielded similar results.

Table 54. Stable isotope analytical results—South Fremont County Nitrate Priority Area Ground Water Monitoring Project.

DEQ Site ID	Sample Date	NAU CPSIL ^a		University of Arizona		
		$\delta^{15}\text{N}_{\text{nitrate}}$ (‰ Air)	$\delta^{18}\text{O}_{\text{nitrate}}$ (‰ VSMOW)	$\delta^{15}\text{N}$ (‰)	$\delta^{18}\text{O}$ (‰ VSMOW)	$\delta^2\text{H}$ (‰ VSMOW)
2434	6/4/2015	5.52	-4.92	—	-17.3	-128
2435	6/4/2015	4.33	-10.26	4.3	-17.4	-129
2436	6/4/2015	9.62	-4.19	—	-17.2	-127
2437	6/4/2015	6.65	-4.79	5.4	-17.1	-127
2439	6/4/2015	1.15	-9.55	—	-17.1	-127
2440	6/4/2015	4.96	-5.46	—	-17.2	-127
2441	6/17/2015	4.98	-4.99	—	-17.3	-127
2442	6/17/2015	7.39	-3.99	—	-16.8	-125
2443	6/17/2015	2.96	-2.33	—	-15.9	-122
2444	6/17/2015	3.63	-3.67	—	-17	-127
2445	6/17/2015	4.57	-7.23	—	-17.4	-128
2447	8/11/2015	2.36	-2.57	—	-16.7	-124

Note: Stable isotope analytical results are presented as delta values (δ) reported as parts per thousand (identified as per mill or ‰) compared to a standard. For $\delta^{15}\text{N}$ and $\delta^{15}\text{N}_{\text{nitrate}}$, delta values represent $^{15}\text{N}/^{14}\text{N}$ of the sample compared to $^{15}\text{N}/^{14}\text{N}$ for nitrogen in air, reported as $\delta^{15}\text{N}_{\text{air}}$. Standards for $\delta^{18}\text{O}$, $\delta^{18}\text{O}_{\text{nitrate}}$, and $\delta^2\text{H}$ are Vienna Standard Mean Ocean Water (VSMOW).

Figure 41 presents stable isotope measurements of $\delta^{15}\text{N}_{\text{nitrate}}$ compared to sulfate/chloride ratios. The SFC NPA wells with the highest nitrite plus nitrate concentrations plotted within the typical inorganic source range (Figure 41). The combination of elevated nitrite plus nitrate with an accompanying increase in sulfate to chloride ratios and $\delta^{15}\text{N}_{\text{nitrate}}$ values in the inorganic range support the assumption of a fertilizer source. While the $\delta^{15}\text{N}_{\text{nitrate}}$ ratio for Well 2436 plots in the waste range, the higher sulfate/chloride ratio suggests that there may be a combination of sources or other factors to consider prior to an interpretation.

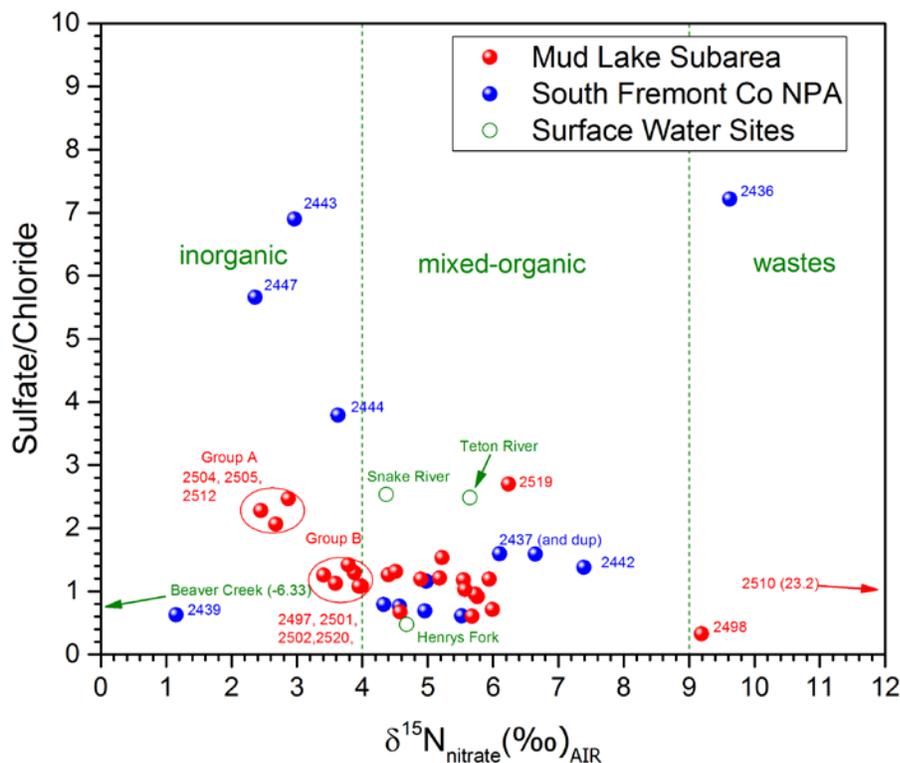


Figure 41. $\delta^{15}\text{N}_{\text{nitrate}}$ versus sulfate/chloride (in mg/L)—South Fremont County NPA Ground Water Monitoring Project 2015.

Figure 42 shows the comparison of $\delta^{15}\text{N}_{\text{nitrate}}$ to $\delta^{18}\text{O}_{\text{nitrate}}$. Well 2436 and Well 2439 plot outside the typical range attributed to natural soil processes. A combination of factors suggest that Well 2439 represents natural ambient conditions: very low nitrite plus nitrate concentration and ammonia detectable at about 20% of that level, low $\delta^{15}\text{N}_{\text{nitrate}}$ value within the range for precipitation, the $\delta^{18}\text{O}_{\text{nitrate}}$ characteristic of the combination of ground water and atmospheric ^{18}O , and a sulfate/chloride ratio similar to the surface water site Henrys Fork. Well 2436 may represent a waste source, but the high sulfate/chloride characteristic for nearby wells with high nitrate and isotope signature is consistent with fertilizer sources. The conflicting evidence suggests that there may be a combination of sources or other factors to consider prior to an interpretation.

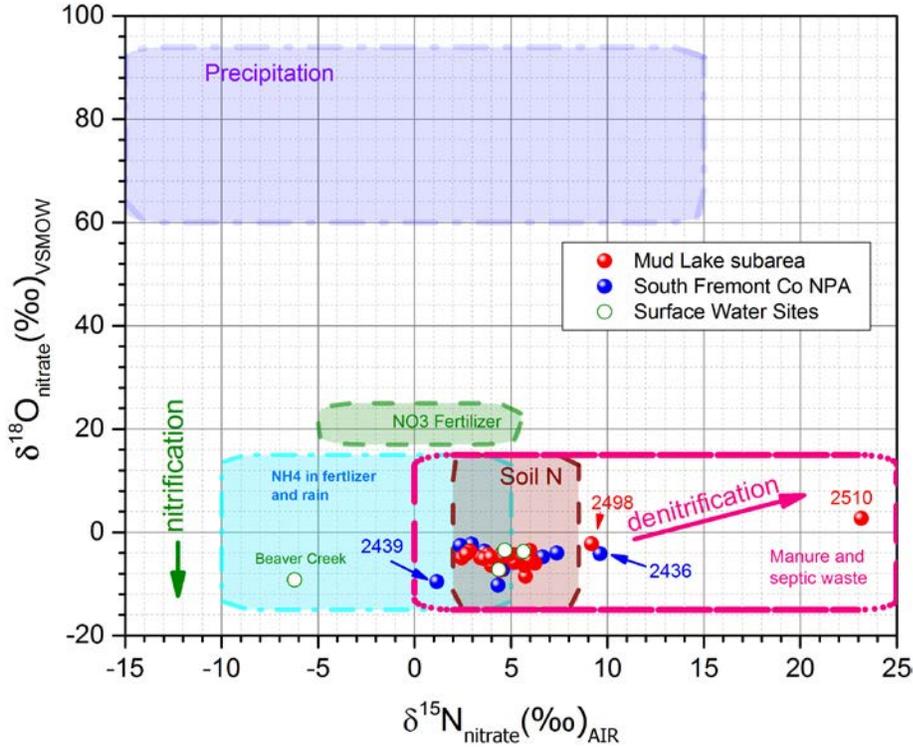


Figure 42. $\delta^{15}\text{N}_{\text{nitrate}}$ versus $\delta^{18}\text{O}_{\text{nitrate}}$ —South Fremont County NPA Ground Water Quality Monitoring Project 2015. Ranges for typical nitrate sources are from Kendall et al. 2007.

Stable isotopes of oxygen and hydrogen in ground water can help identify the likely source and timing of recharge. Results for $\delta^{18}\text{O}$ and $\delta^2\text{H}$ (deuterium) for water are reported relative to Vienna Standard Mean Ocean Water (VSMOW). Results for $\delta^{18}\text{O}$ versus $\delta^2\text{H}$ are presented in Table 54 and Figure 43. The figure also includes for comparison the global meteoric water line (GMWL) from Craig (1961), a local meteoric water line (LMWL) based on regional precipitation, and a compilation of ground water $\delta^{18}\text{O}$ versus $\delta^2\text{H}$ from Cecil et al. (2005).

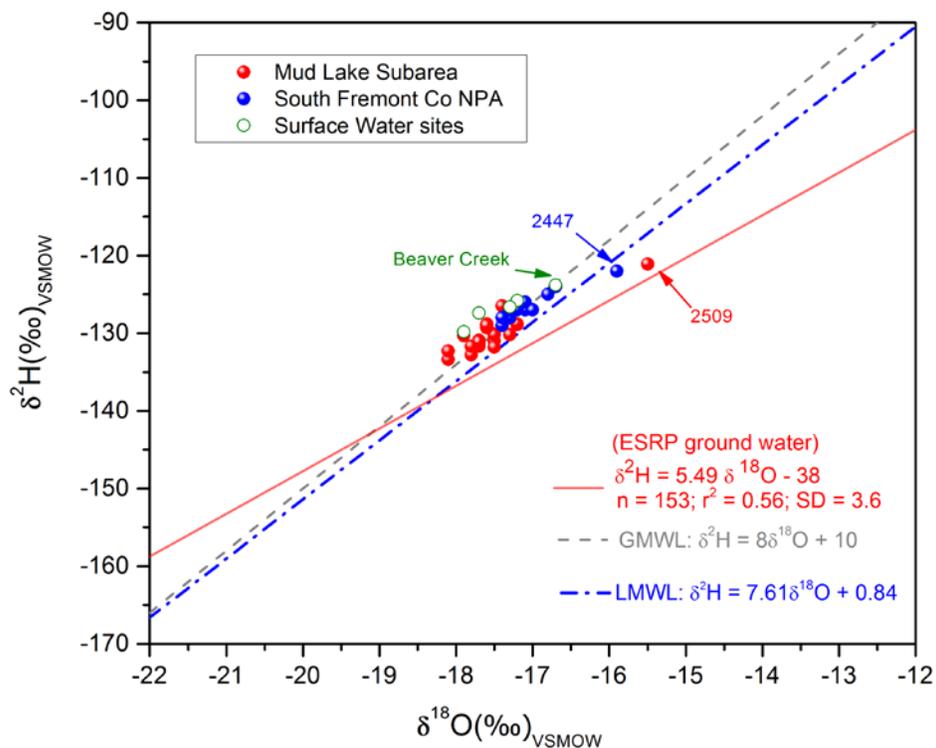


Figure 43. Stable oxygen and deuterium ($\delta^{18}\text{O}$ versus $\delta^2\text{H}$)—South Fremont County Ground Water Quality Monitoring Project 2015.

Most of the sites plot along the GMWL or LMWL. A combination of characteristics strongly suggests an inorganic fertilizer nitrate source for Well 2447: an elevated concentration of nitrite plus nitrate, a high sulfate/chloride ratio, and an inorganic signature based on the $\delta^{15}\text{N}_{\text{nitrate}}$ result. The offset of Well 2447 from the LMWL suggests influence from evaporation. This may be the result of the sample being collected in August when evaporative processes would have more time to influence the water system compared to samples collected in June.

Characteristic Ratios and Trace Elements

Relative concentrations of trace constituents in ground water can provide additional support to distinguish between potential sources of nitrate (Table 55). Ratios of chloride to bromide and relative concentration of boron have been used as indicators by Katz et al. (2011) and Davis et al. (1998). University of Idaho—Center for Advanced Energy Studies provided support for additional parameters and trace constituents. The trace elements boron, lithium, strontium, and uranium were positively detected in all 12 project wells. Bromide was detected in 8 of the 12 project wells. Along with total organic carbon, further analysis of trace elements will be included in a more in-depth analysis of results from regional monitoring to be published later.

An arsenic sample was collected for Well 2439, based on the very low DO measurement (0.87 mg/L). Higher arsenic concentrations in the area are believed to be associated with

anaerobic conditions. The reported concentration of arsenic was 0.9 µg/L. The MCL for arsenic is 10 µg/L.

Table 55. Total inorganic carbon, arsenic, bromide, and trace element results—South Fremont County Nitrate Priority Area Ground Water Monitoring Project.

DEQ Site ID	Sample Date	Total Inorganic Carbon (mg/L)	Arsenic ^a (µg/L)	Bromide (µg/L)	Boron (µg/L)	Lithium (µg/L)	Strontium (µg/L)	Uranium ^a (µg/L)
<i>Primary or Secondary Standard:</i>		<i>NA</i>	<i>10</i>	<i>NA</i>	<i>NA</i>	<i>NA</i>	<i>NA</i>	<i>30</i>
2434	6/04/2015	<0.5	—	25.4	135	24.0	74.6	0.773
2435	6/04/2015	<0.5	—	15.0	76.7	27.8	31.5	0.285
2436	6/04/2015	1.49	—	18.2	62.3	5.42	79.1	0.293
2437	6/04/2015	0.749	—	14.9	63.4	17.9	52.0	0.142
2439	6/04/2015	0.998	0.9	16.2	101	38.7	24.7	0.264
2440	6/04/2015	0.747	—	14.8	112	9.06	49.1	<0.1
2441	6/17/2015	<0.5	—	19.2	86.4	26.6	60.4	0.329
2442	6/17/2015	1.52	—	30.4	100	15.7	92.1	0.302
2443	6/17/2015	3.30	—	46.5	332	9.64	253	<0.1
2444	6/17/2015	0.778	—	24.9	120	19.5	121	0.345
2445	6/17/2015	<0.5	—	13.8	66.9	26.8	33.3	0.168
2447	8/11/2015	1.15	—	28.9	189	22.2	145	0.248

^a Contaminant with a National Primary Drinking Water Regulation standard.

2.2.2.3 Conclusions

Nitrite plus nitrate concentrations exceeded 5 mg/L for 4 of the 12 wells (33%) sampled within the SFC NPA. The principal criteria for designating an NPA is 25% of the sampled wells contain a nitrate concentration greater than or equal to 5 mg/L. Samples from 3 wells (2443, 2444, and 2447) exceeded the MCL of 10 mg/L. Well 2443 had the highest concentration at 38 mg/L. Ammonia was detected in 9 of the 11 wells for which ammonia samples were collected.

Common ion chemistry showed a strong correlation between nitrite plus nitrate concentrations and the sulfate concentration for the SFC NPA. The combination of common ion chemistry, sulfate/chloride ratios, and stable isotopes on nitrogen and oxygen in nitrate suggest that wells with elevated nitrate are influenced by inorganic fertilizer. This suggestion is supported strongly by $\delta^{15}\text{N}_{\text{nitrate}}$ ratios. Although Well 2436 has a $\delta^{15}\text{N}_{\text{nitrate}}$ signature characteristic of waste sources, conflicting evidence suggests there may be other factors to consider to identify the nitrate source.

2.2.2.4 Recommendations

Common ion chemistry, chloride, sulfate, and stable isotopes should be considered for sampling to identify potential nitrate sources. Assessment of the potential sources for nitrite plus nitrate should consider a combination of factors and characterize the potential sources of recharge as well as nitrate sources. Conclusions from this analysis should refine suggested analytes and guidance for interpreting monitoring results for evaluating potential nitrate sources to ground water across Idaho.

2.3 Coeur d'Alene Region

No ground water quality projects were conducted using DEQ funds in the Coeur d'Alene region in 2015.

2.4 Lewiston Region

Two ground water quality monitoring projects were conducted in the Lewiston region in 2015 using public funds.

2.4.1 Clearwater Plateau NPA Ground Water Monitoring Project

This section summarizes the 2015 sampling results from an ongoing ground water quality evaluation of nitrate concentrations in the Clearwater Plateau NPA, north of Grangeville, Idaho. A DEQ investigation by Bentz (1998) found that 24 of 55 wells sampled (44%) had nitrate concentrations exceeding 5 mg/L, which is half the MCL of 10 mg/L. The maximum nitrate concentration reported in the 1998 study was 77.1 mg/L. That value was later determined to be from a point source near the wellhead, and the site has not been sampled in subsequent years.

The Clearwater Plateau NPA was designated in part on the 1998 nitrate investigation results. In the most recent NPA ranking, completed in 2014, the Clearwater Plateau NPA ranked as the 14th-most degraded area in the state; data used in the assessment indicated a decreasing trend in nitrate concentrations.

2.4.1.1 Purpose and Background

To address elevated nitrate concentrations in the Clearwater Plateau NPA, a ground water quality management plan (GWQM plan) was developed (DEQ and ISCC 2008). The GWQM plan encourages implementation of voluntary BMPs to reduce nitrate concentrations in ground water.

As part of the plan, approximately \$1 million of Clean Water Act §319 grant funds were expended within the NPA through 2011 for implementing agricultural ground water protection BMPs, such as direct seed practices. Direct seed practices allow for crop planting with minimal soil disturbance, which may contribute to reduced nitrogen mobility when combined with other BMPs.

DEQ initiated the Clearwater Plateau NPA ground water monitoring project (also known as the Camas Prairie project) in August 2005 as part of a regional ambient ground water monitoring network. The objective of this long-term ground water monitoring is to determine the GWQM plan's effectiveness in improving ground water quality. Nitrate concentration data will be periodically evaluated to determine if ambient concentrations increase or decrease.

The project area is located immediately north of Grangeville, Idaho, straddling Lewis and Idaho Counties and encompassing the towns of Cottonwood, Ferdinand, Craigmont, and Nezperce (Figure 44). The land use is primarily agricultural, specifically dry-land farming. Rangeland and grazing are also commonly found throughout the area.

The geology of the area is characterized by the Tertiary Columbia River Basalts and consists of units that formed when lava flows filled in the pre-existing topography during the Miocene era (Stevens et al. 2003). The majority of the present-day land surface is capped with a thin layer of loess (windblown sediment). Ground water in the area is most commonly found in the basalt aquifers and occasionally in the alluvial valley aquifers and basement rocks. Ground water generally flows to the north and eventually discharges into the Clearwater River (Hagan 2003). Well depths from ground water sampling locations ranged from 28 to 500 feet.

2.4.1.2 Methods and Results

Since 2006, DEQ has conducted quarterly sampling from the Clearwater Plateau NPA network of 23 wells and up to 2 springs for a total of 25 sampling sites. Nitrate concentrations from sampled sites were compared seasonally for several years to identify wells with similar seasonal trends and wells with apparent anomalies. Wells with anomalies were addressed to identify and resolve isolated or localized situations and dropped from the ambient monitoring network.

In 2015, ambient sampling was conducted in on March 18, 20, and 23 and June 1 and 2 in accordance with the Camas Prairie ground water sampling QAPP (DEQ 2005). Samples were collected from 23 wells and 1 spring in March and from 23 wells in June (Figure 44). The samples were submitted to Anatek Labs Inc. for nitrate plus nitrite total nitrogen (nitrate) analysis.

Figure 44 shows sample collection locations and nitrate results for the March sampling event. Water quality field parameters of water temperature and specific conductance were measured prior to sample collection for nitrates in March; only temperature was measured in June (Table 56).

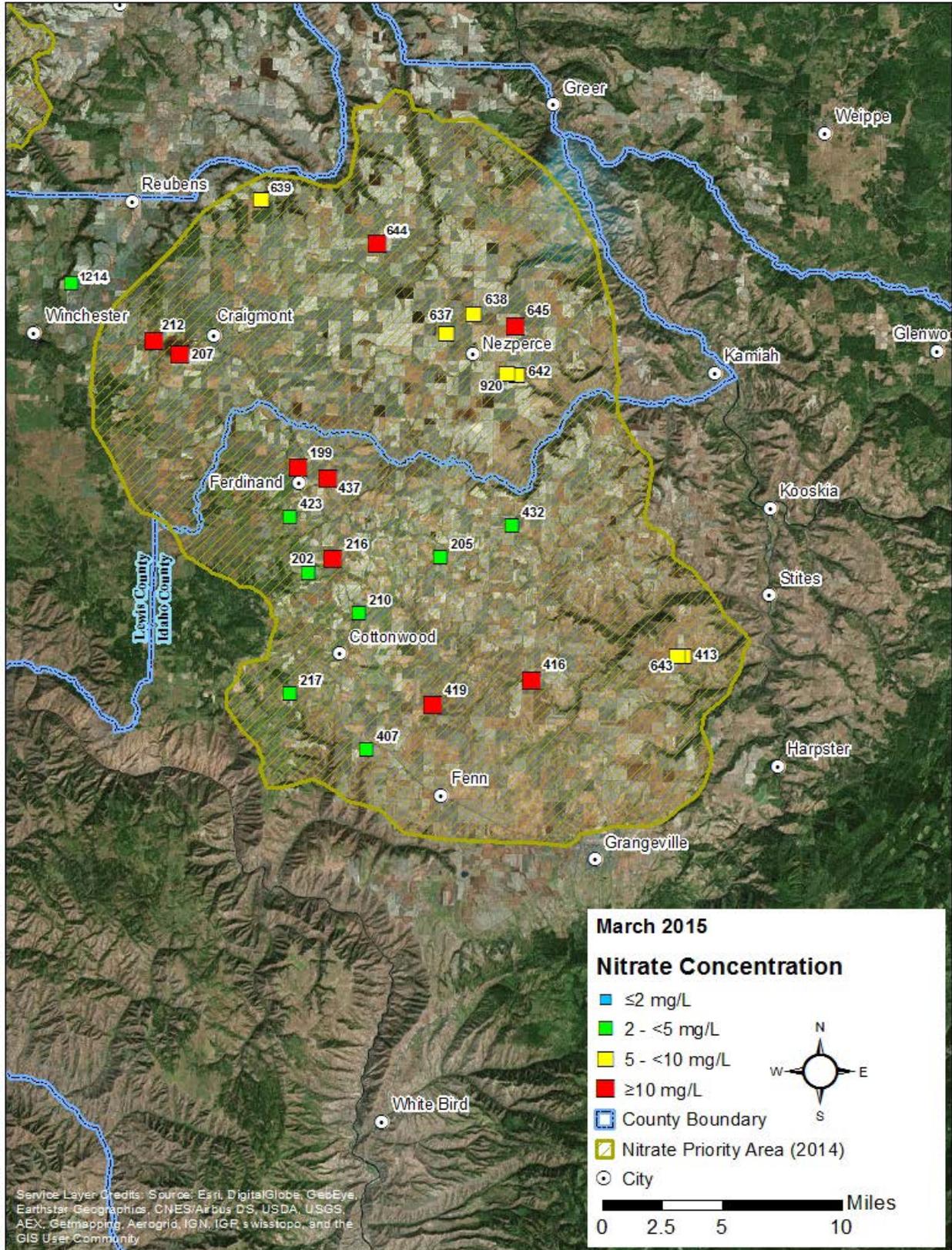


Figure 44. Sampling locations and nitrate concentrations—Clearwater Plateau NPA Ground Water Monitoring Project, March 2015.

Table 56. Water quality field parameter data—Clearwater Plateau NPA Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	March 2015		June 2015
		Spec. Cond. (µs/cm)	Water Temp. (°C)	Water Temp. (°C)
199	140	519	10.1	10.8
202	400	258	10.0	11.5
205	327	—	10.6	14.8 ^a
207	85	626	9.0	11.0
210	500	339	13.1	15.5
212	400	415	10.8	11.9
216	80	579	12.3	13.6
217	500	282	8.6	14.4
407	375	351	8.2	14.0
413	260	395	7.1	13.9
416	187	446	9.7	13.9
419	250	753	9.5	11.0
423	500	231	8.5	11.0
432	135	—	11.1	11.2
437	28	509	6.7	11.4
637	396	—	10.5	11.7
638	90	421	10.1	11.3
639	85	621	9.6	11.6
642	65	—	10.8	11.1
643	145	444	8.3	12.3
644	402	522	7.9	11.5
645	165	—	11.3	11.2
920	300	—	7.5	13.2
1214	Spring	—	9.0	NS

Notes: NS = not sampled; (—) = data not available

^a Well purging volume insufficient to achieve field parameter stabilization.

Nitrate Results

Overall, 9 of the 24 sampled sites reported nitrate concentrations in excess of the EPA MCL of 10 mg/L at least once during the 2015 sampling year (Table 57). For most sites, nitrate concentrations were higher in March than June. Samples collected in 2015 did not meet the temperature requirements for proper preservation and results should be used with caution. The highest reported nitrate concentration was 23.8 mg/L collected from site 419 during the June sampling event. Site 419 had the highest reported mean nitrate concentration for the 2015 sampling events (23.15 mg/L).

Table 57. Nitrate results—Clearwater Plateau NPA Ground Water Monitoring Project.

DEQ Site ID	Well Depth (Feet)	Nitrate Concentration (mg/L)		
		March 2015	June 2015 ^a	2015 Sampling Mean ^b
199	140	12.4	9.47	10.9
202	400	4.38	4.17	4.26
205	327	4.03	2.9 ^c	3.46
207	85	14.0	11.9	12.95
210	500	4.13	3.82	3.98
212	400	17.4	17.3	17.35
216	80	13.0	12.3	12.65
217	500	3.08	2.43	2.76
407	375	3.18	1.05	2.12
413	260	7.09	6.27	6.68
416	187	18.0	16.9	17.45
419	250	22.5	23.8	23.15
423	500	2.24	2.75	2.50
432	135	4.99	4.36	4.68
437	28	11.0	10.0	10.5
637	396	5.17	4.53	4.85
638	90	5.56	5.10	5.33
639	85	6.27	6.17	6.22
642	65	8.53	7.19	7.86
643	145	7.55	8.42	7.98
644	402	12.4	11.2	11.8
645	165	16.0	14.5	15.25
920	300	6.62	5.76	6.19
1214	Spring	3.27	NS	—
Mean		8.87	8.36	8.72

Notes: Bolded red numbers indicate EPA's National Primary Drinking Water Regulation (NPDWR) standard, expressed as a maximum contaminant level (MCL), was exceeded. The MCL for nitrate is 10 mg/L.

^a Sample did not meet temperature preservation requirements; data should be used with caution.

^b 2015 sampling mean was not calculated for sites that were sampled for less than 2 sampling events.

^c Well purging volume insufficient to achieve field parameter stabilization.

The distribution of reported nitrate concentrations for all nitrate samples in the project area for 2015 is shown in Figure 45.

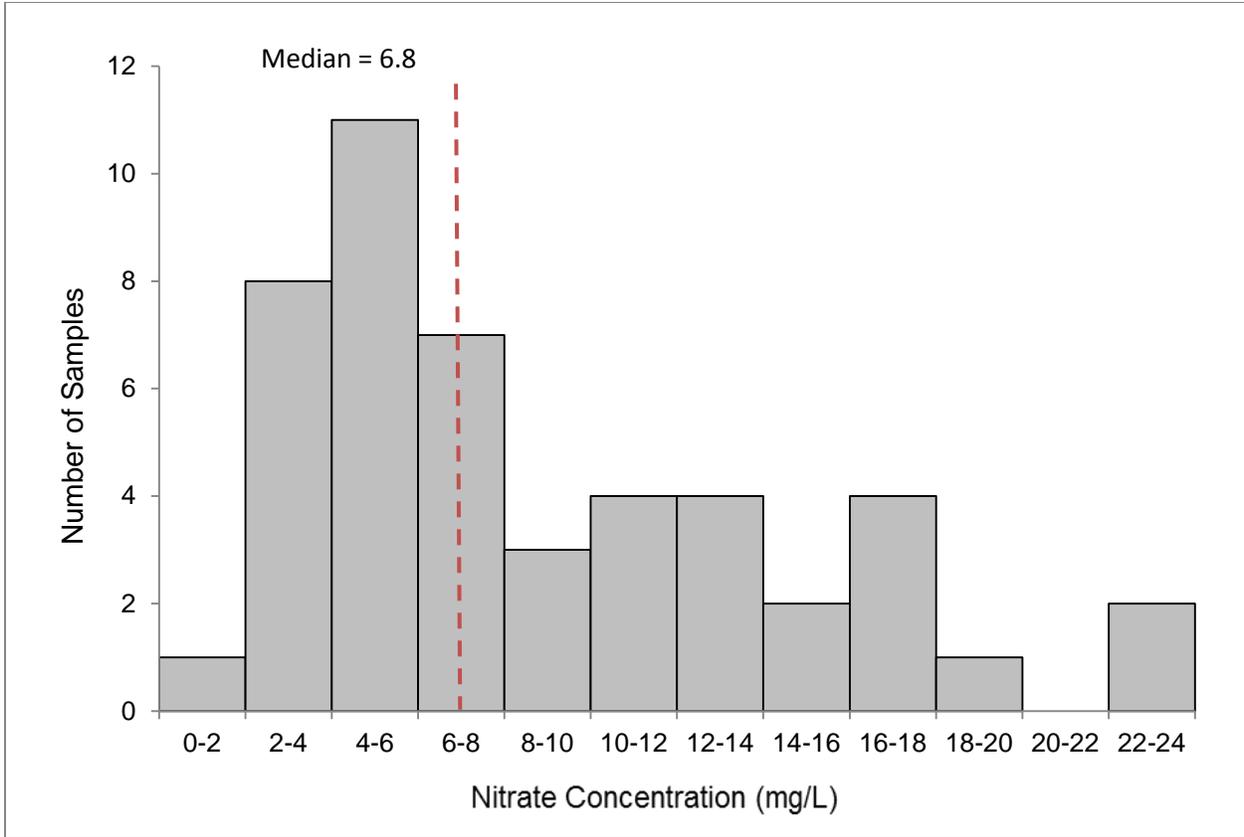


Figure 45. Histogram of nitrate concentrations for all nitrate samples (n = 47)—Clearwater Plateau NPA Ground Water Monitoring Project area. The median nitrate concentration value is below the MCL of 10 mg/L.

Seasonal fluctuations and trends in nitrate concentrations in Clearwater Plateau NPA wells were not evaluated as the samples were collected 90 days apart.

2.4.1.3 Conclusions

The objective of this long-term ground water monitoring is to determine the effectiveness of the GWQM plan in improving ground water quality. Sample results show that ground water in the Clearwater Plateau NPA contains elevated nitrate concentrations, with some locations exceeding the EPA MCL of 10 mg/L.

Nitrogen isotope analysis from previous years suggests that both inorganic and organic nitrogen contribute to the elevated concentrations (DEQ 2013a). Based on the large areal extent of degraded ground water, commercial fertilizer, livestock manure, and septic discharge are all potential sources of elevated nitrate concentrations detected within the project area.

2.4.1.4 Recommendations

Annual variability for individual wells makes it difficult to detect improvements in ground water quality in the project area as BMPs are implemented because concentration changes may be within the range of historic concentrations reported for individual wells. Therefore, this ongoing

project will attempt to identify nitrate trends within the network over multiple years to detect changes in ambient conditions.

Tracking changes in ambient nitrate concentrations relative to changes in land use or source controls could be accomplished by comparing changes in nitrate concentrations over multiple years. As of this report, nitrate data have been collected for 11 years. Completion of an initial analysis of BMP effectiveness by evaluating nitrate levels over time is recommended.

Ground water conditions may also be represented in spring water. Monitoring spring water when ground water provides the only source of water to a spring can also be used to determine ground water nitrogen loads to surface water. This information may be useful in determining if and where ground water nitrogen is contributing to surface water concentrations within the drainage basin. The information may also be useful in identifying areas to focus BMP implementation efforts. A report by Baldwin et al. (2008), which summarizes data collected for this project from 2005 through 2007, is a resource for additional information.

2.4.2 Lindsay Creek NPA Ground Water Monitoring Project

2.4.2.1 Purpose and Background

The Lindsay Creek NPA was designated in 2008 based on ground water quality data from the IDWR, ISDA, USGS, and DEQ. The NPA encompasses the Lindsay and Tammany Creek watersheds. The 2007 Lindsay Creek total maximum daily load (TMDL) determined that ground water base flow is a nitrogen contributor to Lindsay Creek and required a reduction in nitrogen loading (DEQ 2007).

The goal of the Lindsay Creek NPA Ground Water Monitoring Project (previously referred to as the Tammany and Lindsay Creeks Ground Water Monitoring Project) is to create an ambient ground water quality monitoring network to complete a multiple year trend analysis to detect nitrate changes in ground water in the Lindsay Creek NPA and also extend ground water quality monitoring to include the aquifer within the Tammany Creek watershed.

The project area is located east and southeast of Lewiston, Idaho. The land use is primarily agricultural, specifically dry-land farming. Rangeland and grazing are also common in the area. The area is underlain by the Tertiary Columbia River Basalts and consists of units that formed when lava flows filled in the pre-existing topography during the Miocene era (Stevens et al. 2003). A thin layer of loess forms the present-day land surface of a majority of the area. Ground water in the area is most commonly found in the basalt and occasionally in the alluvial valley sediments and basement rocks. Ground water generally flows to the north and eventually discharges into the Clearwater River (Hagan 2003). Well depths from ground water sampling locations ranged from 150 to 1,025 feet.

Limited ground water sampling has also shown elevated nitrate concentrations in the Tammany Creek area. Tammany Creek is located on the south side of the project area, and the watershed has similar spring-fed nutrient load characteristics as the Lindsay Creek watershed on the north side of Lewiston. The ground water in this watershed may also be a potential source of excess nutrients to Tammany Creek. Tammany Creek is currently impaired by nutrients and has an approved nutrient TMDL (DEQ 2010b).

DEQ has collected ground water quality data from 14 locations (wells and springs) as part of an ambient ground water quality monitoring network from 2010 through 2015. Nitrate concentrations from sampled wells and springs were analyzed to determine if seasonal or spatial trends exist in the monitoring network in addition to monitoring long-term regional changes. Anomalous nitrate concentrations were addressed as isolated or localized situations and dropped from the ambient network, if needed.

2.4.2.2 Methods and Results

A total of 13 locations (9 wells and 4 springs) were included in the 2015 sampling efforts for the Lindsay Creek NPA Ground Water Quality Monitoring Project. DEQ sampled 8 wells and 3 springs in March, and 9 wells and 3 springs in June (Table 58; Figure 46).

Water temperature was measured prior to sample collection for nitrate analysis (Table 58).

Table 58. Temperature data—Lindsay Creek NPA Ground Water Monitoring Project.

Site ID	Well Depth (feet)	Water Temp. (°C)	
		March 2015	June 2015
533	225	12.8	15.8
538	228	12.6	14.9
696	295	NS	15.2
1038	150	12.2	13.1
1171	Spring	11.1	18.4
1254	197	10.0	14.2
1255	200	13.9	16.9
1311	Spring	NS	16.9
1312	1025	15.9	18.9
1314	Spring	8.6	NS
1315	476	9.2	14.0
1317	Spring	11.5	13.9
2022	800	10.0	16.9

Notes: NS = not sampled.

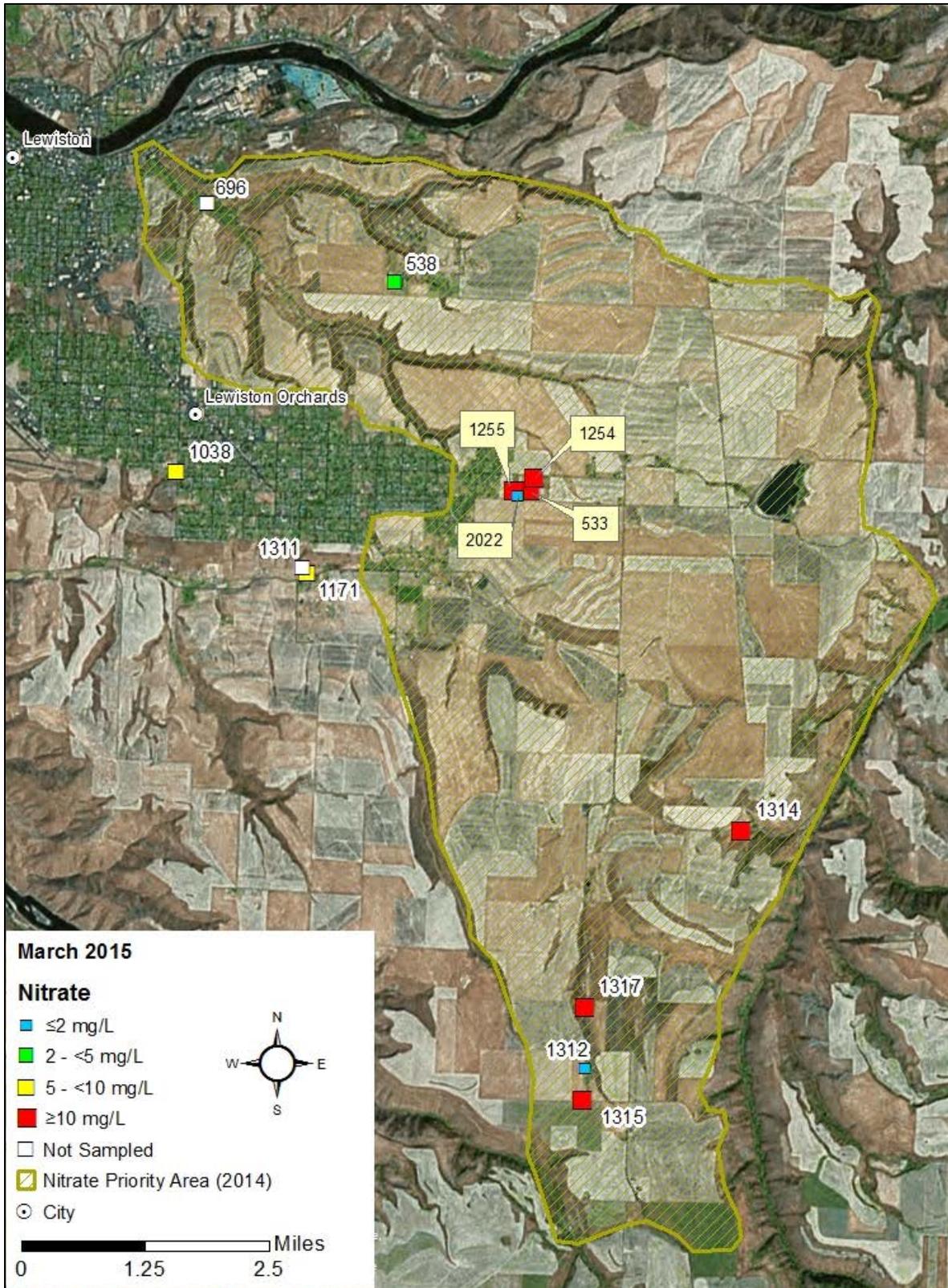


Figure 46. Sample locations and March nitrate concentrations—Lindsay Creek NPA Ground Water Monitoring Project.

Nitrate Results

Nitrate results are presented in Table 59. In the project area, 6 of the 13 sample sites had nitrate concentrations exceeding the MCL of 10 mg/L for at least one sample event. Samples collected in 2015 did not meet the temperature requirements for proper preservation and results should be used with caution. The highest nitrate concentration of 18.2 mg/L was reported for site 1254 during the March 2015 sampling event (Table 59; Figure 46). This site also had the highest mean value (17.4 mg/L) for 2015 samples. Two of the sampled locations had mean concentrations less than 5 mg/L for 2015. Means across the monitoring network ranged from <0.1 mg/L to 17.4 mg/L. Nitrate concentrations were generally highest in March.

Table 59. Nitrate results—Lindsay Creek NPA Ground Water Monitoring Project.

Site ID	Well Depth (Feet)	March 2015 ^a		June 2015 ^a		2015 Sampling Mean ^b
		Date Sampled	Nitrate Concentration (mg/L)	Date Sampled	Nitrate Concentration (mg/L)	
533	225	3/23/2015	11.5	6/3/2015	9.17	10.34
538	228	3/23/2015	4.7	6/3/2015	5.55	5.12
696	295	—	NS	6/3/2015	5.76	—
1038	150	3/23/2015	6.85	6/3/2015	7.17	7.01
1171	Spring	3/23/2015	7.67	6/3/2015	5.09	6.38
1254	197	3/23/2015	18.2	6/3/2015	16.6	17.4
1255	200	3/23/2015	14.1	6/3/2015	13.2	13.6
1311	Spring	—	NS	6/3/2015	8.75	—
1312	1025	3/23/2015	0.383	6/3/2015	0.338	0.36
1314	Spring	3/23/2015	15.4	—	NS	—
1315	476	3/23/2015	12.5	6/3/2015	13.5	13.0
1317	Spring	3/23/2015	14.9	6/3/2015	14.2	14.55
2022	800	3/23/2015	<0.1	6/3/2015	<0.1	<0.1
Mean			9.66		8.28	8.78

Notes: Bolded red numbers indicate EPA's National Primary Drinking Water Regulation (NPDWR) standard, expressed as a maximum contaminant level (MCL), was exceeded. The MCL for nitrate is 10 mg/L.

^a Sample did not meet temperature preservation requirements; data should be used with caution.

^b 2015 sampling mean was not calculated for sites that were sampled for less than 2 sampling events.

The distribution of all reported nitrate concentrations in the project area for 2015 is shown in Figure 47. Analysis was not performed to identify seasonal differences between the sampling events because data were collected 90 days apart.

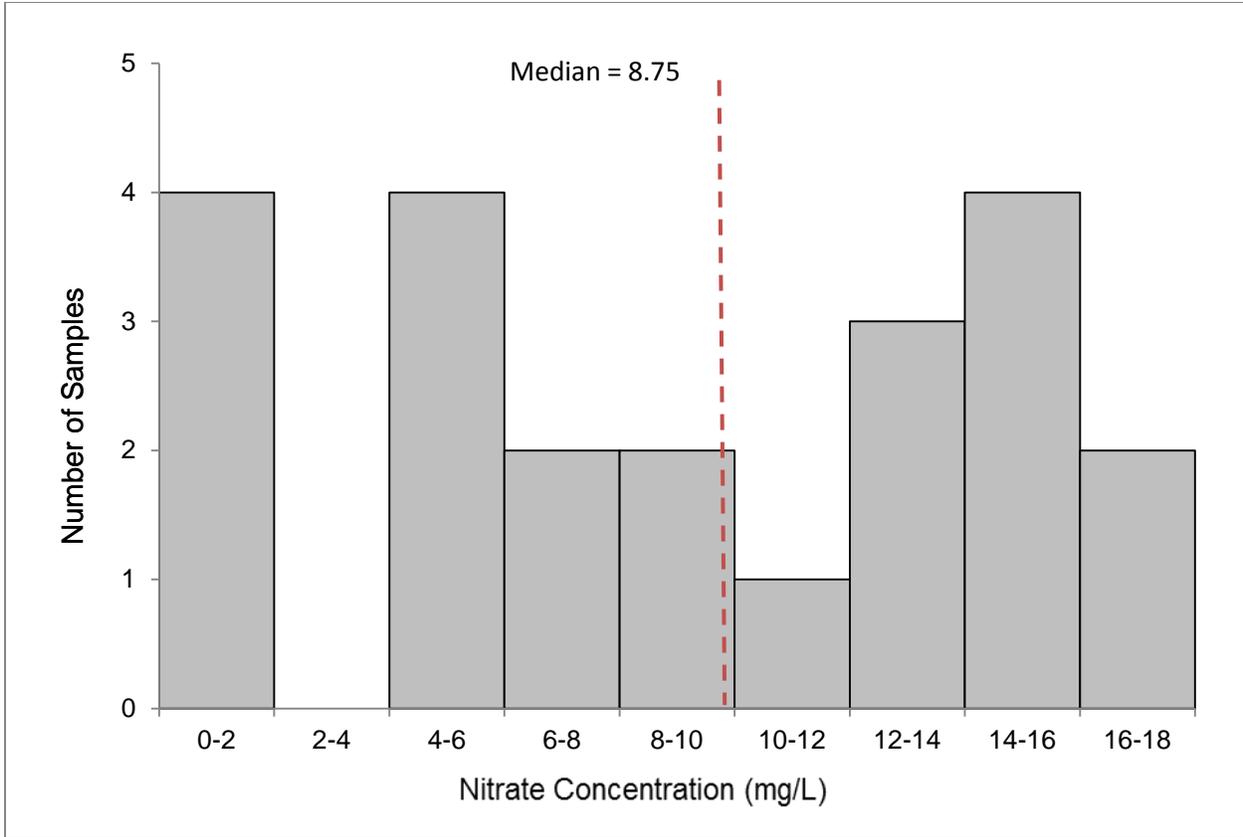


Figure 47. Histogram of nitrate concentrations of all nitrate samples (n = 23)—Lindsay Creek NPA Ground Water Quality Monitoring Project area, 2015. The median nitrate concentration value does not exceed the MCL of 10 mg/L.

2.4.2.3 Conclusions

The objective of this ongoing project is to use an ambient ground water quality monitoring network in the Lindsay Creek NPA to complete a multiple year trend analysis for nitrate. Results show that ground water in the Lindsay Creek NPA project area has elevated nitrate concentrations, with slightly less than half of sample locations exceeding EPA’s MCL of 10 mg/L during at least one 2015 sampling event. Wells available to include in an ambient network are limited, and springs shown to be representative of ground water conditions may continue to be added to the monitoring network to satisfy data needs.

Tracking trends in ambient nitrate ground water concentration due to changes in land uses or source controls will be accomplished by comparing trends over multiple years. This comparison will assist in determining nitrate concentration variability due to changes in cropping patterns and fertilizer application, variation in nitrogen uptake by crops due to growing season conditions, and variations in leaching rates related to the amount and timing of precipitation that is available to mobilize nitrogen below the crop root zone. Multiple year trend analysis of ambient nitrate concentrations has not yet been conducted because additional data and compilation are needed prior to conducting such analyses. Data and resources are anticipated to be available to complete the trend analysis phase of the project in the future.

2.4.2.4 Recommendations

Continued monitoring of available wells and springs is recommended to establish an ambient ground water quality data set to track multiple year trends, specifically for nitrate, in the project area. Outlier tests and common ion chemistry could be used to determine if samples are representative of ambient conditions and to monitor long-term trends in ground water quality, once sufficient data are collected. Wells yielding nitrate concentrations or other parameters inconsistent with the ambient conditions should be evaluated to determine if they represent the affected aquifer. Multiple year trend analysis should be completed to quantify long-term trends in nitrate concentration.

An NPA management plan may be a component of the Lindsay Creek TMDL implementation plan. The Nez Perce County Soil and Water Conservation District has proposed funding the plan through Clean Water Act §319 grant funds on two occasions. The NPA management plan and applications for funding should be continued to assist with ground water protection and nitrogen reduction efforts.

2.5 Pocatello Region

Three ground water quality monitoring projects were conducted in the Pocatello region in 2015 using public funds.

2.5.1 PRO Ambient Ground Water Quality Monitoring Project

2.5.1.1 Purpose and Background

In 1976, the USGS undertook a broad study of ground water quality in southeastern Idaho (Seitz and Norvitch 1979). The study sampled 103 wells in Bannock, Bear Lake, Caribou, and Power Counties (Figure 48) and described the general water quality conditions in the study area. This data set represents a valuable historical reference, against which current conditions can be compared.

The multiyear Pocatello Regional Office (PRO) Ambient Ground Water Quality Monitoring Project is designed to provide the data necessary for evaluating ambient ground water quality in portions of Bannock, Bear Lake, Caribou, and Power Counties. Ground water samples will be collected from the same wells previously examined by Seitz and Norvitch (1979), allowing for direct comparison with historical conditions. Data gathered through this project will help evaluate current ground water conditions, identify areas and possible sources of degraded ground water quality, and evaluate changes in water quality over time. Continuing the work started by Seitz and Norvitch, the data will also provide a reference for future sampling.

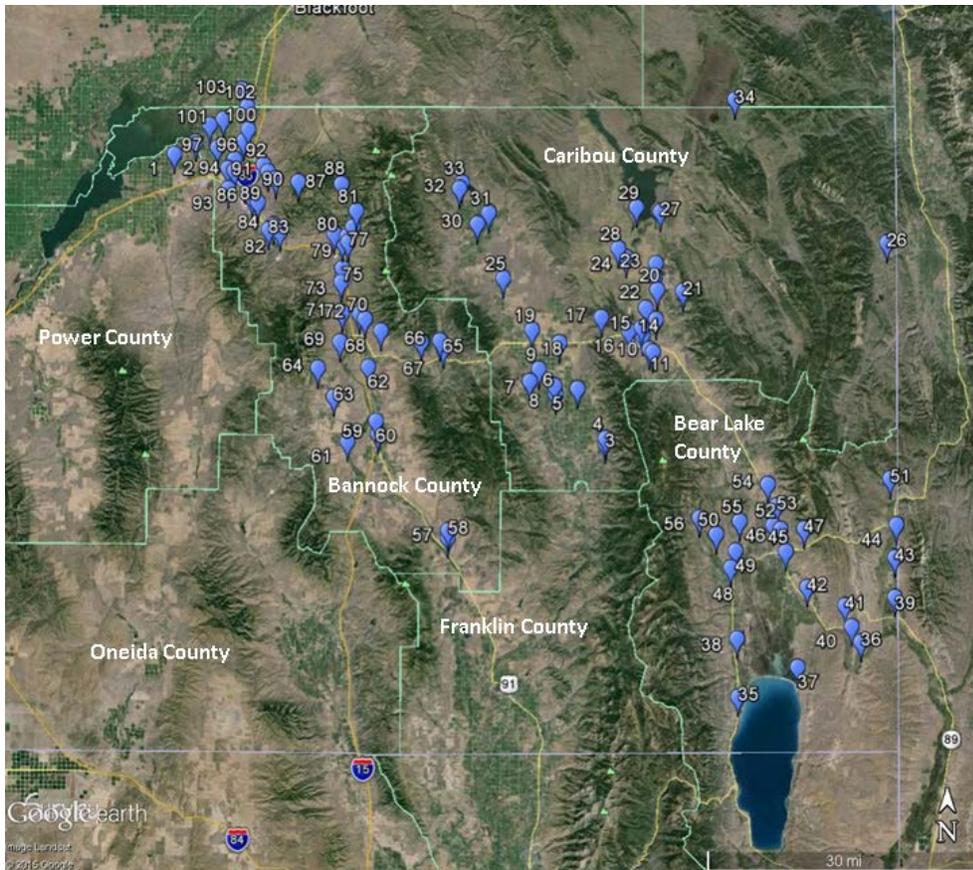


Figure 48. 2014 Google Earth map of approximate locations of 103 wells from Seitz and Norvitch (1979).

2.5.1.2 Methods and Results

Sample sites for the project are identified using information from Seitz and Norvitch (1979). To maintain consistency with that study, sampling is limited to July through September. Each year, a portion of the original wells are investigated for potential resampling with the entire inventory expected to be investigated over several years. In September 2015, nine wells were sampled in Caribou and Bear Lake Counties (Figure 49) in accordance with procedures outlined in the appropriate QAPP (DEQ 2011b) and FSP (DEQ 2014d).

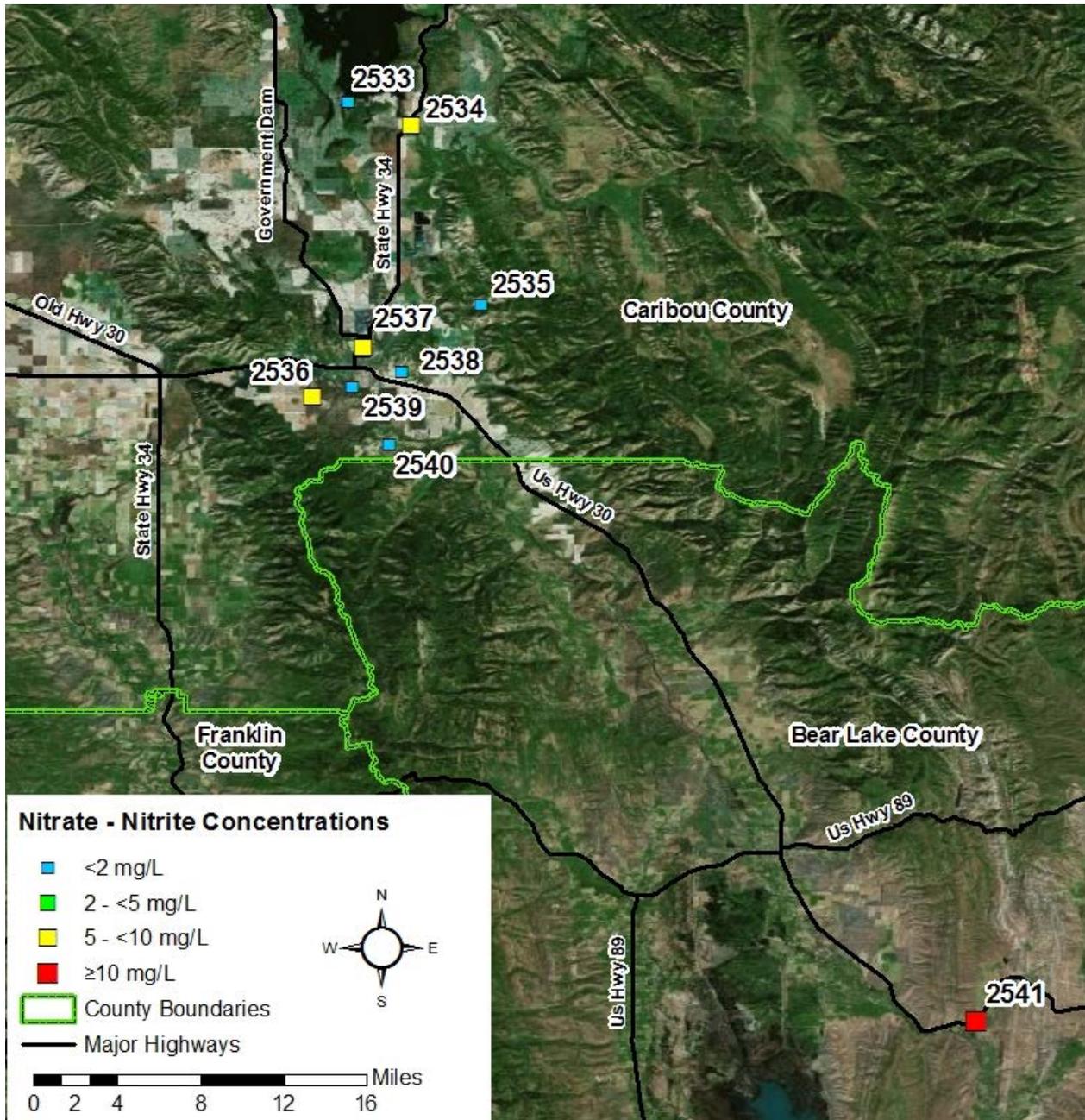


Figure 49. Well locations and nitrate concentrations for September 2015 sampling—PRO Ambient Regional Ground Water Monitoring Project.

Water quality field parameters, including temperature, specific conductivity, pH, and DO, were measured in the field prior to sampling to ensure the well was properly purged and the samples would be representative of aquifer conditions (Table 60). Samples were submitted to IBL for analysis. Water chemistry analyses included calcium, magnesium, sodium, potassium, chloride, sulfate, alkalinity, arsenic, fluoride, silica, nitrate plus nitrite, ammonia, and total phosphorus. Samples were also analyzed at IAS Envirochem in Pocatello for TC and *E. coli* bacteria. Stable isotopes of oxygen and hydrogen ($\delta^{18}\text{O}_{\text{H}_2\text{O}}$ and $\delta\text{D}_{\text{H}_2\text{O}}$) were measured at the University of Arizona Laboratory of Isotope Geochemistry, and samples with a detectable nitrate concentration

were submitted to the NAU CPSIL for quantification of $\delta^{15}\text{N}_{\text{nitrate}}$ and $\delta^{18}\text{O}_{\text{nitrate}}$. Results of the analyses for major ions are presented in Table 61, while additional inorganic constituents, nutrients, isotopes, and bacteria results are presented in Table 62.

Table 60. Water quality field parameters—PRO Ambient Regional Ground Water Monitoring Project.

DEQ Site ID	Project Well Name	Well Depth (feet)	Sample Date	Water Temperature (°C)	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	pH ^a
2533	074112	63	9/30/2015	13.18	591	2.24	7.12
2534	074209	111	9/30/2015	8.68	704	7.95	7.35
2535	084225	392	9/14/2015	10.96	649	6.46	7.20
2536	094113	138	9/30/2015	8.71	598	8.67	7.43
2537	094206	105	9/14/2015	11.75	1,570	3.80	7.00
2538	094209	219	9/14/2015	11.83	671	5.64	7.46
2539	094218	108	9/14/2015	9.24	836	7.01	7.43
2540	094232	104	9/14/2015	9.92	521	4.88	7.41
2541	144514	97	9/15/2015	10.93	789	6.55	7.45

^a Contaminant with a National Secondary Drinking Water Regulation standard. The NSDWR for pH is 6.5–8.5. NSDWR standards are recommended limits for public water systems but can be applied to private wells to evaluate water quality.

Table 61. Major ion results—PRO Ambient Regional Ground Water Monitoring Project.

DEQ Site ID	Project Well Name	Well Depth (feet)	Sample Date	Calcium	Magnesium	Sodium	Potassium	Chloride ^a	Sulfate ^a	Alkalinity (as CaCO ₃)
				(mg/L)						
Primary or Secondary Standard:				NA	NA	NA	NA	250	250	NA
2533	074112	63	9/30/2015	75	23	11	3.0	9.10	7.57	287
2534	074209	111	9/30/2015	74	26	27	2.4	35.6	23.2	263
2535	084225	392	9/14/2015	87	26	6.4	1.1	17.4	11.8	302
2536	094113	138	9/30/2015	69	24	14	2.5	12.3	24.8	250
2537	094206	105	9/14/2015	150	93	39	7.3	64.2	244	495
2538	094209	219	9/14/2015	78	20	18	5.9	43.2	27.8	227
2539	094218	108	9/14/2015	91	46	13	3.5	12.0	39.3	380
2540	094232	104	9/14/2015	66	21	8.6	2.3	11.4	8.79	241
2541	144514	97	9/15/2015	81	33	21	1.7	34.1	129	161

^a Contaminant with a National Secondary Drinking Water Regulation standard.

Table 62. Inorganic, nutrient, isotope, and bacteria results—PRO Ambient Regional Ground Water Monitoring Project.

DEQ Site ID	Project Well Name	Well Depth (feet)	Sample Date	Inorganic and Nutrient Concentrations						Isotopes				Bacteria	
				Arsenic ^a (µg/L)	Fluoride ^a	Silica as SiO ₂	Nitrate plus Nitrite ^a	Ammonia	Total Phosphorus	δ ¹⁵ N _{nitrate}	δ ¹⁸ O _{nitrate}	δD _{H2O}	δ ¹⁸ O _{H2O}	Total Coliform ^b	<i>E. coli</i> ^β
				(mg/L)						(‰)				(MPN/100 mL)	
Primary or Secondary Standard:				10	4	NA	10	NA	NA	NA				1 cfu/100 mL	<1 cfu/100 mL
2533	074112	63	9/30/2015	<2.0	0.304	26	<0.010	0.030	0.14	—	—	-107.6	-13.3	<1	<1
2534	074209	111	9/30/2015	<2.0	0.290	28	5.2	<0.010	0.10	5.04	-4.25	-125.3	-17.0	<1	<1
2535	084225	392	9/14/2015	<2.0	<0.20	16	1.6	<0.010	0.016	6.29	-6.01	-132.5	-18.3	<1	<1
2536	094113	138	9/30/2015	<2.0	<0.20	24	5.2	<0.010	0.066	3.46	-3.08	-121.7	-16.7	<1	<1
2537	094206	105	9/14/2015	<2.0	<0.20	34	6.8	<0.010	0.14	9.36	-6.28	-128.7	-17.4	<1	<1
2538	094209	219	9/14/2015	7.8	0.673	45	1.8	<0.010	0.042	6.25	-6.36	-133.6	-18.3	<1	<1
2539	094218	108	9/14/2015	<2.0	0.231	28	1.6	<0.010	0.038	6.17	-6.00	-131.1	-17.9	<1	<1
2540	094232	104	9/14/2015	<2.0	<0.20	26	0.69	<0.010	0.062 ^c	8.84	-2.87 ^c	-125.1	-17.4	<1	<1
2541	144514	97	9/15/2015	2.0	<0.20	25	11	<0.010	0.032	10.25	0.47	-138.2	-18.5	<1	<1

Notes: Bolded red numbers indicate EPA's National Primary Drinking Water Regulation (NPDWR) standard, expressed as a maximum contaminant level (MCL), was exceeded. These regulations are applicable for public water systems only but are recommended limits and can be applied to private wells to evaluate water quality.

^a Contaminant with a National Primary Drinking Water Regulation standard.

^b Total coliform is not a health threat in itself; it is used to indicate whether other potentially harmful bacteria may be present.

^c Duplicate sample pair did not meet QA/QC precision goals.

General Ground Water Chemistry

Primary or secondary drinking water standards were exceeded at only one site. The nitrate concentration at Well 2541 exceeded the 10 mg/L primary drinking water standard (Table 62). At 11 mg/L, the concentration at this location was significantly higher than the 1.5 mg/L recorded in 1976. Arsenic was detected at two sites, Well 2538 and Well 2541, with values of 7.8 and 2.0 µg/L, respectively. These values were below the primary standard for arsenic of 10 µg/L. No bacteria were detected at the sampled locations. Fluoride concentrations were all below the 4 mg/L drinking water standard, with the maximum value of 0.673 mg/L recorded at Well 2538.

Figure 50 illustrates the general major ion chemistry of the samples. The Piper diagram (trilinear plot) shows that calcium and bicarbonate are the predominant ions in most of the sampled wells, while in Well 2537 calcium and magnesium are present in nearly equal proportions. Two sites—Well 2537 and Well 2541—exhibit significant sulfate concentrations.

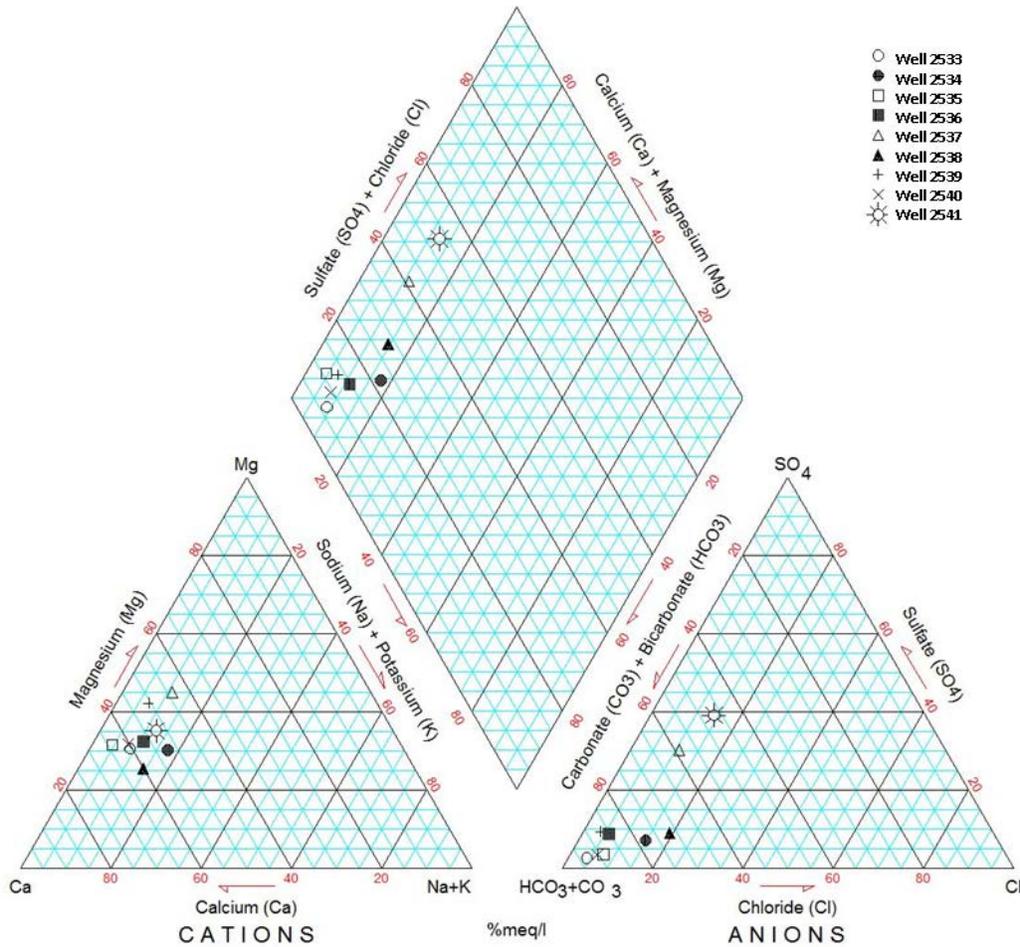


Figure 50. Piper diagram—PRO Ambient Regional Ground Water Monitoring Project.

The Stiff diagrams (Figure 51) also allow a graphical comparison of the major ion chemistry of each sample. Both the Piper and Stiff diagrams show that the ground water samples at Wells

2537 and 2541 were most dissimilar from the remainder of the samples. For example, these two sites exhibit significant sulfate concentrations. Well 2537, which is no longer used as a domestic source, is located near an area of known ground water contamination from industrial land uses, and its chemistry may be reflective of that contamination. The dissimilarity observed at Well 2541 is likely a result of the comparative geographical isolation of the site and the likely influence of animal or human wastes, which are also responsible for the highest nitrate concentration among the sampled sites.

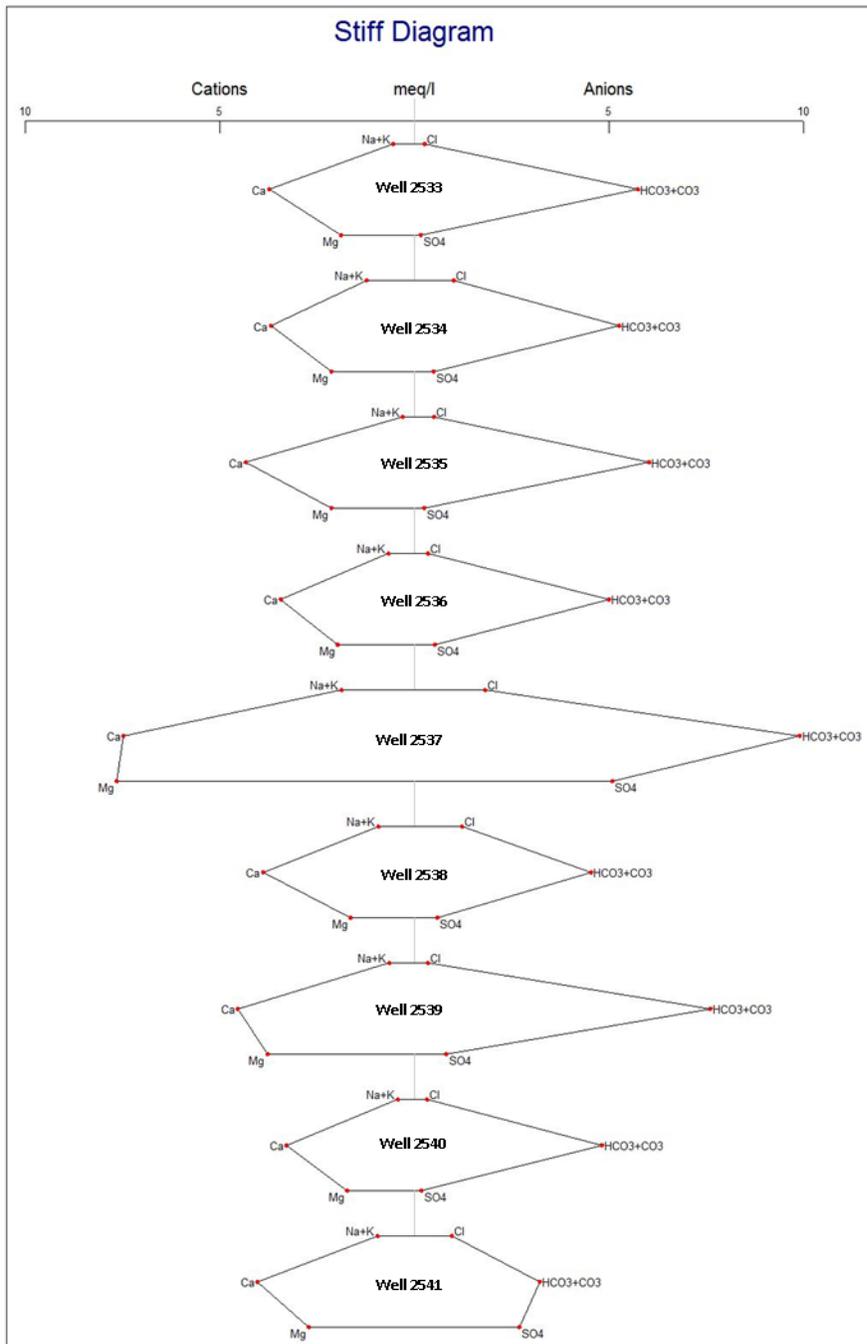


Figure 51. Stiff diagrams—PRO Ambient Regional Ground Water Monitoring Project.

With the exception of chloride and sulfate, most of the major ionic constituents exhibited only minor variations between the 1976 and 2015 samples. In the 2015 samples, chloride ranged from 9.10 to 64.2 with a median value of 17.4 mg/L. In 1976, these wells had chloride concentrations ranging from 4.8 to 63 with a median value of 8.8 mg/L. Chloride concentrations increased in 7 of the 9 wells (2533, 2534, 2535, 2537, 2538, 2540, and 2541). The 2 wells with the greatest increases in chloride concentration were Wells 2534 and 2541, increasing from 5.3 mg/L to 35.6 mg/L and 4.8 mg/L to 34.1 mg/L, respectively (Table 63). The 2015 sulfate concentration was higher than the 1976 concentration for 4 of the 9 wells (Table 63). The 2 wells with the greatest increases in sulfate concentration were Wells 2534 and 2537, with the concentrations increasing from 8.8 mg/L to 23.2 mg/L and 150 mg/L to 244 mg/L, respectively (Table 63). Welhan and Poulson (2009) have related elevated sulfate and chloride concentrations to various contaminant sources including septic discharge, feedlot runoff, inorganic fertilizers, and evaporation from shallow ground water.

Table 63. 1976 and 2015 comparison of chloride, sulfate, and nitrate+nitrite—PRO Ambient Regional Ground Water Monitoring Project.

DEQ Site ID	Project Well Name	1976	2015	1976	2015	1976 Nitrate	2015
		Chloride ^a	Chloride ^a	Sulfate ^a	Sulfate ^a	+ Nitrite ^b	Nitrate + Nitrite ^b
		(mg/L)					
<i>Primary or Secondary Standard:</i>		<i>250</i>		<i>250</i>		<i>10</i>	
2533	074112	6.2	9.1	14	7.57	0.04	<0.010
2534	074209	5.3	35.6	8.8	23.2	0.82	5.2
2535	084225	6	17.4	16	11.8	0.21	1.6
2536	094113	26	12.3	26	24.8	4.1	5.2
2537	094206	63	64.2	150	244	6.8	6.8
2538	094209	21	43.2	27	27.8	0.53	1.8
2539	094218	12	12	49	39.3	1.1	1.6
2540	094232	8.8	11.4	11	8.79	0.92	0.69 ^c
2541	144514	4.8	34.1	120	129	1.5	11

Notes: Bolded red numbers indicate EPA's National Primary Drinking Water Regulation (NPDWR) standard, expressed as a maximum contaminant level (MCL), was exceeded. These regulations are applicable for public water systems only but are recommended limits and can be applied to private wells to evaluate water quality.

^a Contaminant with a National Secondary Drinking Water Regulation standard.

^b Contaminant with a National Primary Drinking Water Regulation standard.

^c Duplicate sample pair did not meet QA/QC precision goals.

Nitrate and Total Phosphorous Results

Nitrate concentrations in the sampled wells ranged from <0.010 mg/L (Well 2533) to 11 mg/L (Well 2541). Four wells had concentrations of 5.0 mg/L or greater, and two-thirds of the sampled wells showed an increase in nitrate concentration from the 1976 result. Nitrate concentration increases were greatest at Well 2534 and Well 2541. The nitrate concentration in Well 2534 increased from 0.82 mg/L to 5.2 mg/L, which is above half the MCL. The nitrate concentration in Well 2541 increased from 1.5 mg/L to 11 mg/L, which is above the MCL. Total phosphorus concentrations ranged from 0.016 to 0.14 mg/L. Although the increases were small, all of the sampled wells exhibited increases in total phosphorus concentrations from the 1976 results.

Bacteria Results

All nine wells were sampled for TC and *E. coli*. None of the samples had a positive detection of either.

Fluoride Results

Fluoride concentrations were all well below the MCL of 4 mg/L; the results ranged from <0.20 mg/L to 0.673 mg/L (Table 62).

Isotope Results

$\delta^{15}\text{N}$ and $\delta^{18}\text{O}$ values were obtained for the eight samples with sufficient nitrate concentrations. Five of the samples had $\delta^{15}\text{N}$ values between 4 and 9‰. Typical $\delta^{15}\text{N}$ values for common nitrates sources are listed in Table 3. The apparent source of nitrate in those five samples is either organic nitrogen in the soil or a mixture of fertilizers and waste. Well 2536 had a $\delta^{15}\text{N}$ value of 3.46‰, suggesting impacts from commercial fertilizer. Using Seiler's classification, the $\delta^{15}\text{N}$ values observed at Well 2537 and Well 2541, 9.36 and 10.25‰ respectively, are suggestive of contamination by animal or human waste. Elevated chloride and sulfate concentrations and the location of Well 2541 near a corral support the waste source hypothesis. However, the location of Well 2537 in an area of known industrial ground water contamination suggests that the isotopic signature of that sample could be a result of denitrification of an inorganic nitrate source, as described by Kendall et al. (2007).

2.5.1.3 Conclusions

The objectives of this project are to characterize current ground water conditions, identify areas and possible sources of degraded ground water quality, and evaluate changes in ground water quality over time. The data also provide a reference for future sampling. The data set presented here is the second year of a multiyear effort to resample the regional monitoring network established by Seitz and Norvitch (1979). As such, a broader and more complete analysis will be reserved until data collection is complete.

The data set compiled from the 2015 sampling suggests the following:

- Chloride and sulfate ion concentrations show the greatest change from the 1976 sampling event.
- Primary drinking water standards were exceeded at one site, Well 2541, for nitrate (11 mg/L).
- Calcium and bicarbonate are dominant cations and anions in most of the wells sampled. Sulfate is a significant anionic component in two wells.
- Nitrate concentrations increased in two-thirds of the samples from 1976 concentrations.
- Isotopic ratios suggest that the source of nitrate in most of the sampled wells is organic nitrogen in the soil or a mixture of fertilizers and waste. One well had an isotopic signature suggestive of chemical fertilizers, while two others had signatures of animal or human waste. However, denitrification may have altered the isotopic composition of some samples, making the determination of nitrate source uncertain.

2.5.1.4 Recommendations

- The multiyear data collection effort should be continued to allow project goals to be achieved.
- Homeowners are encouraged to regularly test their wells for known contaminants and to maintain septic systems and well heads.

2.5.2 Bannock County Volatile Organic Compound Reconnaissance

2.5.2.1 Purpose and Background

The Fort Hall Mine Landfill is a large, municipal solid waste disposal facility located southeast and hydrologically upgradient of Pocatello, Idaho (Figure 52). The landfill is owned and operated by Bannock County. The site currently includes three separate cells: Cell 1 (closed in 1993, unlined); Cell 2 (currently operating, lined); and Cell 4 (the expansion cell currently being prepared for operation in 2016). Private residential property is located immediately north of the landfill property boundary.

Cell 1 initially operated as an informal dump in the north-trending Fort Hall Mine Canyon, and operations were later formalized and managed under several owners. By the time it closed in 1993, Cell 1 covered approximately 60 acres and had accepted many 55-gallon drums and tanker truckloads of liquid waste (Maxim 2000). This liquid waste apparently included significant quantities of chlorinated solvents such as trichloroethene (TCE) and tetrachloroethene (PCE).

Ground water in the immediate area of the landfill moves primarily through the alluvial deposits of Fort Hall Mine Canyon and the underlying tuffaceous Starlight Formation (Maxim 2000). This water moves generally north until reaching the Portneuf Valley and its underlying aquifer. Ground water movement in the Lower Portneuf River Valley Aquifer is characterized by high-velocity flow through the highly permeable Michaud Gravels that were deposited approximately 14,000 years ago by the Lake Bonneville flood. This water moves to the northwest beneath the City of Pocatello (Figure 52) (Maxim 2000).

In October 1991, ground water samples from monitoring wells near the landfill were found to be contaminated with TCE, PCE, and other VOCs originating from Cell 1 (Maxim 2000). Shortly thereafter, high concentrations of TCE were observed in downgradient wells in the Portneuf Valley and several municipal wells were closed. Those high concentrations of TCE, and to a lesser degree PCE, continued throughout the 1990s indicating that a significant mass of contaminants moved downgradient from the landfill and through the Portneuf Valley.

By September 2000, contaminant concentrations of TCE in downgradient municipal wells had fallen below the National Primary Drinking Water Regulation standard of 5 µg/L. The county installed a ground water pump-and-treat remediation system on the landfill site in August 2002 to help remove VOCs from the ground water.

In March 2015, DEQ completed a review of Bannock County's ground water monitoring and remediation program at Cell 1. The review noted the following issues:

- Monitoring wells at the landfill are exhibiting upward trends in concentrations of the contaminants of concern (TCE, PCE, and the breakdown product vinyl chloride), both upgradient and downgradient of the remediation system (CES 2016a).

- TCE concentrations at the northern boundary of the landfill property have increased by a factor of 5 since completion of the remedial investigation, and ground water leaving the site in January 2016 had a TCE concentration of 262 µg/L, over 50 times the drinking water standard of 5 µg/L (CES 2016a).
- The pump-and-treat remediation system is pumping only a small fraction of the water that it was designed to treat and has largely been ineffective at removing contamination from the environment (CES 2015).
- The nature and extent of the contamination is insufficiently characterized, and the conceptual site model, upon which the remediation system was designed, does not appear to accurately represent the site (Maxim 2000).

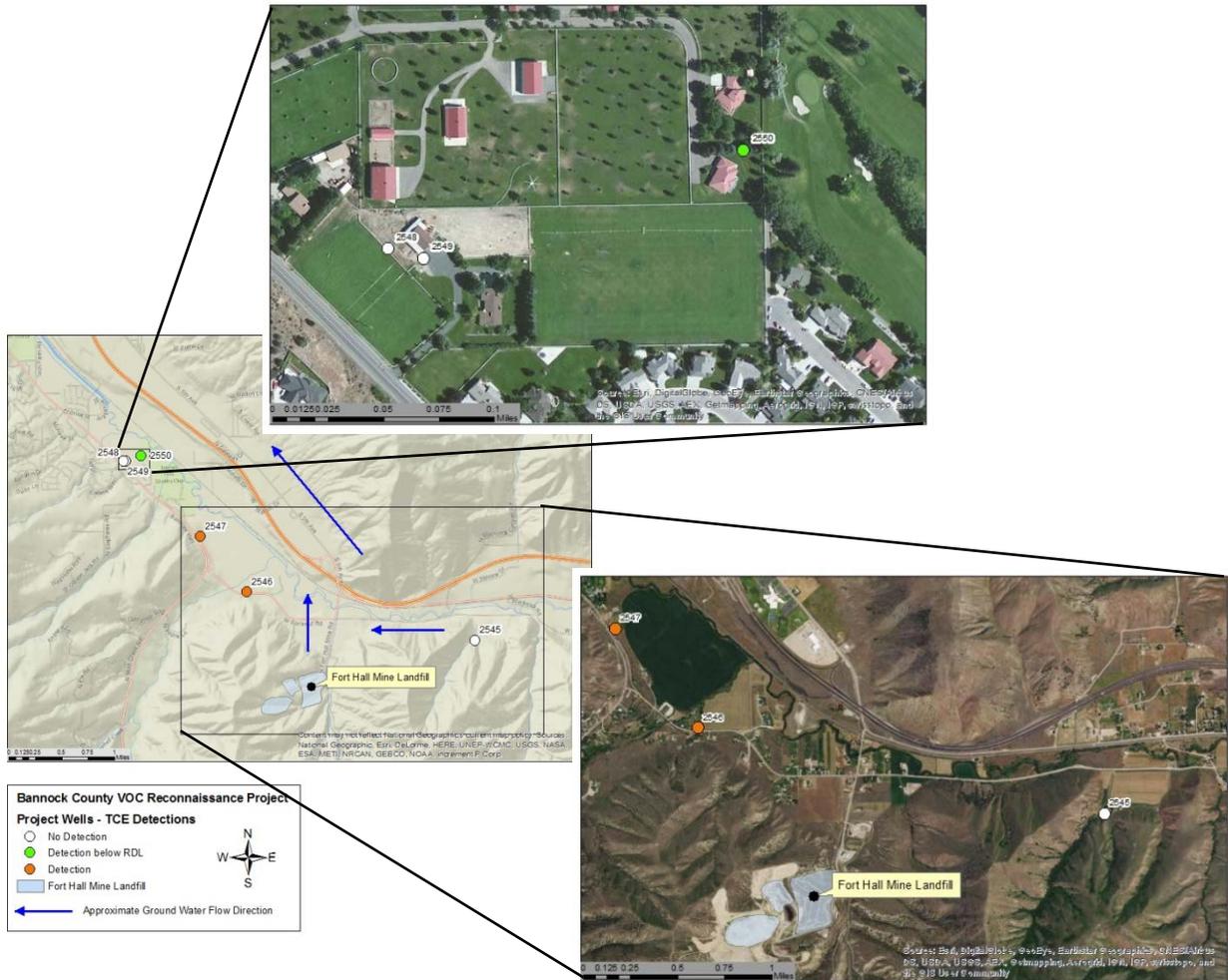


Figure 52. TCE detections in project wells—Bannock County Volatile Organic Compound Reconnaissance Project.

Upon completion of the review, DEQ requested that the county begin the site characterization process to establish a valid conceptual site model. As part of that process, DEQ requested that the county inventory all residential properties to the north and west of the landfill and determine well locations and the drinking water source for each residence (e.g., municipal or private well).

Ground water monitoring conducted by the county is currently limited to the immediate area of the landfill property, and no recent ground water data exist for the residential area. With the intention of collecting interim information until a more complete characterization could be conducted by the county, DEQ conducted a limited reconnaissance of the offsite residential area downgradient from the landfill. The purpose of the May 2015 study was to gather current VOC data from six wells in the area (five downgradient and one upgradient of the landfill) and, where possible, compare them to historical data (from IDWR) from the same locations.

2.5.2.2 Methods and Results

Several wells in the area had been sampled previously as part of the Statewide Ground Water Quality Monitoring Program and were located in the area of interest (IDWR 2016). Three of the six project wells (2546, 2547, and 2548) are located along the known path of contaminant migration downgradient from the landfill (Figure 52) and all had historical detections of the contaminants of concern. Well 2545 is located upgradient of the landfill and had no previous detections of the contaminants present at the site. Well 2549 was selected because it is a deep irrigation well located immediately adjacent to the shallower Well 2548, allowing for a comparison of water quality at various depths. Similarly, the position of Well 2550 in relation to the paired shallow-deep wells (2548 and 2549) allows for the evaluation of lateral differences across the ground water flow path. No previous VOC sampling had occurred at either Well 2549 or Well 2550. The downgradient wells are also located approximately 700 feet north of a closed municipal well that exhibited high contaminant concentrations during the 1990s.

With the exception of Well 2549, the wells were sampled on May 27 or 28, 2015. Because of a pipe rupture that occurred immediately before scheduled sampling, sampling at Well 2549 was postponed until July 28, 2015, after repairs could be made. All wells were sampled in accordance with procedures outlined in the QAPP (DEQ 2011b).

Water quality field parameters—including temperature, specific conductivity, pH, and DO—were measured in the field prior to sampling to ensure that the well had been properly purged and the samples would be representative of aquifer conditions (Table 64). Samples were collected for laboratory analysis at IBL in Boise. Water chemistry analyses were conducted for 82 VOCs, including those previously detected at the landfill. The complete list of analytes and the reporting detection limits (RDLs) for each are included in Appendix B.

Table 64. Water quality field parameters—Bannock County Volatile Organic Compound Reconnaissance Project.

DEQ Site ID	Project Well Names	Well Depth (feet)	Sample Date	Water Temperature (°C)	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	pH ^a
2545	408187	165	5/27/2015	13.01	702	4.11	7.42
2546	368575	90	5/27/2015	11.70	783	6.52	7.25
2547	361603	102	5/28/2015	11.60	847	7.43	7.45
2548	322335	100	5/27/2015	12.95	480	3.23	7.42
2549	342180	315	7/28/2015	14.48	474	—	7.69
2550	423081	115	5/27/2015	11.80	727	6.10	7.22

Note: (—) = field conditions prevented collection of this information.

^a Contaminant with a National Secondary Drinking Water Regulation standard.

Table 65 includes the three primary organic contaminants observed in monitoring wells at Cell 1: TCE, PCE, and vinyl chloride. Because anaerobic decay of PCE and TCE may produce other VOCs, Table 65 includes all those associated breakdown products depicted in Figure 53.

The only VOCs detected were TCE and PCE. They were only detected in three of the six wells (2546, 2547, and 2550). Consistent with landfill monitoring well data, TCE concentrations were higher than those of PCE (CES 2016a). Concentrations were highest at Well 2547 and Well 2546, with TCE concentrations of 3.7 and 2.3 µg/L, respectively. Detections of TCE at Well 2550 and PCE at Well 2546 were greater than the laboratory method detection limit but below the RDL and are estimated values. No primary or secondary drinking water standards were exceeded for any sampled constituent at any of the six project wells.

Figure 54 is a time-series graph of three of the wells that have had historical detections of TCE (IDWR 2016). TCE concentrations at Wells 2547 and 2546 were similar to the last available sampling data; however, the concentration in Well 2546 appears to be increasing over the last two data points. The TCE concentration at Well 2548 was lower than all previous samples for this well. The detection (a lab estimated value) at Well 2550, which had not been previously sampled, is not included in the graph but does indicate the continuing presence of contaminants at the downgradient margin of this reconnaissance.

Table 65. Selected organic compound results—Bannock County Volatile Organic Compounds Reconnaissance Project.

DEQ Site ID	Project Well Name	Well Depth (feet)	Sample Date	Trichloro-ethene ^a	Tetrachloro-ethene ^a	Vinyl Chloride ^a	cis-1,2-Dichloro-ethene ^a	1,1-Dichloro-ethene ^a	trans-1,2-Dichloro-ethene ^a
				(µg/L)					
<i>Primary or Secondary Standard:</i>				5	5	2	70	7	100
2545	408187	165	5/27/2015	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
2546	368575	90	5/27/2015	2.3	0.33J	<0.50	<0.50	<0.50	<0.50
2547	361603	102	5/28/2015	3.7	0.54	<0.50	<0.50	<0.50	<0.50
2548	322335	100	5/27/2015	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
2549	342180	315	7/28/2015	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
2550	423081	115	5/27/2015	0.43J	<0.50	<0.50	<0.50	<0.50	<0.50

Notes: J = result is above the method detection limit but below the reporting detection limit and is an estimated value

^a Contaminant with a National Primary Drinking Water Regulation standard.

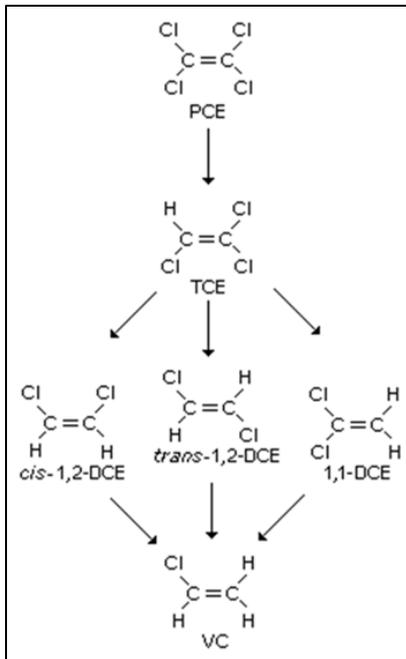


Figure 53. Pathway for anaerobic microbial degradation of chlorinated ethenes to form vinyl chloride (VC) (from WHO 1999).

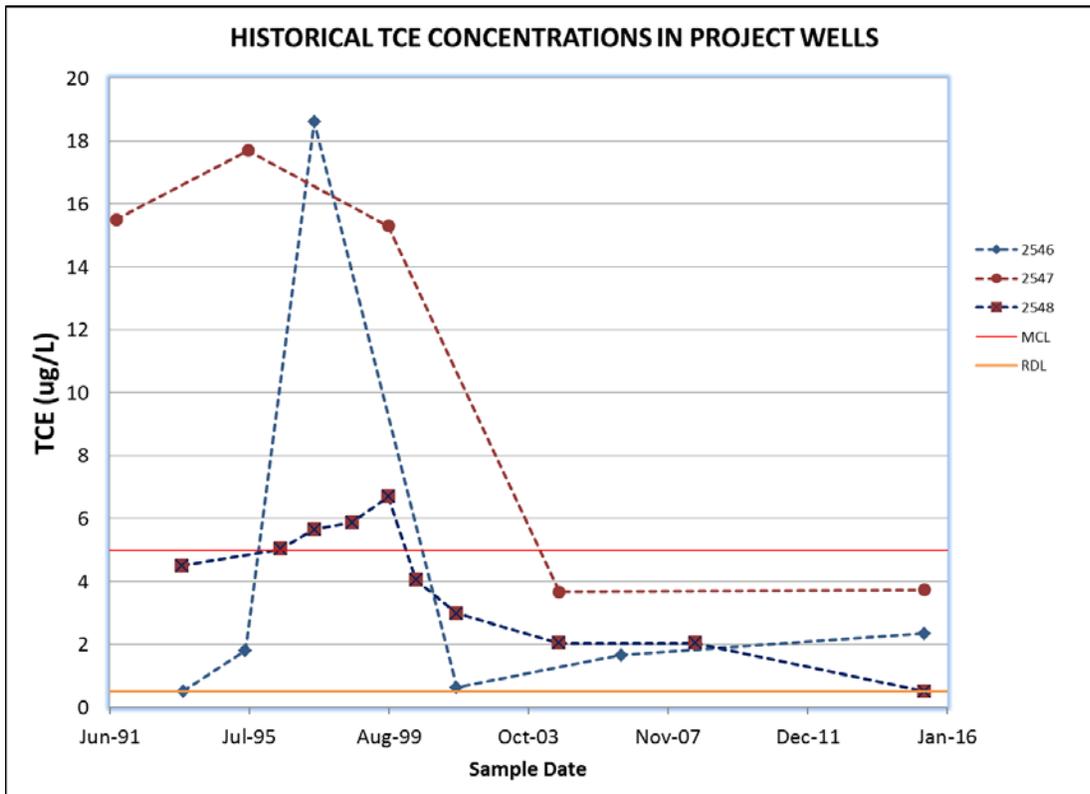


Figure 54. Time-series graph of TCE concentrations in selected project wells (data prior to 2015 from IDWR 2016). Wells 2545, 2549, and 2550 are not shown.

2.5.2.3 Conclusions

The objectives of this project were to gather current VOC data from six wells near the Fort Hall Mine Landfill and, where possible, compare them to historical data from the same locations.

The data set compiled from this reconnaissance can be summarized as follows:

- Contaminants originating at Cell 1 (TCE and PCE) were observed in three of five downgradient wells.
- TCE, the primary contaminant of concern, was observed at the far end of the reconnaissance area in Well 2550.
- Vinyl chloride and other breakdown products of chlorinated ethenes were not detected in any of the six project wells.
- All contaminant concentrations were below drinking water standards.
- The available data are insufficient to determine a trend in contaminant concentrations at the project wells or in the residential area downgradient of the landfill.

2.5.2.4 Recommendations

DEQ has requested that Bannock County undertake the following tasks:

- Perform extensive and continuing sampling of the offsite residential area downgradient from the landfill and advise affected parties of the findings of the data collection efforts.
- Conduct a new site characterization of the landfill area to redevelop a valid conceptual site model.
- Re-evaluate the effectiveness of the existing remediation systems.
- Use the newly developed conceptual site model to develop cleanup goals.
- Evaluate potential remediation techniques and implement the selected methods.
- Redesign the ground water monitoring system.
- Continually re-evaluate the implemented remedy and make appropriate changes, as needed, to meet the cleanup goals.

2.5.3 Dayton Landfill Springs Monitoring Project

2.5.3.1 Purpose and Background

The Dayton Landfill is a closed municipal solid waste facility located in southwest Franklin County approximately 4 miles west of Preston, Idaho, and 2 miles east of Dayton, Idaho (Figure 55). The landfill covers approximately 21.6 acres and is situated immediately west of Fivemile Creek, a tributary of the Bear River. The maximum thickness of landfill material is 110 feet at the toe of the steep, eastern slope, while the average thickness is 70 feet (Player 2003). The top of the landfill is approximately level with the surrounding terrain and is sloped slightly to the southeast. Relief, from the eastern edge of the filled area to the bottom of the steep ravine to the east, is approximately 150 feet. The landfill waste fills a former east-west gully that was a tributary of Fivemile Creek, similar to the one lying just south of the site. Private property surrounds the landfill and includes the steep ravines to the east and southeast (Figure 55). Land use on the surrounding property includes farming and grazing. The closest residences lie approximate 350 feet northwest and 1,200 feet south of the landfill site.

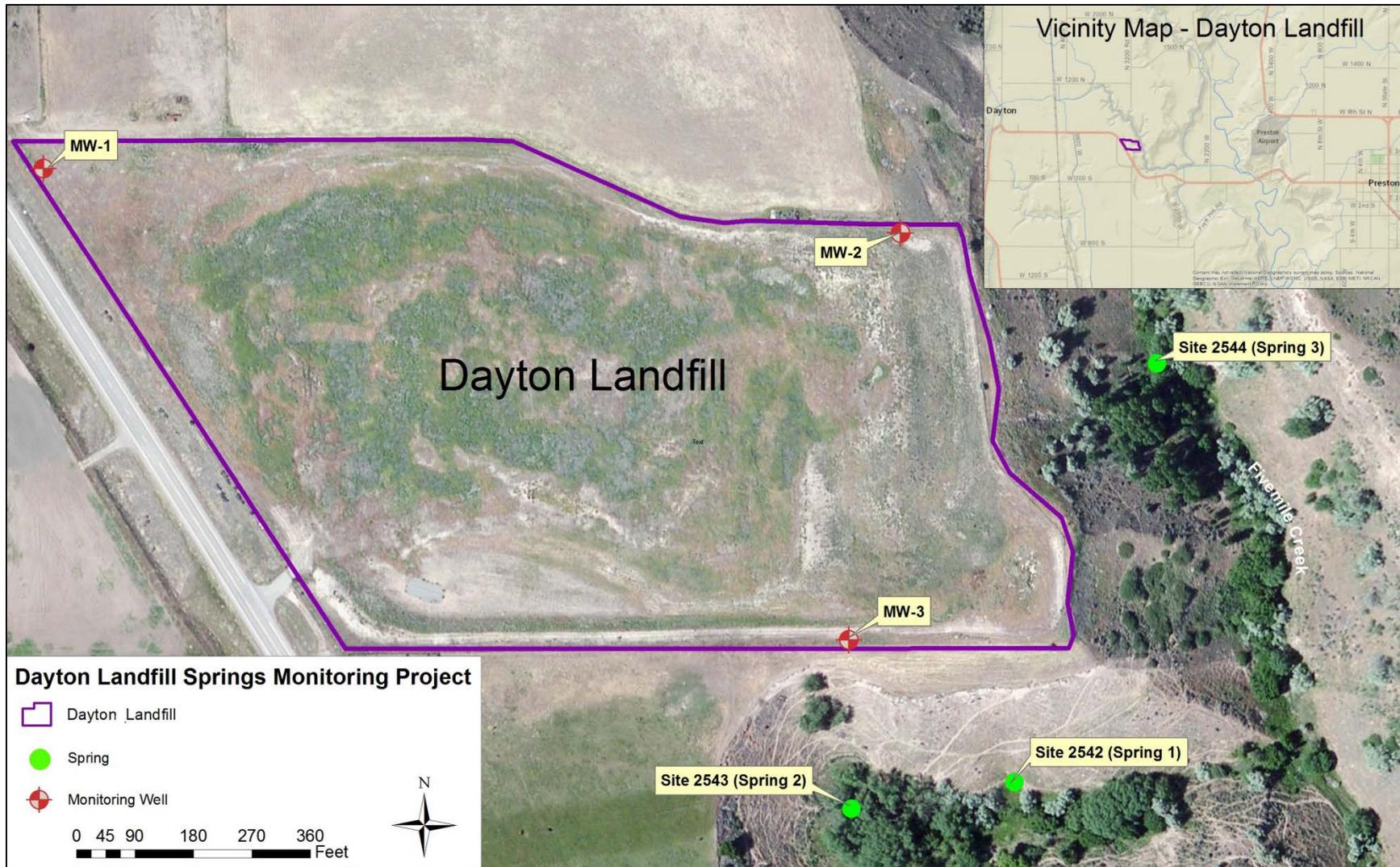


Figure 55. Spring and landfill monitoring well locations—Dayton Landfill Springs Monitoring Project.

Soils surrounding the landfill are lacustrine shoreline deposits of the Pleistocene Lake Bonneville, ranging from clays to clean sands.

Ground water flows in a southeasterly direction across the landfill site and produces several seeps and springs where the steep ravines intersect the water table. In 2002, white foam was observed at Site 2542 (Spring 1), located southeast of the landfill (Figure 55). In May 2002, DEQ sampled Site 2542 (Spring 1), Site 2543 (Spring 2), and Site 2544 (Spring 3) to investigate the possibility that ground water was being impacted by leachate from the landfill (Figure 55). The 2002 sampling indicated that ground water at Site 2542 was impacted by landfill leachate because it exhibited higher specific conductivity, lower pH, and generally higher concentrations of dissolved constituents than the other two springs. The sample from Spring 1 also contained low concentrations of some man-made organic compounds, including cis-1,2-dichloroethene (cis-1,2-DCE) and TCE. At the time of the 2002 sampling, Sites 2543 and 2544 did not appear to be contaminated (CES 2003).

As a result of the contamination detected at Site 2542, three ground-water monitoring wells were installed (MW-1, MW-2, and MW-3) in 2003 as part of the facility closure monitoring plan (Figure 55) (CES 2003). Long-term monitoring at MW-3 confirms the continuing presence of cis-1,2-DCE and TCE along with benzene, vinyl chloride, arsenic, and several metals. Samples from the other two wells, MW-1 and MW-2, have not presented any indicators of ground water contamination, as reported in the 2016 ground water monitoring report from CES (2016b). The landfill was closed in 2003, but monitoring of the wells continues biannually in accordance with the requirements of 40 CFR §258 (EPA 1993).

The purpose of this study was to evaluate the quality of the ground water at the three spring Sites 2542, 2543, and 2544. Because the springs have been used for stock watering, and occasionally for human consumption, contamination at the springs is a public health concern. Additionally, these springs supply Fivemile Creek and have the potential to impact the quality of that surface water resource. This sampling project will help evaluate current ground water conditions, provide an opportunity for direct comparison with the 2002 results and landfill monitoring well data, and be used to guide future monitoring efforts around the landfill.

2.5.3.2 Methods and Results

General spring locations for the project were identified from unpublished records associated with the 2002 DEQ spring sampling, and specific sampling locations were refined based on conditions in the field. To maintain consistency with the previous data set, samples were collected in May. The three springs were sampled in accordance with procedures outlined in the QAPP (DEQ 2011b).

Samples were collected and sent to IBL in Boise for analysis. Water chemistry analyses included major ions, inorganic constituents, and VOCs and are listed in Appendix B. The set of 111 analytes were selected based on those examined in 2002, the analyte list in Appendix I of 40 CFR §258 (USGPO 2016), and a laboratory-defined suite of VOCs that included a number of constituents not previously examined in 2002. Water temperature and specific conductivity were measured in the field prior to collecting the laboratory samples (Table 66). Due to equipment failure, values for pH and DO were not collected in the field.

Table 66. Water quality field parameters—Dayton Landfill Springs Monitoring Project.

DEQ Site ID	Project Site ID	Sample Date	Water Temperature (°C)	Specific Conductivity (µS/cm)
2542	Spring 1	5/13/2015	16.71	1,570
2543	Spring 2	5/13/2015	14.07	904
2544	Spring 3	5/13/2015	14.13	837

The specific conductivity measured at Spring 1 is similar to typical values observed at nearby MW-3, which has shown impacts from landfill leachate. Ground water at Sites 2543 and 2544 have specific conductivity values comparable to those of upgradient well MW-1, as reported in the facility monitoring report (CES 2016b).

General Ground Water Chemistry

Results of the analyses for major ions are presented in Table 67 and displayed graphically in Figure 56. The observation of higher conductivity at Site 2542 is supported by generally higher concentrations of the major ions exhibited in Figure 56.

Table 67. Major ion results—Dayton Landfill Springs Monitoring Project.

DEQ Site ID	Project Site ID	Sample Date	Calcium	Magnesium	Sodium	Potassium	Chloride ^a	Sulfate ^a	Alkalinity (as CaCO ₃)
Primary or Secondary Standard:			NA	NA	NA	NA	250	250	NA
2542	Spring 1	5/13/2015	120	62	120	13	146	34.4	602
2543	Spring 2	5/13/2015	82	32	62	7.2	37.3	38.1	397
2544	Spring 3	5/13/2015	90	29	35	8.8	37.9	48.6	343

^a Contaminant with a National Secondary Drinking Water Regulation standard.

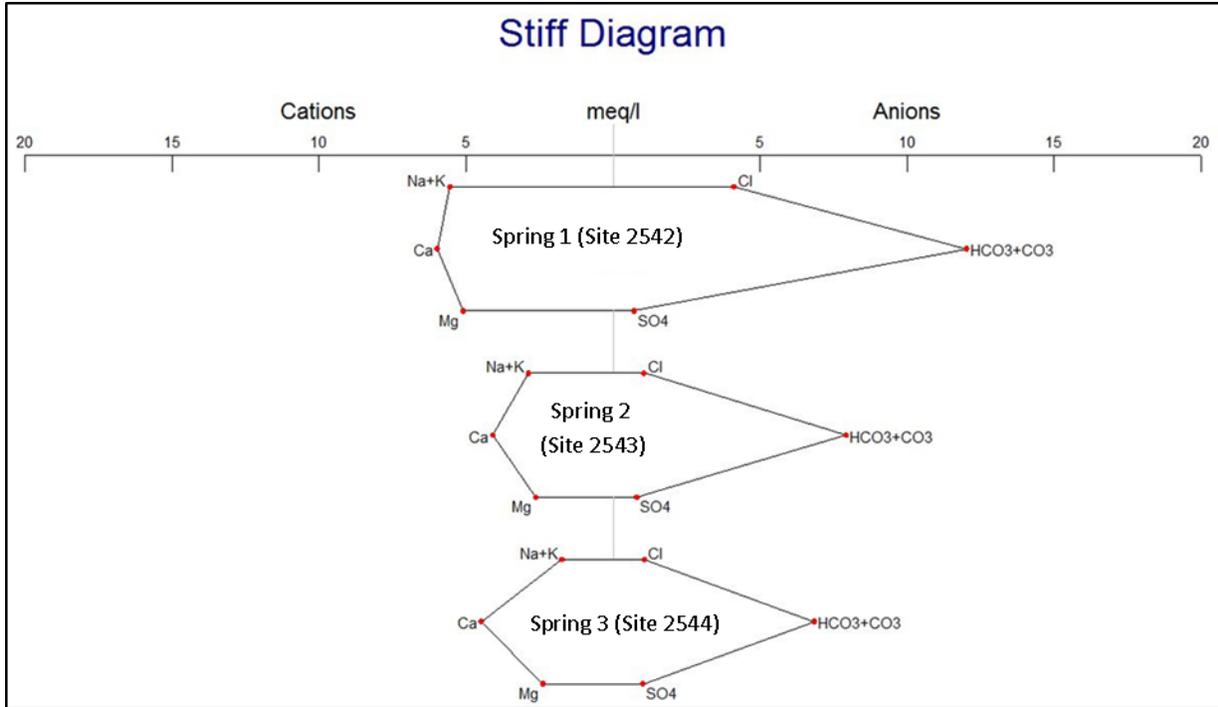


Figure 56. Water chemistry data shown with Stiff diagrams—Dayton Landfill Springs Monitoring Project.

Inorganic and Nutrient Results

Table 68 includes those inorganic constituents for which at least one of the three springs displayed concentrations above the laboratory RDL and thus were quantifiable by the laboratory. Results for all other constituents were below the RDL. No NPDWR standards were exceeded for any constituent at any of the three springs. The aesthetically based NSDWR standard for TDS of 500 mg/L was exceeded at Sites 2542 and 2543. While the arsenic concentration at Site 2542 was well below the MCL of 10 µg/L, it was significantly higher than the concentration at Sites 2543 and 2544 and possibly reflective of a rising trend in concentration at nearby well MW-3 (CES 2016b). The table also includes the results of nutrient analyses, all of which are considered relatively low.

Table 68. Inorganic and nutrient analytical results—Dayton Landfill Springs Monitoring Project.

DEQ Site ID	Project Site ID	Sample Date	Arsenic ^a (µg/L)	Barium ^a	Chromium ^a	Cobalt	Copper ^b	Iron ^c	Lead ^a	Nickel	Zinc ^c	Nitrate as N ^a	Ammonia as N	Total Kjeldahl Nitrogen	Total Hardness	Total Dissolved Solids ^c
<i>Primary or Secondary Standard:</i>			<i>10</i>	<i>2</i>	<i>0.1</i>	<i>NA</i>	<i>1.3</i>	<i>0.3</i>	<i>0.015</i>	<i>NA</i>	<i>5</i>	<i>10</i>	<i>NA</i>	<i>NA</i>	<i>NA</i>	<i>500</i>
2542	Spring 1	5/13/2015	4.2	0.72	0.0014	0.0016	0.0011	0.026	<0.001	0.0097	<0.005	<0.18	0.022	0.96	550	<i>880</i>
2543	Spring 2	5/13/2015	<2.0	0.28	<0.001	<0.001	<0.001	0.040	0.0011	0.0021	0.0061	0.353	0.023	0.34	340	<i>510</i>
2544	Spring 3	5/13/2015	2.2	0.71	<0.001	<0.001	<0.001	<0.01	0.0011	0.0012	<0.005	<0.18	0.26	0.52	340	480

Notes: Italicized red numbers indicate EPA's National Secondary Drinking Water Regulation (NSDWR) standard exceeded. These regulations are applicable for public water systems only but are recommended limits and can be applied to private wells to evaluate water quality.

^a Contaminant with a National Primary Drinking Water Regulation standard.

^b EPA established a treatment technique rather than an MCL for copper. If more than 10% of tap water samples exceed the copper action level of 1.3 mg/L, water systems must take additional steps to reduce corrosiveness.

^c Contaminant with a National Secondary Drinking Water Regulation standard.

VOCs and Chemical Oxygen Demand Results

Those organic compounds that were detected above the laboratory method detection limit (MDL), either in 2002 or 2015, are included in Table 69. In 2002, only two organic compounds—cis-1,2-DCE and TCE—were detected at Site 2542 and no organic compounds were detected at Sites 2543 and 2544. The cis-1,2-DCE concentration has decreased from 12.4 µg/L in 2002 to below the RDL in 2015. The TCE concentration in 2002 was 0.67 µg/L and was not detected in 2015. Vinyl chloride was not detected in 2002 but was detected below the RDL in 2015 at an estimated concentration of 0.31 µg/L at Site 2542. The apparent increase in vinyl chloride, combined with a decrease in TCE and cis-1,2-DCE, might be indicative of the anaerobic decay of TCE and cis-1,2-DCE into their breakdown product vinyl chloride, as depicted in Figure 57.

Table 69. Organic and chemical oxygen demand analytical results—Dayton Landfill Springs Monitoring Project.

DEQ Site ID	Project Site ID	Sample Date	Diethyl Ether	Tetrahydrofuran	Acetone	cis-1,2-Dichloroethene ^a	Trichloroethene ^a	Vinyl Chloride ^a	Chemical Oxygen Demand (mg/L)
			(µg/L)						
Primary or Secondary Standard:			NA^b	NA^c	NA^d	70	5	2	NA
2542	Spring 1	5/13/2015	3.1	1.1	2.0J	0.45J	<0.5	0.31J	22.8
2543	Spring 2	5/13/2015	<0.5	<1	<10	<0.5	<0.5	<0.5	<20
2544	Spring 3	5/13/2015	<0.5	<1	<10	<0.5	<0.5	<0.5	<20

Notes: J = result is above the method detection limit but below the reporting detection limit and is an estimated value.

^a Contaminant with a National Primary Drinking Water Regulation standard.

^b While EPA has established no NPDWR or NSDWR for this compound, the State of Minnesota has established a standard of 200 µg/L. Provided for reference only.

^c While EPA has established no NPDWR or NSDWR for this compound, the State of New Hampshire has established a standard of 154 µg/L. Provided for reference only.

^d While EPA has established no NPDWR or NSDWR for this compound, the State of New Hampshire has established a standard of 6,000 µg/L. Provided for reference only.

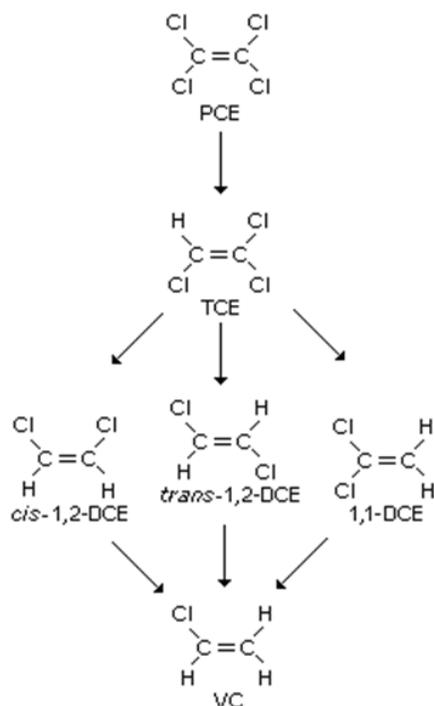


Figure 57. Pathway for anaerobic microbial degradation of chlorinated ethenes to form vinyl chloride (VC) (from WHO 1999).

Diethyl ether and tetrahydrofuran were detected in the sample from Site 2542 at concentrations of 3.1 and 1.1 µg/L, respectively. Acetone was also detected at Site 2542 at an estimated concentration of 2.0 µg/L, which is below the RDL. While neither the EPA nor the State of Idaho have established drinking water standards for these compounds. The concentrations observed at Site 2542 are well below existing standards in some other states (Table 69) (MDH 2016; NHDES 2007; NHDES 2013). Analysis for those compounds was not conducted in 2002.

Table 69 also includes the result of the analysis for chemical oxygen demand, which is often used as a general indicator of ground water pollution, particularly with respect to oxidizable materials (Hem 1992). While chemical oxygen demand at Sites 2543 and 2544 was below the detection limit, chemical oxygen demand at Site 2542 decreased from 34 mg/L in 2002 to 22.8 mg/L in 2015, suggesting a general improvement in ground water quality.

2.5.3.3 Conclusions

The objectives of this project were to characterize the current ground water conditions at the three springs near the Dayton Landfill, compare the results to previous sampling data from the springs and landfill monitoring wells, and use the information to guide future sample planning.

The data set compiled from this sampling effort suggests the following:

- Ground water emerging at Site 2542 has been impacted by leachate from the Dayton Landfill and is similar to that observed in long-term monitoring of well MW-3.
- Sites 2543 and 2544 exhibit no clear indications of contamination and do not appear to have been impacted by landfill leachate.

- Concentrations of most constituents detected in the ground water at Site 2542 have decreased from the 2002 sampling, and concentrations of organic compounds are very low. This finding is consistent with the trends observed at MW-3.
- No primary drinking water standards were exceeded at any of the springs for any of the 111 analytes included in this study.
- The secondary drinking water standard for TDS was exceeded at Sites 2542 and 2543.

2.5.3.4 Recommendations

Ground water monitoring at the springs should be continued throughout the post-closure phase of the landfill. The low concentrations of observed contaminants suggest that a 5-year sampling frequency would be sufficient. However, contaminant concentration trends in nearby well MW-3 should be used to guide future monitoring decisions.

2.6 Twin Falls Region

One ground water quality monitoring project was conducted in the Twin Falls region in 2015 using public funds.

2.6.1 Springdale Ground Water Monitoring Project

2.6.1.1 Purpose and Background

The purpose of this project was to further investigate and evaluate any changes in ground water nitrate concentrations, nitrogen isotope ratios, and major ion chemistry in the Springdale area by resampling project wells from previous DEQ ground water studies (Schorzman and Baldwin 2009; DEQ 2013e).

In 2008–2009, DEQ conducted a ground water evaluation of nitrate near the community of Springdale, Idaho, which is located in Cassia County on the southern edge of the ESRP aquifer (Figure 58). The project area is southeast of Burley, Idaho, and south of the Snake River within the Marsh Creek Nitrate Priority Area (NPA). The H and J canal systems lie on the south end of the study area and transport water from the Snake River to irrigate agricultural land. The study area is situated at the northern edge of the Oakley Fan, an alluvial fan between the Albion Mountain Range on the south and the Snake River to the north. Generally, ground water flow direction follows the natural drainage of the Oakley Fan from southeast to the northwest (Schorzman and Baldwin 2009). However, localized flow varies within the study area.

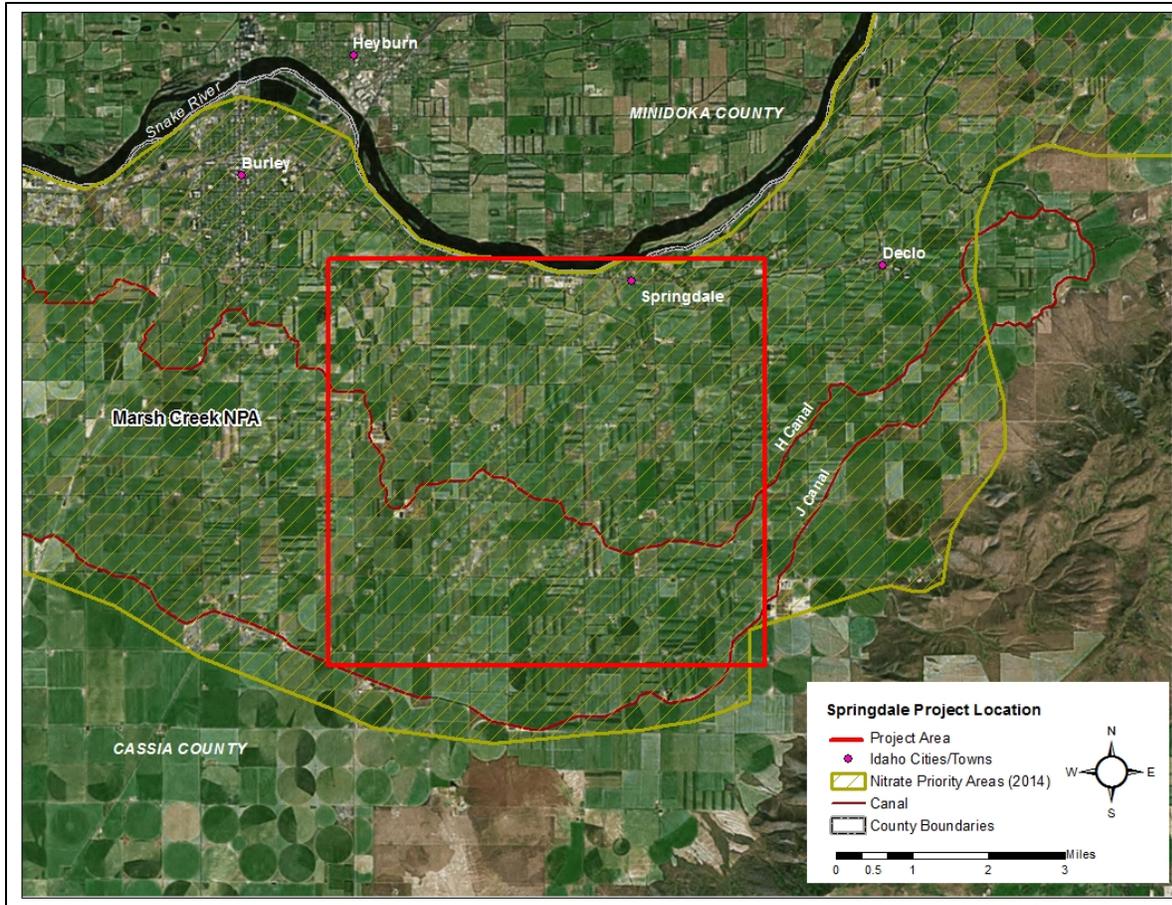


Figure 58. Project location map—Springdale Ground Water Monitoring Project.

The 2008–2009 ground water study included both fall and spring sampling of 13 domestic wells, all of which were completed in the shallow alluvial aquifer (less than 200 feet deep). Follow-up sampling was done in 2010 at 12 of the 13 wells plus an additional 7 wells. Both the 2009 and 2010 studies concluded that nitrate concentrations depended on local land-use practices in proximity to each well. Nitrogen isotope values suggested the source of nitrogen in most wells was a mixture of commercial fertilizer and animal or human waste or organic nitrogen in soil (Schorzman and Baldwin 2009; DEQ 2013e). This area was also extensively studied by ISDA for many years prior to 2008 (Carlson et al. 2005; Tesch et al. 2003a; Tesch et al. 2003b). Annual ground water nitrate sampling was conducted from 1998 to 2004, when anywhere from 33% to 45% of wells fell within the 5–10 mg/L nitrate range and 9–19% exceeded the EPA drinking water standard of 10 mg/L for nitrate (Carlson et al. 2005).

In 2014, the Marsh Creek NPA, which includes the Springdale area and the city of Burley, was ranked as the most impacted NPA in the state and showed an increasing trend in nitrate levels. The NPA includes 154 square miles of northern Cassia County along the Snake River. Mean nitrate level was 7.16 mg/L, and of 402 sample sites, 64% showed nitrate levels higher than 5 mg/L.

Geology in the project area consists of older sedimentary units, followed by rhyolite and basalt units, topped by the most recent alluvial deposits. Remnants of prehistoric Burley Lake deposits

consisting of clay, silt, sand, and gravel that range from unconsolidated to well-compacted overlie the basalt flows (Schorzman and Baldwin 2009). The Albion Mountains to the southeast represent the sedimentary rocks composed of limestone, sandstone, and shale. The wells sampled for this project draw water from the shallow upper alluvium, which is composed of sand and gravel with interbedded clay layers (Carlson et al. 2005). None of the wells encounter the underlying basalt flows according to the well lithology.

2.6.1.2 Methods and Results

In July and August 2015, a total of 10 wells were sampled within the Springdale project area after gaining homeowner permission; 8 of the 10 wells were sampled in the 2009 and 2010 Springdale studies. Wells 2470 and 2471 were added to the project. The 2 new wells were added when permissions for sampling could not be obtained for some of the previously sampled wells. They were selected based on their proximity to previously sampled wells. Wells 908 and 910 are part of the ISDA sampling network for the Cassia Ground Water Monitoring Project. Sampling of these two wells was coordinated with ISDA and conducted in July to coincide with their sampling schedule.

Well logs were located for 6 of the 10 wells sampled in 2015, including for 5 of the 8 previously sampled wells and 1 of the new wells.

Water quality field parameters (pH, temperature, specific conductivity, and DO) were measured at each site prior to sample collection to ensure adequate purging of the well for a representative sample of the local aquifer (Table 70).

Samples were collected for calcium, magnesium, sodium, potassium, chloride, bromide, sulfate, total alkalinity, TDS, boron, nitrate plus nitrite, TC, and *E. coli*. Wells with DO less than 4.00 mg/L were analyzed for ammonia, as described in the project FSP (DEQ 2015m). All samples were submitted to Magic Valley Labs in Twin Falls for analysis.

Nitrogen isotope samples were collected at each sampling location and submitted to NAU CPSIL for stable isotopes analysis of nitrogen ($\delta^{15}\text{N}_{\text{nitrate}}$) and oxygen in nitrate ($\delta^{18}\text{O}_{\text{nitrate}}$) and to the University of Arizona for the stable isotope analysis of total nitrogen in water ($\delta^{15}\text{N}$).

All sampling was conducted in accordance with the QAPP (DEQ 2013b) and FSP (DEQ 2015m).

Table 70. Water quality field parameters—Springdale Ground Water Monitoring Project.

DEQ Site ID	Well Name	Well Depth (feet)	Sample Date	Water Temperature (°C)	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	pH ^a
906	SC-1	57	8/20/2015	12.71	802	4.98	7.29
907	SC-2	—	8/19/2015	15.31	991	3.37	7.30
908	SC-3	58	7/21/2015	15.03	936	3.19	7.27
910	SC-5	61	7/21/2015	12.48	972	5.93	7.36
911	SC-6	155	8/20/2015	13.76	1,291	1.80	7.25
912	SC-7	55	8/19/2015	12.20	1,067	1.79	7.40
917	SC-12	—	8/19/2015	12.95	927	3.45	7.57
918	SC-13	—	8/19/2015	12.44	1,024	5.00	7.34
2470	SC-7A	191	8/19/2015	14.99	828	4.90	7.52
2471	SC-15	—	8/20/2015	13.38	611	6.19	7.46

Notes: (—) = data are unavailable or were not analyzed.

^a Contaminant with a National Secondary Drinking Water Regulation standard. The NSDWR for pH is 6.5-8.5. NSDWR standards are recommended limits for public water systems but can be applied to private wells to evaluate water quality.

General Ground Water Chemistry

All results for major ion and nutrient constituents from 2015 are presented in Table 71. Trilinear plotting (Piper Diagram) indicates some clustering in the middle-left portion of the diamond-shaped plot (Figure 59), which suggests that the ground water sampled is a calcium bicarbonate-type water. This finding is consistent with the 2009 evaluation of the project area (DEQ 2011d). Well 2470, which was not sampled in the 2009 study, has somewhat different chemistry. It is the deepest well in the project with a completed depth of 191 feet bgs. This well had higher chloride concentrations and a lower sodium and potassium concentration than the other, shallower wells. Because this well is completed to a deeper depth, it is likely tapping into deeper strata, which could explain the differences in water chemistry. The well log indicates that the well is cased to a depth of 188 feet bgs, and lithology (from the well log) shows a 49-foot thick clay layer from 89 to 138 feet bgs, below which sandy clay and cemented gravel layers occur. Additionally, the shallower wells are likely more susceptible to influences from the land surface, which may account for different ground water chemistry.

Table 71. Major ion and nutrient results—Springdale Ground Water Monitoring Project.

DEQ Site ID (Well Name)	Sample Date	Calcium	Magnesium	Sodium	Potassium	Chloride ^a	Sulfate ^a	Bromide	Alkalinity (as CaCO ₃)	TDS ^a	Boron (µg/L)	Nitrate + Nitrite/N ^b	Ammonia/N
		(mg/L)										(mg/L)	
<i>Primary or Secondary Standard:</i>		<i>NA</i>	<i>NA</i>	<i>NA</i>	<i>NA</i>	<i>250</i>	<i>250</i>	<i>NA</i>	<i>NA</i>	<i>500</i>	<i>NA</i>	<i>10</i>	<i>NA</i>
906 (SC-1)	8/20/15	76.6	34.9	41.4	15.3	35.7	73.0	<0.10	254	210	236	7.31	—
907 (SC-2)	8/19/15	100	22.2	60.8	16.3	46.9	79.7	0.11	232	650	228	26.0	<0.05
908 (SC-3)	7/21/15	106	18.2	70.4	14.5	39.2	67.1	<0.10	395	670	174	13.5	<0.05
910 (SC-5)	7/21/15	102	31.7	61	17.7	32.6	67.2	<0.10	354	660	183	12.0	—
911 (SC-6)	8/20/15	140	37.7	94	26.5	61.4	100	0.11	380	720	371	21.0	<0.05
912 (SC-7)	8/19/15	89.2	26.1	99	21.7	42.4	99.5	0.11	313	740	310	18.9	<0.05
917 (SC-12)	8/19/15	90	23.6	64	19.6	35.8	81.3	<0.10	272	610	240	12.9	<0.05
918 (SC-13)	8/19/15	100	28.9	65	21.5	50.3	90.8	<0.10	266	700	278	16.6	—
2470 (SC-7A)	8/19/15	110	25.5	16	13.3	92.3	61.8	0.23	181	560	112	3.97	—
2471 (SC-15)	8/20/15	63.8	18.7	34.5	15.8	21.7	47.3	<0.10	218	340	206	4.63	—

Note: Bolded red numbers indicate EPA's National Primary Drinking Water Regulation (NPDWR) standard, expressed as a maximum contaminant level (MCL), was exceeded. Italicized red numbers indicate EPA's National Secondary Drinking Water Regulation (NSDWR) standard was exceeded. These regulations are applicable for public water systems only but are recommended limits and can be applied to private wells to evaluate water quality.

^a Contaminant with a National Secondary Drinking Water Regulation standard.

^b Contaminant with a National Primary Drinking Water Regulation standard.

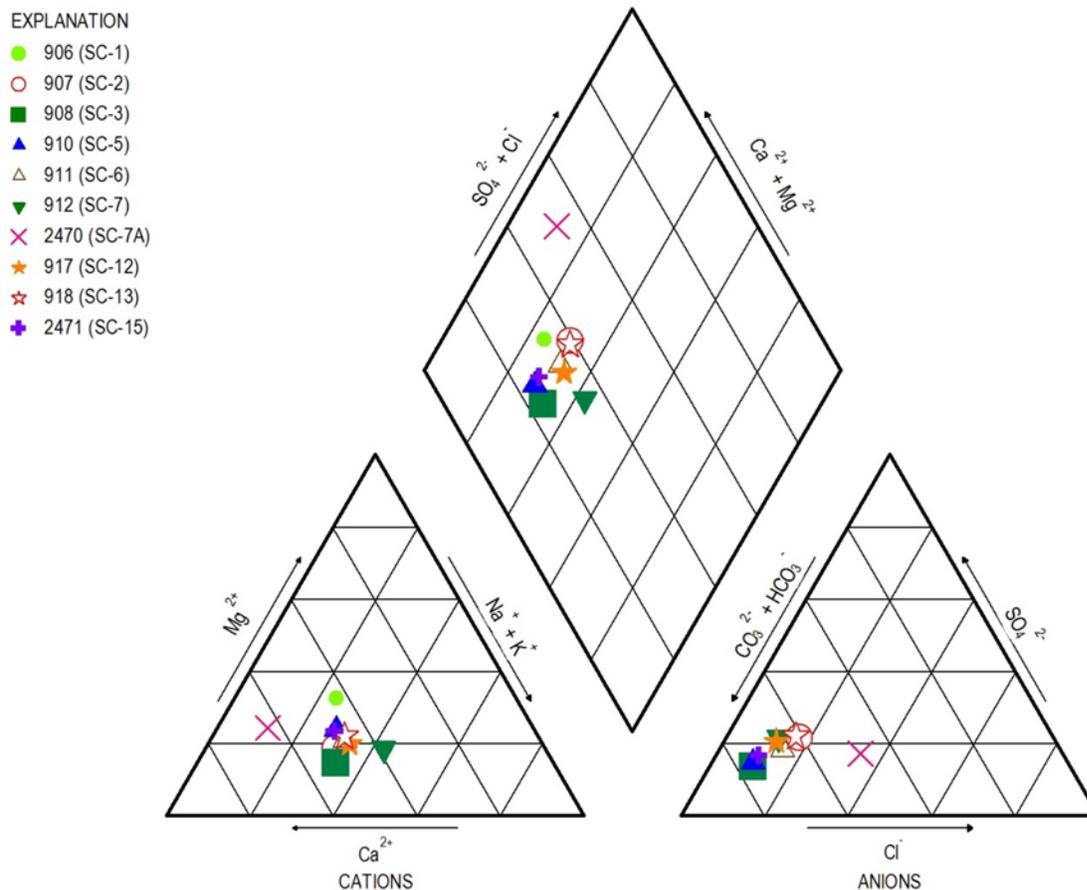


Figure 59. Piper trilinear diagram—Springdale Ground Water Monitoring Project. (The symbol size is determined by the TDS concentration for each sample.)

Nitrate plus Nitrite Results

Nitrate plus nitrite-N (nitrate) concentrations ranged from 3.97 mg/L (Well 2470) to 26.0 mg/L (Well 907). Nitrate concentrations exceeded the MCL of 10 mg/L in 7 of the 10 wells. Well 907 and Well 911 had the highest nitrate results with concentrations of 26.0 mg/L and 21.0 mg/L, respectively. Well 907 was also one of 2 wells with the highest nitrate levels in 2009 and 2010. Figure 60 shows the spatial distribution of nitrate concentrations across the Springdale study area.

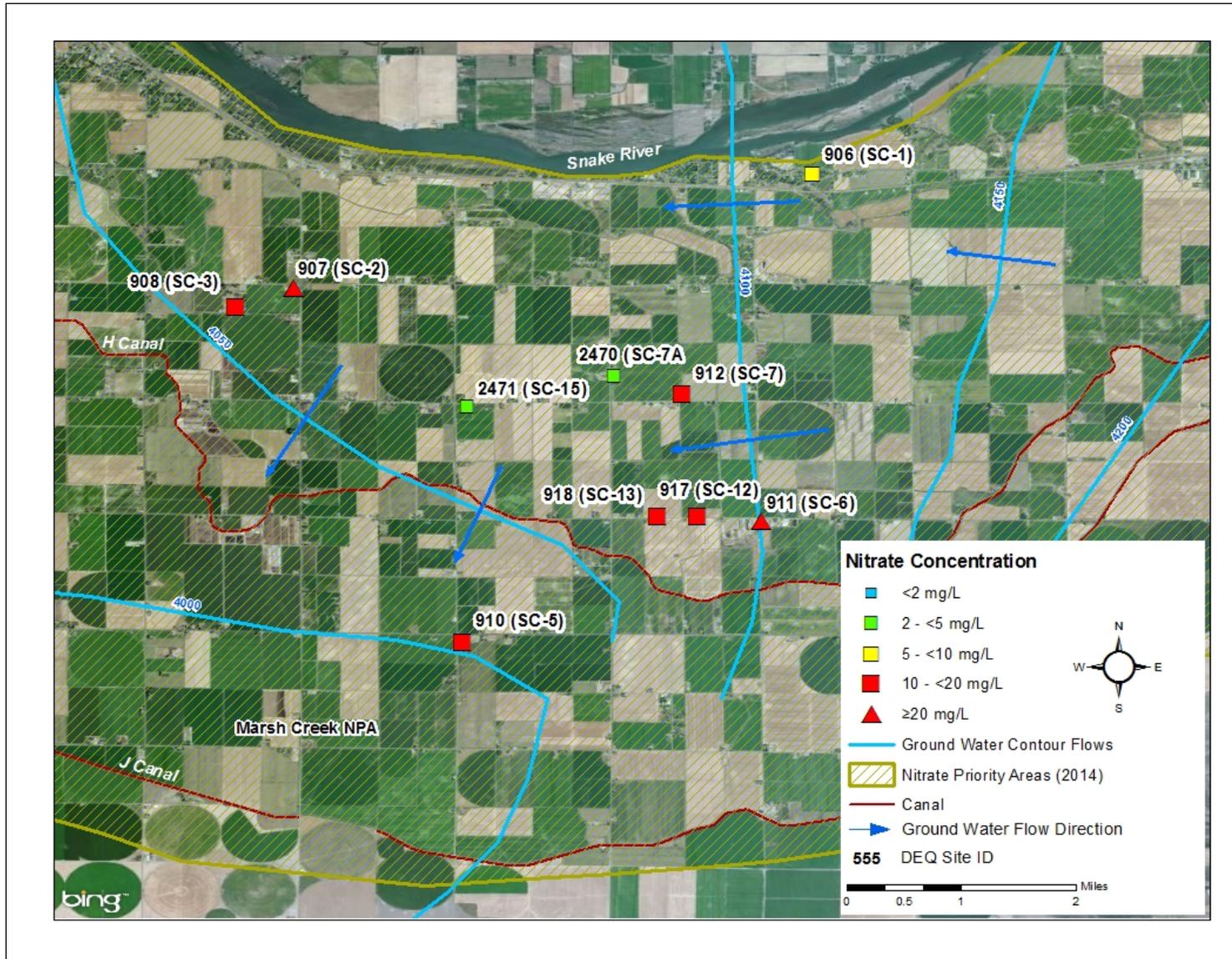


Figure 60. Sampling locations and nitrate concentrations—Springdale Ground Water Sampling Project.

Total Dissolved Solids Results

TDS is a measure of the combined content of all inorganic and organic substances contained in a liquid in suspended form. The TDS concentrations ranged from 210 mg/L to 740 mg/L; 8 of the 10 wells had concentrations that exceeded the NSDWR standard of 500 mg/L (Table 71). The 2009 Springdale study found a strong linear relationship between nitrate and TDS concentrations at the 8 sites in common with this project ($R^2 = 0.74$). The relationship between nitrate and TDS concentrations from this sampling was not as strong ($R^2 = 0.41$) (Figure 61).

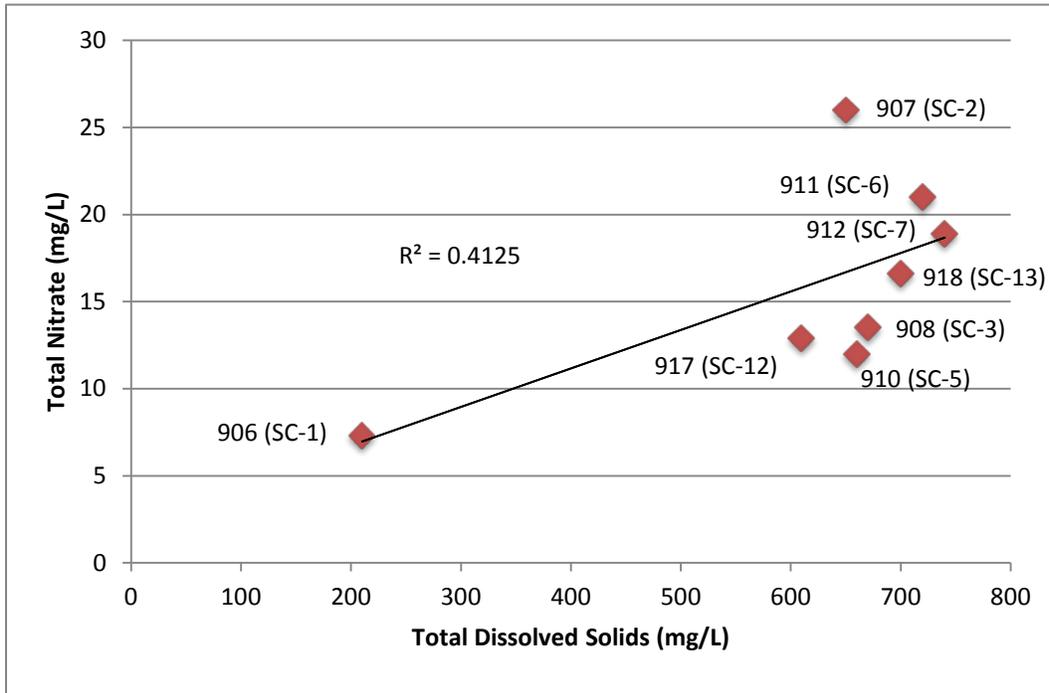


Figure 61. Total dissolved solids versus nitrate concentrations—Springdale Ground Water Sampling Project.

Chloride and Sulfate Results

Chloride concentrations ranged from 21.7 mg/L (Well 2471) to 92.3 mg/L (Well 2470), while sulfate concentrations ranged from 47.3 mg/L (Well 2471) to 100 mg/L (Well 911) (Table 71, Figure 62). Neither the chloride nor the sulfate NSDWR standard of 250 mg/L was exceeded in any of the samples, and results are similar to the 2009 and 2010 sampling results.

The sulfate/chloride mass ratio is plotted against chloride in Figure 62. The deepest well (2470) exhibited the greatest chloride concentration relative to sulfate. The samples from the shallower wells had higher sulfate concentrations than chloride concentrations, which may be attributable to either the gypsum-producing old Burley Lake beds coming in contact with ground water or contributions from sulfate-based fertilizer (Schorzman and Baldwin 2009).

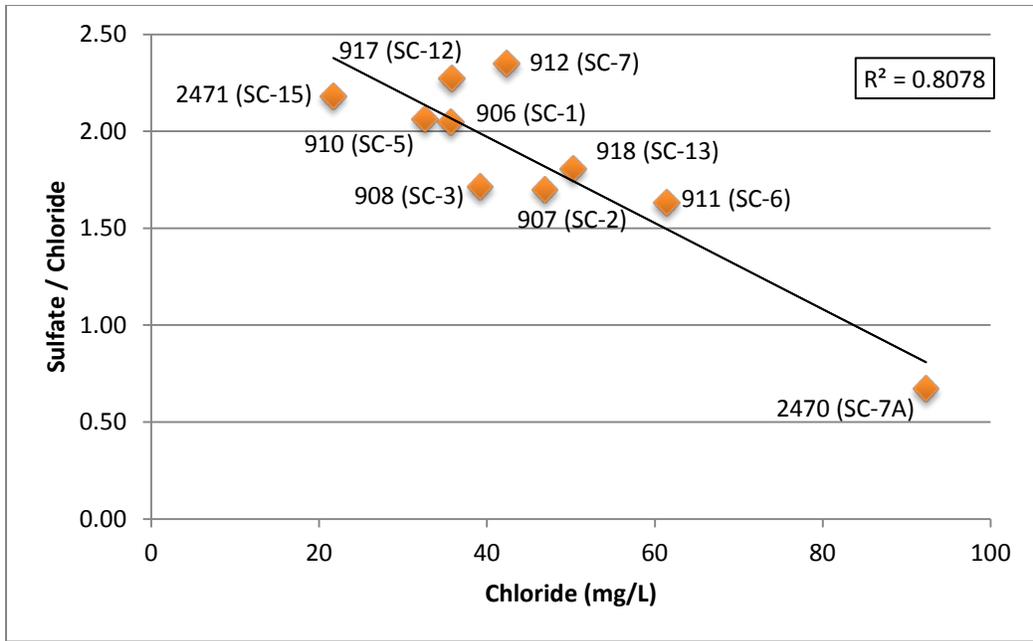


Figure 62. Sulfate/chloride mass ratio versus chloride concentration—Springdale Ground Water Monitoring Project.

Chloride and nitrate concentrations showed a linear correlation when the deepest well sampled (Well 2470) was not included (Figure 63). Well 2470 had the highest chloride level but the lowest nitrate concentration.

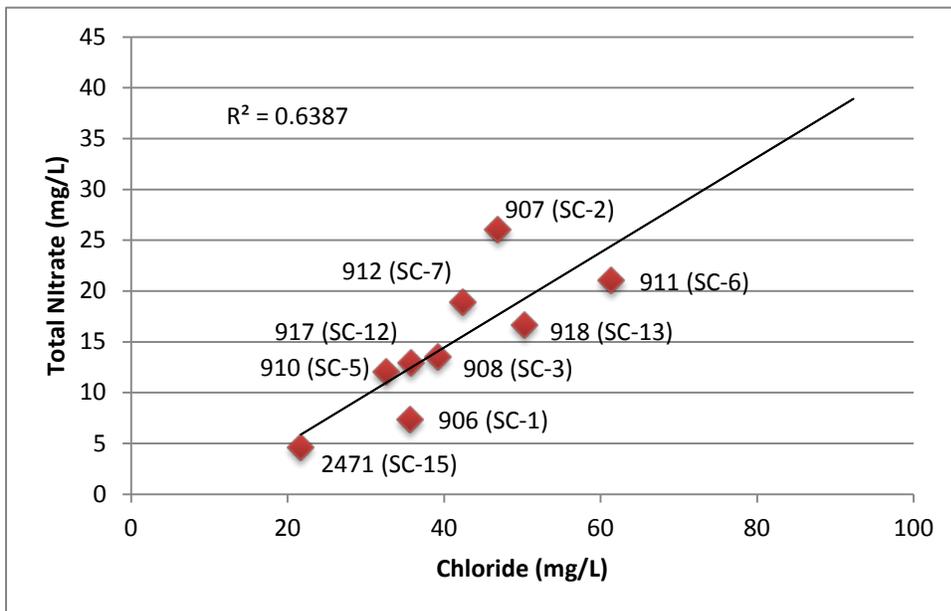


Figure 63. Chloride versus nitrate concentrations—Springdale Ground Water Monitoring Project.

Nitrogen Isotopes

Nitrogen isotope ratios (typically denoted as $\delta^{15}\text{N}$) are used in differentiating potential sources of nitrate in the ground water, especially in combination with oxygen isotope ratios and major ion

chemistry. Sources of nitrate in agricultural areas include commercial fertilizers, animal or human waste, and other organic nitrogen sources in the soil. Each of these has a distinguishing nitrogen isotope signature. Typical $\delta^{15}\text{N}$ ranges for fertilizer and waste are -4‰ to $+4\text{‰}$ and greater than 9‰ , respectively. Organic or mixed sources are considered to fall between 4‰ and 9‰ (Seiler 1996).

Two types of nitrogen isotope ratio analysis were performed on all samples collected for this project. Total $\delta^{15}\text{N}$ captures the isotope fractionation occurring from all forms of nitrogen in the sample, including ammonia. Therefore, it may be most useful for determining nitrogen sources in samples with detectable ammonia. Samples were analyzed for total $\delta^{15}\text{N}$ for comparison with results from the 2009 and 2010 studies (Table 71). The other type of nitrogen isotope analysis, measures the stable nitrogen isotope ratio only from the nitrate (typically denoted as $\delta^{15}\text{N}_{\text{nitrate}}$) in the sample and is useful when evaluating nitrogen in oxygenated ground water, as it is most often found in the nitrate form. Figure 64 is a plot of $\delta^{15}\text{N}$ versus $\delta^{15}\text{N}_{\text{nitrate}}$ with a linear regression. It appears there is a strong correlation between the values from the two analysis methods. The strong correlation suggests the $\delta^{15}\text{N}_{\text{nitrate}}$ is accurately representing the nitrogen present in the sample or that all of the nitrogen is in the form of nitrate. The lack of ammonia in the samples also allows the nitrogen isotope methods to be evaluated for comparability. The Shapiro-Wilk normality test indicated the differences between the data pairs were normally distributed. Therefore, a paired t-test statistical method was used and indicates, with 95% confidence, that the results from the two methods are not statistically different.

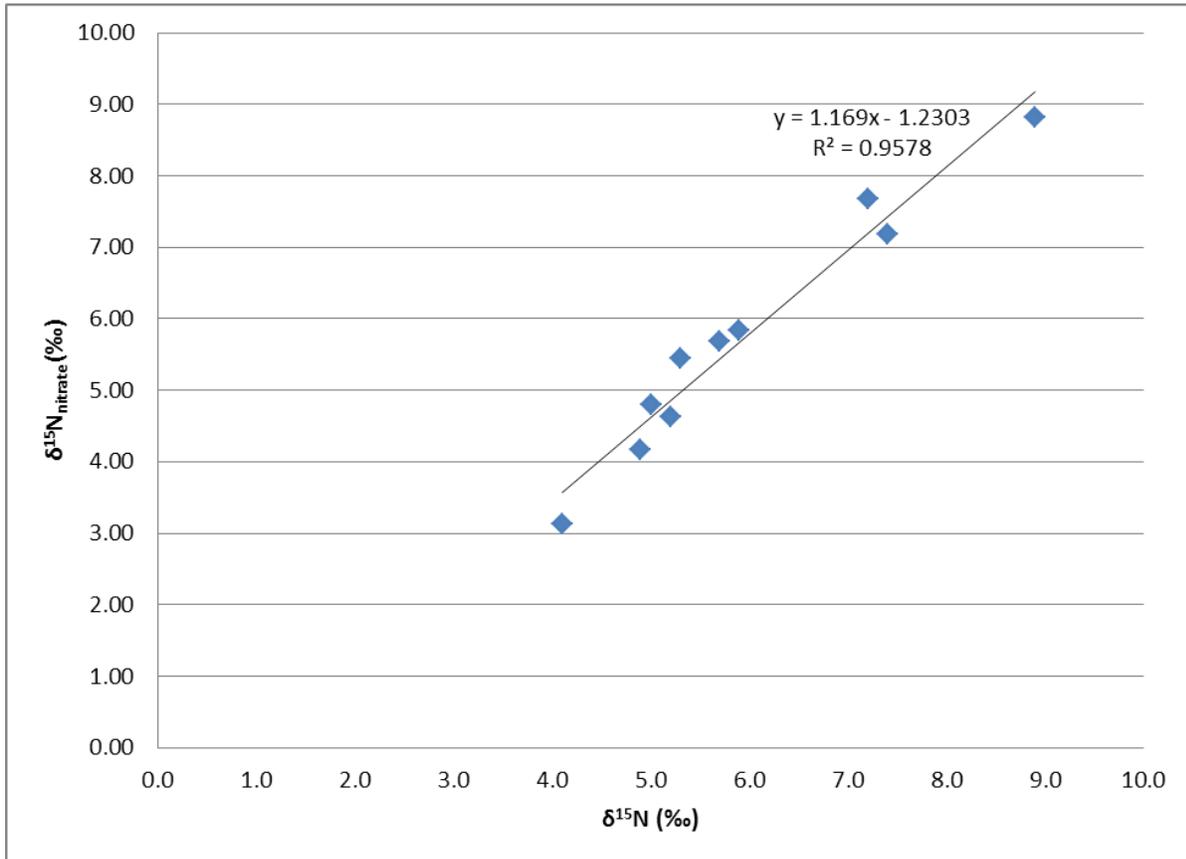


Figure 64. $\delta^{15}\text{N}$ versus $\delta^{15}\text{N}_{\text{nitrate}}$ —Springdale Ground Water Monitoring Project.

Results for all isotope ratio analyses are presented in Table 72. During the data review of the $\delta^{15}\text{N}_{\text{nitrate}}$ and $\delta^{18}\text{O}_{\text{nitrate}}$ results, the legitimacy of the results for Well 906 was questioned. The lab reran the sample from Well 906 plus three additional samples (from Wells 907, 910, and 911). The rerun results are shown as the second entry for those wells (Table 72). The $\delta^{15}\text{N}$ and $\delta^{15}\text{N}_{\text{nitrate}}$ values ranged from 3.12‰ to 8.9‰, which are all in the range of organic nitrogen in the soil or mixed waste sources, with the exception of one value (for Well 918) which fell in the range of a fertilizer source (Seiler 1996).

Table 72. Major stable isotope results—Springdale Ground Water Monitoring Project.

DEQ Site ID	Project Well Name	Well Depth (feet)	Sample Date	U of A	NAU	
				$\delta^{15}\text{N}$	$\delta^{15}\text{N}_{\text{nitrate}}$	$\delta^{18}\text{O}_{\text{nitrate}}$
(‰) or per mil						
906	SC-1	57	8/20/2015	5.3	-16.53	-1.03
					5.45	-4.15
907	SC-2	—	8/19/2015	7.4	6.74	-4.74
					7.19	-4.62
908	SC-3	58	7/21/2015	8.9	8.82	-5.56
910	SC-5	61	7/21/2015	5.7	5.20	-6.82
					5.69	-7.15
911	SC-6	155	8/20/2015	7.2	7.06	-3.45
					7.67	-4.02
912	SC-7	55	8/19/2015	5	4.80	-2.76
917	SC-12	—	8/19/2015	5.2	4.63	-5.46
918	SC-13	—	8/19/2015	4.1	3.12	-7.73
2470	SC-7A	195	8/19/2015	4.9	4.16	-6.93
2471	SC-15	—	8/20/2015	5.9	5.84	-6.25

Samples analyzed for $\delta^{15}\text{N}_{\text{nitrate}}$ were also analyzed for the stable isotope of oxygen ($\delta^{18}\text{O}_{\text{nitrate}}$) (using the oxygen atom in the nitrate molecule) (Table 72). The $\delta^{18}\text{O}_{\text{nitrate}}$ analysis allows for a dual-isotope approach that can help explain nitrogen cycling and trace nitrate sources (Kendall 1998). The $\delta^{15}\text{N}_{\text{nitrate}}$ and $\delta^{18}\text{O}_{\text{nitrate}}$ results are presented in Figure 65. The rerun sample results are used in Figure 65. As nitrogen in the form of ammonia undergoes nitrification, oxygen from the air and from soil or irrigation water is added; the typical ratio is one $\delta^{18}\text{O}$ from air (usually $\delta^{18}\text{O} = 23\text{‰}$) and two from the soil water, either precipitation or irrigation water ($\delta^{18}\text{O} \sim -17\text{‰}$), yielding an expected $\delta^{18}\text{O}$ value of ~ -4 or -5‰ (Kendall 1998). Figure 65 shows that the results are spatially distributed in a relatively small area of the available spectrum for potential nitrogen sources (Figure 35). Based on Kendall et al. 2007, the most likely sources of nitrate appear to be organic nitrogen in the soil or a mixture of fertilizer and waste sources.

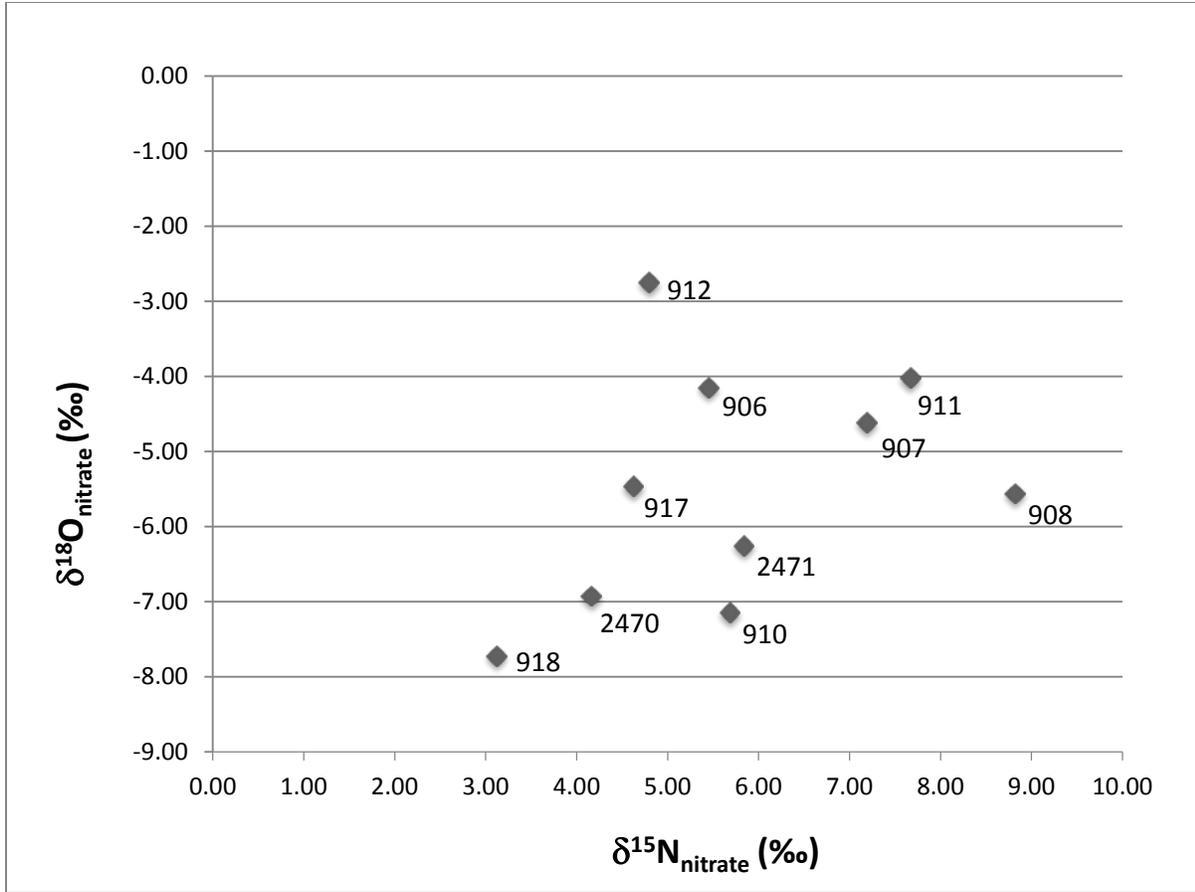


Figure 65. $\delta^{15}\text{N}_{\text{nitrate}}$ versus $\delta^{18}\text{O}_{\text{nitrate}}$ —Springdale Ground Water Monitoring Project. The $\delta^{15}\text{N}_{\text{nitrate}}$ results used in this figure are the results from the batch rerun.

Bacteria Results

Bacteria samples were collected at all 10 sites and were included in the project primarily as a service to the homeowners who allowed their wells to be used for the study. Of the 10 wells tested, 3 had positive detections of TC bacteria; concentrations ranged from 21 to 248 MPN/100 mL (Table 73). All 10 wells were negative for *E. coli*. Follow-up sampling was conducted on August 25 using a sampling point within the home at 2 of the 3 wells with positive TC detections. Both follow-up samples collected were negative for TC and *E. coli*. The third location (Well 907) did not permit follow-up sampling within the home; however, a follow-up sample was collected from the outside faucet. This sample was positive for TC but negative for *E. coli*. An outside faucet is not the best sampling site to prevent contamination of a sample due to the ubiquitous nature of TC.

Table 73. Bacteria results—Springdale Ground Water Monitoring Project.

DEQ Site ID	Well Name	Well Depth (feet)	Sample Date	Total Coliform <i>E. coli</i>	
				(MPN/100 mL)	
<i>Primary or Secondary Standard:</i>				<i>1 cfu/100 mL</i>	<i><1 cfu/100 mL</i>
906	SC-1	57	8/20/2015	<1	<1
907	SC-2	—	8/19/2015	93	<1
			8/25/2015	48	<1
908	SC-3	58	7/21/2015	<1	<1
910	SC-5	61	7/21/2015	<1	<1
911	SC-6	155	8/20/2015	<1	<1
912	SC-7	55	8/19/2015	<1	<1
917	SC-12	—	8/19/2015	<1	<1
918	SC-13	—	8/19/2015	21	<1
			8/25/2015	<1	<1
2470	SC-7A	191	8/19/2015	<1	<1
2471	SC-15	—	8/20/2015	248	<1
			8/25/2015	<1	<1

Notes: Total coliform and *E. coli* standards are from the Idaho Ground Water Quality Rule (IDAPA 58.01.11.200). An exceedance of the primary ground water quality standard for total coliform (indicated by gray shaded numbers) is not a violation of these rules. Total coliform is not a health threat in itself; it is used to indicate whether other potentially harmful bacteria may be present. Although the standards are given in cfu/100 mL, analytical results provided in MPN/100 mL are acceptable for comparison to the standard.

2.6.1.3 Conclusions

The purpose of this project was to further investigate and evaluate any changes in ground water nitrate concentrations, nitrogen isotope ratios, and ion chemistry in the Springdale area since studies were done by DEQ in 2009 and 2010. The general water chemistry results for the 8 original project wells were similar to the results obtained from the 2009 and 2010 studies. Of the wells sampled for this project, 7 of the 10 wells (70%) exceeded EPA's MCL for nitrate. TDS concentrations exceeded the NSDWR standard of 500 mg/L in 8 of the 10 wells (80%). There were no nitrogen isotope signatures showing a waste source signature, unlike previous sampling rounds. Well 908 had the highest nitrogen isotope signature of 8.9‰; in 2008 the $\delta^{15}\text{N}$ was 10‰ and in 2010 it was 9.8‰. The majority of wells continue to show primarily a mixed source nitrogen isotope signature with only localized differences as in previous studies. These results imply that all three sources of nitrate (i.e., commercial fertilizer, animal and human waste, and plant decay) are contributing nitrate to ground water and need to be part of the solution to improve ground water quality in the area.

2.6.1.4 Recommendations

Additional ground water quality monitoring should be conducted throughout the Marsh Creek NPA and Springdale area to more fully document any nitrate trends over time and to better understand the sources of the nitrate contamination in the region. Future studies in this area would benefit from sampling newer wells with well drillers reports and uncompromised wellheads so that sources of contamination coupled with well or casing depth and lithology can better be evaluated.

Follow-up nitrate sampling of this project was recommended for spring 2016. This additional data along with historical ground water data from DEQ and ISDA could be used to conduct a trend analysis to determine if nitrate trends are still increasing.

If resources become available in the future, it is recommended that DEQ create a comprehensive report aimed at compiling and analyzing all ground water data collected by ISDA, IDWR, and DEQ for this area (dating back to the late 1990s) for the purpose of gaining a better understanding of the area and the apparent ground water impact from nitrate.

Nitrate concentrations continue to exceed the MCL in a majority of the sampled wells completed in the shallow alluvial aquifer of Springdale. This area appears to be very susceptible to contamination from various land uses. DEQ should continue promoting the use of BMPs, which have been proven to protect ground water from excessive nitrate leaching from soils on agricultural and residential land.

3 DEQ Cooperative Projects

This section presents data from special ground water quality monitoring and investigation projects that were conducted jointly by DEQ and other state agencies in calendar year 2015.

3.1 DEQ–ISDA Ground Water Monitoring Project

3.1.1 Purpose

The ISDA Ground Water Program has developed a ground water monitoring network across the state of Idaho to assess the impacts of pesticide use on ground water quality. DEQ partnered with ISDA and paid for analysis of nitrate and $\delta^{15}\text{N}$ to help assess ground water quality across the state. The ground water samples were collected by ISDA staff in conjunction with pesticide sampling events, while DEQ paid for the analysis. The data will help identify areas of concern and potential health threats associated with degraded ground water quality. Additionally, the information will be used to augment data from PWSs, the IDWR Statewide Ambient Ground Water Quality Monitoring Network, and local-scale monitoring projects to be used in the NPA ranking process.

3.1.2 Methods and Results

ISDA collected and analyzed samples from 214 domestic wells across the state following its EPA-approved QAPP (ISDA 2011). Samples were submitted to IBL in Boise, Idaho, for analysis of nitrate. Samples collected from 12 wells in Owyhee County were also analyzed for ammonia due to the anaerobic nature of the aquifer in the area. Most samples with nitrate concentrations above 5 mg/L were sent to the University of Arizona for $\delta^{15}\text{N}$ analysis. Field parameter and nitrate results are shown in Appendix C.

Nitrate and Nitrite Results

Nitrate concentrations for this project ranged from nondetect (<0.18 mg/L) to 113 mg/L. Out of the 214 samples collected for nitrate analysis, 54 samples (25%) met or exceeded the EPA MCL

of 10 mg/L for nitrate. In total, 169 samples (79%) were at or greater than 2 mg/L, indicating some type of non-naturally occurring nitrogen source; 2 mg/L is generally considered background level (DEQ 2014a).

Two wells (7901101 and 7904001) had samples analyzed for nitrite; nitrite concentrations in both samples were below the laboratory reporting limit of 0.30 mg/L.

Well locations and nitrate concentrations are shown in Table C1 and Figures C1–C17 in Appendix C.

Nitrogen Isotope Results

Nitrogen isotope ratio analysis was performed on 81 samples, all of which had nitrate concentrations at or greater than 5 mg/L. The $\delta^{15}\text{N}$ values ranged from 1.4‰ to 20.3‰ (Appendix C, Table C1). Samples from 21 wells had $\delta^{15}\text{N}$ values ranging from +1.4‰ to +3.9‰, suggesting commercial fertilizer as the likely nitrate source; 53 samples had $\delta^{15}\text{N}$ values between +4.0‰ and +8.7‰, suggesting organic nitrogen in soil or a mixed nitrogen source as the likely nitrate source; 7 wells had $\delta^{15}\text{N}$ values greater than +9‰, suggesting an animal or human waste source as the likely nitrate source (Table 3).

3.1.3 Conclusions

The cooperative project between ISDA and DEQ resulted in the cost-effective collection of additional nitrate and nitrogen isotope data that helped assess ground water quality across the state. Out of the 214 samples collected for nitrate analysis, 54 samples (25%) met or exceeded the EPA MCL of 10 mg/L for nitrate. The nitrate results indicate degraded ground water in specific vulnerable aquifers. The nitrogen isotope ratios provide one line of evidence for the potential sources of nitrogen contributing to the nitrate concentrations in ground water. These data will be helpful in the next NPA delineation and ranking process conducted by DEQ and the Ground Water Monitoring Technical Committee.

3.1.4 Recommendations

This project is an example of a cooperative effort between state agencies in Idaho saving time and money by using existing ground water monitoring networks and sampling schedules. ISDA and DEQ should continue these cooperative efforts to increase program efficiency and protect ground water quality in the state of Idaho.

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Appendix A. Missile Base Road Appendix

Table A1. WELL 2482 = ISDA Well 8650301, Owyhee County, Near Grandview.

ISDA Well ID	Sample No	Sample Date	Temp	pH	Spec Cond	TDS	Nitrate	Nitrite	OrthoP	Chloride	Sulfate	Ammonia	Bromide	Fluoride	Total Alkalinity
8650301	8650103	5/23/2006	15.6	7.14	2240	1120	120	ND	ND	160	400	BDL	ND	0.73	
8650301	8650703	5/15/2007	16.1	7.12	2513	1230	110	ND	ND	150	400	BDL	0.72	0.90	
8650301	8650790	5/15/2007	16.1	7.12	2513	1230	110	ND	ND	150	400	BDL	0.69	0.87	
8650301	8650603	5/16/2006	15.4	7.00	2320	1140	110	ND	BDL	150	380	BDL	ND	0.81	
8650301	8650803	7/26/2006	16.2	7.14	2560	1280	121	NA	NA	NA	NA	BDL	NA	NA	
8650301	8650703	6/29/2006	16.1	7.29	3620	1810	113	NA	NA	NA	NA	0.011	NA	NA	
8650301	8650903	8/30/2006	16.0	7.24	2390	1190	106	NA	0.02	159	396	BDL	NA	NA	
8650301	8651003	10/2/2006	15.6	7.25	2320	1160	120	NA	NA	NA	NA	NA	NA	NA	
8650301	8651103	11/6/2006	15.4	7.29	2610	1300	122	NA	NA	NA	NA	NA	NA	NA	
8650301	8651203	1/31/2007	15.3	7.28	2087	1460	122	NA	NA	NA	NA	NA	NA	NA	
8650301	8651303	3/29/2007	15.7	7.09	2547	1248	132	NA	NA	NA	NA	NA	NA	NA	
8650301	8650803	5/20/2008	15.6	7.21	2175	1066	100	ND	ND	140	420	BDL	0.63	1.0	
8650301	8650903	5/18/2009	15.8	6.95	3100	1519	100	ND	BDL	140	460	NA	0.65	0.98	
8650301	8651303	6/5/2013	15.4	6.50	2433	1191	97	ND	ND	150	490	NA	0.63	0.99	390
8650301	8651390	6/5/2013	15.4	6.50	2433	1191	98	ND	ND	150	500	NA	0.63	0.86	390
8650301	8651403	5/28/2014	15.3	6.95	2512	1230	110	NA	NA	NA	NA	BDL	NA	NA	

ISDA WellID	Sample No	Sample Date	Calcium	T_Iron	T_Mag	Magnesium	Potassium	Sodium	TKN	Total Coliform	Qual1	E_Coli	Qual2
8650301	8650103	5/23/2006	NA	NA	NA	NA	NA	NA	NA		<		<
8650301	8650703	5/15/2007	NA	NA	NA	NA	NA	NA	NA		<		<
8650301	8650790	5/15/2007	NA	NA	NA	NA	NA	NA	NA		<		<
8650301	8650603	5/16/2006	NA	NA	NA	NA	NA	NA	NA	100	<1	100	<1
8650301	8650803	7/26/2006	NA	NA	NA	NA	NA	NA	NA		<		<
8650301	8650703	6/29/2006	NA	NA	NA	NA	NA	NA	NA		<		<
8650301	8650903	8/30/2006	176	0.01	68	68	7.1	252	BDL		<		<
8650301	8651003	10/2/2006	NA	NA	NA	NA	NA	NA	NA		<		<
8650301	8651103	11/6/2006	NA	NA	NA	NA	NA	NA	NA		<		<
8650301	8651203	1/31/2007	NA	NA	NA	NA	NA	NA	NA		<		<
8650301	8651303	3/29/2007	NA	NA	NA	NA	NA	NA	NA		<		<
8650301	8650803	5/20/2008	NA	NA	NA	NA	NA	NA	NA		<		<
8650301	8650903	5/18/2009	NA	NA	NA	NA	NA	NA	NA		<		<
8650301	8651303	6/5/2013	300	NA	NA	78	6.2	260	NA		<		<
8650301	8651390	6/5/2013	200	NA	NA	76	6.3	260	NA		<		<
8650301	8651403	5/28/2014	NA	NA	NA	NA	NA	NA	NA		<		<

ISDA Well ID	Sample No	Sample Date	Barium	Cadmium	Cobalt	Chromium	Copper	Iron	Manganese	Molybdenum	Nickel	Vanadium	Zinc
8650301	8650103	5/23/2006											
8650301	8650703	5/15/2007											
8650301	8650790	5/15/2007											
8650301	8650603	5/16/2006											
8650301	8650803	7/26/2006											
8650301	8650703	6/29/2006											
8650301	8650903	8/30/2006							BDL				
8650301	8651003	10/2/2006											
8650301	8651103	11/6/2006											
8650301	8651203	1/31/2007											
8650301	8651303	3/29/2007											
8650301	8650803	5/20/2008											
8650301	8650903	5/18/2009											
8650301	8651303	6/5/2013	0.047	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.068	0.028
8650301	8651390	6/5/2013	0.047	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.067	0.028
8650301	8651403	5/28/2014											

ND = Not Detected NA = Not Sampled BDL = Below Detection Limit

Table A2. VOC results - Missile Base Rd. sampling event.

Site ID	Sample Date	Di-chloro-difluoro-methane	Chloro methane	Vinyl chloride	Bromo methane	Chloro ethane	Trichloro fluoromethane	Diethyl ether	1,1-Dichloro ethene	Acetone	Iodo methane	Carbon disulfide
(ug/L)												
2482	11/23/2015	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<10.0	<1.00	<0.500
2491	11/23/2015	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<10.0	<1.00	<0.500
2496	11/23/2015	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<10.0	<1.00	<0.500

Site ID	Sample Date	Allyl chloride	Methylene chloride	MTBE	trans-1,2-Dichloro ethene	Acrylo nitrile	1,1-Dichloro ethane	2,2-Dichloro propane	cis-1,2-Dichloro ethene	2-Butanone	Methyl Acrylate	Propio nitrile
(ug/L)												
2482	11/23/2015	<0.500	<0.500	<0.500	<0.500	<1.00	<0.500	<0.500	<0.500	<10.0	<0.500	<0.500
2491	11/23/2015	<0.500	<0.500	<0.500	<0.500	<1.00	<0.500	<0.500	<0.500	<10.0	<0.500	<0.500
2496	11/23/2015	<0.500	<0.500	<0.500	<0.500	<1.00	<0.500	<0.500	<0.500	<10.0	<0.500	<0.500

Site ID	Sample Date	Bromo chloro methane	Tetrahydro furan	Meth acrylo nitrile	Chloro form	1,1,1-Trichloro ethane	1-Chloro butane	Carbon tetra chloride	1,1-Dichloro propene	Benzene	1,2-Dichloro ethane	Trichloro ethene
(ug/L)												
2482	11/23/2015	<0.500	<1.00	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<10.0	<0.500	<0.500
2491	11/23/2015	<0.500	<1.00	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<10.0	<0.500	<0.500
2496	11/23/2015	<0.500	<1.00	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<10.0	<0.500	<0.500

Site ID	Sample Date	1,2-Dichloro propane	Methyl meth acrylate	Methacrylo nitrile	Dibromo methane	Bromo dichloro methane	2-Nitro propane	cis-1,3-Dichloro propene	Methyl Isobutyl Ketone	1,1-Dichloro-2-Propanone	Toluene	Ethylmeth acrylate
(ug/L)												
2482	11/23/2015	<0.500	<0.500	<0.500	<0.500	<0.500	<1.00	<0.500	<2.50	<5.00	<0.500	<0.500
2491	11/23/2015	<0.500	<0.500	<0.500	<0.500	<0.500	<1.00	<0.500	<2.50	<5.00	<0.500	<0.500
2496	11/23/2015	<0.500	<0.500	<0.500	<0.500	<0.500	<1.00	<0.500	<2.50	<5.00	<0.500	<0.500

Table A2 (continued). VOC results - Missile Base Rd. sampling event.

Site ID	Sample Date	trans-1,3-Dichloro propene	1,1,2-Trichloro ethane	Tetra chloro ethene	1,3-Dichloro propane	2-Hexanone	Dibromo chloro methane	1,2-Dibromo ethane	Chloro benzene	Ethyl benzene	1,1,1,2-Tetrachloro ethane	Xylene (total)
(ug/L)												
2482	11/23/2015	<1.00	<0.500	<0.500	<0.500	<2.50	<0.500	<0.500	<0.500	<0.500	<0.500	<1.00
2491	11/23/2015	<1.00	<0.500	<0.500	<0.500	<2.50	<0.500	<0.500	<0.500	<0.500	<0.500	<1.00
2496	11/23/2015	<1.00	<0.500	<0.500	<0.500	<2.50	<0.500	<0.500	<0.500	<0.500	<0.500	<1.00

Site ID	Sample Date	m,p-Xylene	o-Xylene	Styrene	Bromo form	Isopropyl benzene (Cumene)	Bromo benzene	1,1,2,2-Tetrachloro ethane	trans-1,4-Dichloro-2-Butene	2-Chloro toluene	1,3,5-Trimethyl benzene	4-Chloro toluene
(ug/L)												
2482	11/23/2015	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<1.00
2491	11/23/2015	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<1.00
2496	11/23/2015	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<1.00

Site ID	Sample Date	tert-Butyl benzene	1,2,4-Trimethyl benzene	Penta Chloro ethane	sec-Butyl benzene	p-Isopropyl toluene	1,3-Dichloro benzene	1,4-Dichloro benzene	n-Butyl benzene	1,2-Dichloro benzene	Hexachloro ethane	1,2-Dibromo-3-chloro propane
(ug/L)												
2482	11/23/2015	<0.500	<1.00	<1.00	<1.00	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500
2491	11/23/2015	<0.500	<1.00	<1.00	<1.00	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500
2496	11/23/2015	<0.500	<1.00	<1.00	<1.00	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500

Site ID	Sample Date	1,2,4-Trichloro benzene	Hexa chloro butadiene	Naphthalene	1,2,3-Trichlorobenzene
(ug/L)					
2482	11/23/2015	<0.500	<0.500	<0.500	<0.500
2491	11/23/2015	<0.500	<0.500	<0.500	<0.500
2496	11/23/2015	<0.500	<0.500	<0.500	<0.500

Table A3. Pesticide Results - Missile Base Rd. Synoptic Ground Water Monitoring Project 2015.

Site ID	Sample Date	4,4- DDD	4,4- DDE	4,4- DDT	Alachlor	Aldrin	alpha- BHC	Atrazine	Azinphos- methyl	beta- BHC	Bolstar	Bromacil	Carbo phenothion	Chlorpyrifos
(ug/L)														
2482	11/23/2015	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
2491	11/23/2015	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
2496	11/23/2015	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

Site ID	Sample Date	Coumaphos	delta- BHC	Demeton	Diazinon	Dichlorvos	Dieldrin	Dimethoate	Disulfoton	Endosulfan I	Endosulfan II
(ug/L)											
2482	11/23/2015	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
2491	11/23/2015	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
2496	11/23/2015	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

Site ID	Sample Date	Endosulfan sulfate	Endrin	Endrin aldehyde	Endrin ketone	EPN	Ethoprop	Ethyl parathion	Fensulfothion	Fenthion	gamma- BHC (Lindane)	Heptachlor
(ug/L)												
2482	11/23/2015	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
2491	11/23/2015	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
2496	11/23/2015	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

Site ID	Sample Date	Heptachlor epoxide	Malathion	Merphos	Methoxychlor	Methyl parathion	Metolachlor	Metribuzin	Mevin phos	Mono crotophos	Naled	Pendi methalin
(ug/L)												
2482	11/23/2015	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
2491	11/23/2015	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
2496	11/23/2015	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

Site ID	Sample Date	Permethrin	Phorate	Phosmet	Ronnel	Simazine	Stirophos	Sulfotep	Terbacil	Tokuthion	Trichloronate	Trifluralin
(ug/L)												
2482	11/23/2015	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
2491	11/23/2015	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
2496	11/23/2015	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

Appendix B. Project Analyte Lists

Bannock County Volatile Organic Compound Reconnaissance Project.

Constituent	RDL	Units
Dichlorodifluoromethane	0.5	ug/L
Chloromethane	0.5	ug/L
Vinyl chloride	0.5	ug/L
Bromomethane	0.5	ug/L
Chloroethane	0.5	ug/L
Trichlorofluoromethane	0.5	ug/L
Diethyl ether	0.5	ug/L
1,1-Dichloroethene	0.5	ug/L
Acetone	10	ug/L
Iodomethane	1	ug/L
Carbon disulfide	0.5	ug/L
Allyl chloride	0.5	ug/L
Methylene chloride	0.5	ug/L
MTBE	0.5	ug/L
trans-1,2-Dichloroethene	0.5	ug/L
Acrylonitrile	1	ug/L
1,1-Dichloroethane	0.5	ug/L
2,2-Dichloropropane	0.5	ug/L
cis-1,2-Dichloroethene	0.5	ug/L
2-Butanone	10	ug/L
Methyl Acrylate	0.5	ug/L
Propionitrile	0.5	ug/L
Bromochloromethane	0.5	ug/L
Tetrahydrofuran	1	ug/L
Methacrylonitrile	0.5	ug/L
Chloroform	0.5	ug/L
1,1,1-Trichloroethane	0.5	ug/L
1-Chlorobutane	0.5	ug/L

Constituent	RDL	Units
Carbon tetrachloride	0.5	ug/L
1,1-Dichloropropene	0.5	ug/L
Benzene	0.5	ug/L
1,2-Dichloroethane	0.5	ug/L
Trichloroethene	0.5	ug/L
1,2-Dichloropropane	0.5	ug/L
Methyl methacrylate	0.5	ug/L
Dibromomethane	0.5	ug/L
Bromodichloromethane	0.5	ug/L
2-Nitropropane	1	ug/L
cis-1,3-Dichloropropene	0.5	ug/L
Methyl Isobutyl Ketone	2.5	ug/L
1,1-Dichloro-2-Propanone	5	ug/L
Toluene	0.5	ug/L
Ethyl methacrylate	0.5	ug/L
trans-1,3-Dichloropropene	1	ug/L
1,1,2-Trichloroethane	0.5	ug/L
Tetrachloroethene	0.5	ug/L
1,3-Dichloropropane	0.5	ug/L
2-Hexanone	2.5	ug/L
Dibromochloromethane	0.5	ug/L
1,2-Dibromoethane	0.5	ug/L
Chlorobenzene	0.5	ug/L
Ethylbenzene	0.5	ug/L
1,1,1,2-Tetrachloroethane	0.5	ug/L
Xylene (total)	1	ug/L
m,p-Xylene	0.5	ug/L
o-Xylene	0.5	ug/L

Constituent	RDL	Units
Styrene	0.5	ug/L
Bromoform	0.5	ug/L
Isopropylbenzene (Cumene)	0.5	ug/L
Bromobenzene	0.5	ug/L
1,1,2,2-Tetrachloroethane	0.5	ug/L
n-Propylbenzene	0.5	ug/L
1,2,3-Trichloropropane	0.5	ug/L
trans-1,4-Dichloro-2-Butene	0.5	ug/L
2-Chlorotoluene	0.5	ug/L
1,3,5-Trimethylbenzene	0.5	ug/L
4-Chlorotoluene	0.5	ug/L
tert-Butylbenzene	0.5	ug/L
1,2,4-Trimethylbenzene	1	ug/L
Pentachloroethane	1	ug/L
sec-Butylbenzene	1	ug/L
p-Isopropyltoluene	0.5	ug/L
1,3-Dichlorobenzene	0.5	ug/L
1,4-Dichlorobenzene	0.5	ug/L
n-Butylbenzene	0.5	ug/L
1,2-Dichlorobenzene	0.5	ug/L
Hexachloroethane	0.5	ug/L
1,2-Dibromo-3-chloropropane	0.5	ug/L
1,2,4-Trichlorobenzene	0.5	ug/L
Hexachlorobutadiene	0.5	ug/L
Naphthalene	0.5	ug/L
1,2,3-Trichlorobenzene	0.5	ug/L

ug/L = micrograms per liter; RDL = Reporting Detection Level

Dayton Landfill Springs Monitoring Project.

Constituent	RDL	Units
Chloride	4	mg/L
Ammonia as N	0.01	mg/L
Alkalinity as (CaCO ₃)	1	mg/L
Total Kjeldahl Nitrogen	0.1	mg/L
Total Dissolved Solids	10	mg/L
Nitrate as N	0.18	mg/L
Sulfate	0.8	mg/L
Antimony	0.001	mg/L
Arsenic	0.002	mg/L
Barium	0.001	mg/L
Beryllium	0.001	mg/L
Cadmium	0.001	mg/L
Chromium	0.001	mg/L
Calcium	0.1	mg/L
Cobalt	0.001	mg/L
Copper	0.001	mg/L
Total Hardness	1	mg/L
Iron	0.01	mg/L
Lead	0.001	mg/L
Magnesium	0.1	mg/L
Potassium	0.1	mg/L
Nickel	0.001	mg/L
Sodium	0.1	mg/L
Selenium	0.002	mg/L
Silver	0.001	mg/L
Thallium	0.001	mg/L
Vanadium	0.001	mg/L
Zinc	0.005	mg/L
Dichlorodifluoromethane	0.5	ug/L
Chloromethane	0.5	ug/L
Vinyl chloride	0.5	ug/L
Bromomethane	0.5	ug/L
Chloroethane	0.5	ug/L
Trichlorofluoromethane	0.5	ug/L
Diethyl ether	0.5	ug/L
1,1-Dichloroethene	0.5	ug/L
Acetone	10	ug/L

Constituent	RDL	Units
Iodomethane	1	ug/L
Carbon disulfide	0.5	ug/L
Allyl chloride	0.5	ug/L
Methylene chloride	0.5	ug/L
MTBE	0.5	ug/L
trans-1,2-Dichloroethene	0.5	ug/L
Acrylonitrile	1	ug/L
1,1-Dichloroethane	0.5	ug/L
2,2-Dichloropropane	0.5	ug/L
cis-1,2-Dichloroethene	0.5	ug/L
2-Butanone	10	ug/L
Methyl Acrylate	0.5	ug/L
Propionitrile	0.5	ug/L
Bromochloromethane	0.5	ug/L
Tetrahydrofuran	1	ug/L
Methacrylonitrile	0.5	ug/L
Chloroform	0.5	ug/L
1,1,1-Trichloroethane	0.5	ug/L
1-Chlorobutane	0.5	ug/L
Carbon tetrachloride	0.5	ug/L
1,1-Dichloropropene	0.5	ug/L
Benzene	0.5	ug/L
1,2-Dichloroethane	0.5	ug/L
Trichloroethene	0.5	ug/L
1,2-Dichloropropane	0.5	ug/L
Methyl methacrylate	0.5	ug/L
Dibromomethane	0.5	ug/L
Bromodichloromethane	0.5	ug/L
2-Nitropropane	1	ug/L
cis-1,3-Dichloropropene	0.5	ug/L
Methyl isobutyl Ketone	2.5	ug/L
1,1-Dichloro-2-Propanone	5	ug/L
Toluene	0.5	ug/L
Ethyl methacrylate	0.5	ug/L
trans-1,3-Dichloropropene	1	ug/L
1,1,2-Trichloroethane	0.5	ug/L
Tetrachloroethene	0.5	ug/L

Constituent	RDL	Units
1,3-Dichloropropane	0.5	ug/L
2-Hexanone	2.5	ug/L
Dibromochloromethane	0.5	ug/L
1,2-Dibromoethane	0.5	ug/L
Chlorobenzene	0.5	ug/L
Ethylbenzene	0.5	ug/L
1,1,1,2-Tetrachloroethane	0.5	ug/L
Xylene (total)	1	ug/L
mp-Xylene	0.5	ug/L
o-Xylene	0.5	ug/L
Styrene	0.5	ug/L
Bromoform	0.5	ug/L
Isopropylbenzene (Cumene)	0.5	ug/L
Bromobenzene	0.5	ug/L
1,1,1,2-Tetrachloroethane	0.5	ug/L
n-Propylbenzene	0.5	ug/L
1,2,3-Trichloropropane	0.5	ug/L
trans-1,4-Dichloro-2-Butene	0.5	ug/L
2-Chlorotoluene	0.5	ug/L
1,3,5-Trimethylbenzene	0.5	ug/L
4-Chlorotoluene	0.5	ug/L
tert-Butylbenzene	0.5	ug/L
1,2,4-Trimethylbenzene	1	ug/L
Pentachloroethane	1	ug/L
sec-Butylbenzene	1	ug/L
p-Isopropyltoluene	0.5	ug/L
1,3-Dichlorobenzene	0.5	ug/L
1,4-Dichlorobenzene	0.5	ug/L
n-Butylbenzene	0.5	ug/L
1,2-Dichlorobenzene	0.5	ug/L
Hexachloroethane	0.5	ug/L
1,2-Dibromo-3-chloropropane	0.5	ug/L
1,2,4-Trichlorobenzene	0.5	ug/L
Hexachlorobutadiene	0.5	ug/L
Naphthalene	0.5	ug/L
1,2,3-Trichlorobenzene	0.5	ug/L
Chemical oxygen demand	20	mg/L

mg/L = milligrams per liter; ug/L = micrograms per liter; RDL = Reporting Detection Limit.

Appendix C. Idaho State Department of Agriculture (ISDA) 2015 Data

Table C1. DEQ–ISDA Ground Water Monitoring Project data.

ISDA Well ID	Sample Date	Temperature (°C)	pH ^a	Specific Conductivity (µS/cm)	TDS ^a (mg/L)	Nitrate ^b (mg/L)	Ammonia (mg/L)	δ ¹⁵ N (‰)
<i>Primary or Secondary Standard:</i>			6.5–8.5	NA	500	10	NA	NA
2200301	5/14/2015	14.3	7.02	685	335	11.3	NA	3.2
2201701	5/14/2015	17.8	6.92	364	178	2.64	NA	NA
2201801	5/13/2015	13.6	6.68	536	262	4.75	NA	NA
2203001	5/13/2015	13.9	6.51	542	266	4.89	NA	NA
2203101	5/13/2015	13.7	6.63	784	385	8.08	NA	6.3
2204701	5/14/2015	15.1	6.68	685	336	6.24	NA	5.5
2205701	5/14/2015	14.4	6.95	556	272	5.79	NA	4.8
2207301	5/14/2015	14.9	7.15	413	202	3.28	NA	NA
2207801	5/13/2015	13.8	6.45	697	341	13.9	NA	6.3
3003001	9/9/2015	13.6	7.33	281	138	<0.18	NA	NA
3003101	9/9/2015	12.6	6.95	285.7	140	4.22	NA	NA
3003601	9/9/2015	16.1	6.34	174.6	85	7.69	NA	4.9
3003701	9/9/2015	11.8	6.88	181.1	89	1.72	NA	NA
3004601	6/15/2015	17.5	7.54	931	456	13.8	NA	NA
3100201	6/8/2015	20.6	7.3	2044	1002	0.531	5.6	NA
3100401	6/8/2015	21	7.67	2078	1019	<0.18	8.0	NA
3100601	6/8/2015	22.6	7.52	2355	1154	0.645	8.4	NA
3101101	6/8/2015	19.8	7.39	2460	1205	<0.18	10	NA
3101601	6/8/2015	20.5	7.62	2180	1070	0.702	8.8	NA
3200101	6/17/2015	9.1	7.04	357	175	8.62	NA	NA
3300401	8/12/2015	21.5	8.08	167.8	82	1.60	NA	NA
3300501	8/12/2015	16.4	8.05	211.5	104	<0.18	NA	NA
3400101	5/18/2015	15.4	6.90	835	408	7.69	NA	2.6
3400501	5/18/2015	15.1	6.93	930	455	11.0	NA	3.9
3400701	5/18/2015	15.7	6.98	714	350	0.685	NA	NA
3401401	5/18/2015	14.7	6.96	648	317	5.91	NA	5.1
3401501	5/18/2015	14.4	7.18	827	406	9.32	NA	3.2
5302001	5/12/2015	13.2	7.08	486	238	12.0	NA	6.8
5302401	5/12/2015	13.2	6.56	690	339	16.9	NA	8.2
5303301	5/12/2015	14	6.72	653	320	25.9	NA	8.7
5303401	5/13/2015	13.7	6.41	940	462	41.3	NA	7.9
5303701	5/12/2015	13.4	6.61	684	335	29.5	NA	7.0
7100101	5/21/2015	16.5	7.01	910	446	4.40	NA	NA
7100201	5/21/2015	14.3	6.92	1446	709	52.3	NA	3.5
7100401	5/21/2015	16.5	7.14	472	231	0.268	NA	NA
7100501	6/3/2015	13.8	7.14	741	363	12.8	NA	1.7

ISDA Well ID	Sample Date	Temperature (°C)	pH ^a	Specific Conductivity (µS/cm)	TDS ^a (mg/L)	Nitrate ^b (mg/L)	Ammonia (mg/L)	δ ¹⁵ N (‰)
<i>Primary or Secondary Standard:</i>			6.5–8.5	NA	500	10	NA	NA
7100601	6/3/2015	15.5	6.92	779	382	12.5	NA	4.2
7100901	6/1/2015	14.5	7.01	845	414	13.1	NA	4.3
7101201	6/4/2015	13.2	7.27	881	432	8.92	NA	6.7
7101701	6/3/2015	15	6.88	644	316	8.94	NA	2.6
7102101	6/1/2015	14.5	6.85	522	256	5.05	NA	6.4
7102301	6/3/2015	14.1	7.28	639	313	6.42	NA	5.1
7102501	6/1/2015	14.5	6.72	1338	656	14.3	NA	7.2
7102701	6/3/2015	13.4	7.18	642	315	<0.18	NA	NA
7102901	6/4/2015	13.7	7.22	500	245	3.79	NA	NA
7103301	5/27/2015	15.8	7.04	640	313	6.94	NA	5.5
7103601	6/4/2015	12.7	7.53	812	398	3.63	NA	NA
7103701	5/21/2015	14.4	6.96	600	294	3.71	NA	NA
7103801	6/1/2015	16.7	6.96	772	378	10.8	NA	4.4
7103901	6/1/2015	14.8	6.82	586	287	6.16	NA	2.0
7104001	6/3/2015	14.4	7.10	841	412	19.0	NA	1.9
7104101	5/27/2015	13.5	6.96	1547	758	28.7	NA	3.9
7104201	6/1/2015	14.8	6.90	582	285	9.20	NA	6.2
7104401	5/21/2015	16.1	6.78	802	393	10.0	NA	2.9
7104601	6/4/2015	15.1	7.18	669	328	7.31	NA	4.4
7104701	6/4/2015	16	6.98	956	468	12.3	NA	2.9
7104801	5/27/2015	14.2	7.16	823	403	11.7	NA	1.4
7105101	6/3/2015	14	6.94	683	334	9.93	NA	5.5
7107001	5/27/2015	13.8	7.03	1107	542	27.0	NA	2.1
7107101	5/27/2015	14	7.04	576	282	1.52	NA	NA
7300201	7/16/2015	13.7	6.95	883	433	8.65	NA	4.8
7300501	7/14/2015	17.3	7.05	435	214	2.13	NA	NA
7300801	7/13/2015	12.3	7.12	1084	531	24.2	NA	NA
7300901	7/15/2015	14.2	7.26	1052	515	7.48	NA	20.3
7301101	7/14/2015	15.3	7.08	455	224	5.71	NA	NA
7301301	7/16/2015	17.2	7.12	553	271	1.04	NA	NA
7301501	7/16/2015	15	7.15	609	297	<0.18	NA	NA
7301601	7/14/2015	12.9	6.84	633	308	9.72	NA	NA
7301801	7/16/2015	15.5	7.08	790	387	6.60	NA	4.4
7301901	7/15/2015	15.5	7.03	1033	506	14.3	NA	10.2
7302001	7/14/2015	16.8	6.96	437	214	3.72	NA	NA
7302301	7/16/2015	17.6	7.02	570	279	3.55	NA	NA
7302801	7/15/2015	13.9	7.26	2421	1186	8.50	NA	13.0
7303001	7/16/2015	15.8	7.18	576	282	2.95	NA	NA
7303101	7/15/2015	15.8	7.33	662	324	4.78	NA	NA
7303201	7/16/2015	14	6.98	3570	1752	45.1	NA	10.0

ISDA Well ID	Sample Date	Temperature (°C)	pH ^a	Specific Conductivity (µS/cm)	TDS ^a (mg/L)	Nitrate ^b (mg/L)	Ammonia (mg/L)	δ ¹⁵ N (‰)
<i>Primary or Secondary Standard:</i>			6.5–8.5	NA	500	10	NA	NA
7303401	7/15/2015	13.7	7.36	576	283	<0.18	NA	NA
7303501	7/13/2015	14.5	7.02	742	361	0.388	NA	NA
7303901	7/16/2015	16	7.03	641	314	7.92	NA	4.0
7304101	7/14/2015	14.5	6.97	502	247	9.75	NA	NA
7304301	7/16/2015	16.2	7.02	640	313	3.15	NA	NA
7304501	7/14/2015	18.2	6.98	681	332	10.6	NA	NA
7400401	7/16/2015	14.2	6.92	542	265	1.79	NA	NA
7401801	7/14/2015	14.2	6.97	638	312	5.84	NA	5.2
7402001	7/14/2015	14.1	7.08	718	352	6.41	NA	6.0
7403201	7/14/2015	14.7	6.97	609	299	4.60	NA	NA
7404801	7/13/2015	14.4	7.12	590	289	8.10	NA	NA
7404901	7/13/2015	16.1	7.15	302	148	0.792	NA	NA
7405101	7/14/2015	15.7	6.97	536	263	5.53	NA	5.7
7501401	7/7/2015	15	7.04	456	223	3.88	NA	NA
7502401	7/7/2015	15.6	7.00	469	230	3.12	NA	NA
7504701	7/7/2015	15.8	7.11	436	214	1.78	NA	NA
7504801	7/7/2015	18.6	7.09	446	218	2.94	NA	NA
7505501	7/8/2015	15.2	7.12	390	191	8.44	NA	NA
7505601	7/7/2015	14.9	7.05	433	212	3.26	NA	NA
7505801	7/8/2015	15.2	7.12	421	206	3.16	NA	NA
7506601	7/8/2015	15.6	7.02	370	181	7.62	NA	NA
7507001	7/8/2015	14.8	7.13	763	375	11.0	NA	NA
7807401	7/9/2015	16.4	7.01	442	217	3.11	NA	NA
7600601	5/12/2015	13.5	6.63	738	361	39.2	NA	7.4
7701101	5/20/2015	14.7	6.92	539	264	6.46	NA	4.6
7701401	5/19/2015	15.4	7.08	611	299	<0.18	NA	NA
7701701	5/19/2015	12.7	6.98	904	443	3.87	NA	NA
7702001	5/20/2015	15	6.90	1297	636	21.1	NA	10.5
7703001	5/20/2015	14.3	7.02	255	125	1.76	NA	NA
7703201	5/19/2015	14.4	7.03	730	358	3.34	NA	NA
7703501	5/19/2015	14.5	7.61	176.7	86	<0.18	NA	NA
7703601	5/19/2015	14.4	6.94	810	397	15.1	NA	4.8
7705301	5/18/2015	14.4	7.03	830	407	13.4	NA	3.8
7801701	7/9/2015	15	7.00	639	313	7.72	NA	3.5
7803601	7/9/2015	13.2	7.01	730	358	8.48	NA	5.9
7804201	7/8/2015	13.1	7.12	575	282	7.72	NA	6.6
7804301	7/8/2015	14.2	7.13	620	304	7.69	NA	7.5
7804401	7/9/2015	15.4	7.00	601	295	3.48	NA	NA
7805501	7/8/2015	14	7.00	592	290	2.92	NA	NA
7805601	7/9/2015	14.3	7.00	582	285	6.82	NA	7.2

ISDA Well ID	Sample Date	Temperature (°C)	pH ^a	Specific Conductivity (µS/cm)	TDS ^a (mg/L)	Nitrate ^b (mg/L)	Ammonia (mg/L)	δ ¹⁵ N (‰)
<i>Primary or Secondary Standard:</i>			6.5–8.5	NA	500	10	NA	NA
7805701	7/9/2015	14	7.01	578	284	8.57	NA	8.1
7806401	7/9/2015	14.7	7.02	484	237	4.03	NA	NA
7806601	7/8/2015	12.8	7.01	563	277	4.80	NA	NA
7900101	7/23/2015	17.2	7.40	870	427	4.82	NA	NA
7900601	7/20/2015	13.4	7.18	834	409	8.33	NA	5.3
7900701	7/20/2015	14	6.98	754	370	11.0	NA	5.5
7900801	7/22/2015	13.7	7.28	779	381	10.1	NA	7.0
7900901	7/22/2015	14.1	7.15	669	328	4.91	NA	NA
7901001	7/22/2015	14.2	7.14	825	395	11.2	NA	3.4
7901101	7/23/2015	16.3	7.27	622	305	3.85	NA	NA
7901301	7/20/2015	16.3	6.96	516	253	3.35	NA	NA
7901401	7/21/2015	13.4	7.17	920	450	14.7	NA	9.1
7901501	7/22/2015	14.1	7.28	869	425	7.34	NA	3.5
7901601	7/21/2015	12.3	7.15	864	423	10.2	NA	4.5
7901701	7/21/2015	13.6	7.18	697	341	6.99	NA	4.0
7901801	7/22/2015	14.1	7.30	510	250	1.12	NA	NA
7901901	7/21/2015	12.5	7.26	958	469	13.4	NA	5.9
7902001	7/21/2015	13.6	7.20	807	394	11.9	NA	4.3
7902101	7/21/2015	16.4	7.22	756	370	12.2	NA	4.4
7902201	7/22/2015	13.3	7.05	668	327	1.48	NA	NA
7902401	7/22/2015	12.5	6.98	884	433	5.41	NA	5.6
7903201	7/22/2015	12.6	7.14	777	382	7.24	NA	6.9
7903501	7/21/2015	12.4	7.12	936	460	13.4	NA	6.2
7903601	7/20/2015	14.2	7.12	774	379	9.70	NA	6.8
7903701	7/20/2015	14.8	6.94	694	340	8.01	NA	7.5
7903801	7/23/2015	16.3	7.12	672	330	4.84	NA	NA
7904001	7/23/2015	14.6	7.06	680	333	4.53	NA	NA
7904101	7/23/2015	13.1	7.12	614	301	5.58	NA	6.6
7904401	7/22/2015	14.2	7.32	570	279	3.15	NA	NA
8050301	6/17/2015	10.6	7.01	490	240	9.56	NA	NA
8051301	6/17/2015	12.5	7.14	274.8	135	5.37	NA	NA
8051401	6/17/2015	10.1	7.02	358	175	7.73	NA	NA
8050801	6/17/2015	12	7.28	288.6	141	5.82	NA	NA
8053401	6/17/2015	10	7.04	239.2	117	1.52	NA	NA
8053501	6/17/2015	9	7.01	369	181	11.1	NA	NA
8054601	6/17/2015	11.1	7.12	382	187	16.1	NA	NA
8100401	6/11/2015	14.3	7.42	1109	NA	13.1	NA	NA
8101601	6/11/2015	14.9	6.92	452	223	13.0	NA	NA
8102101	6/15/2015	14.8	7.12	443	218	9.62	NA	NA
8102601	6/11/2015	12.7	6.88	1069	524	9.07	NA	NA

ISDA Well ID	Sample Date	Temperature (°C)	pH ^a	Specific Conductivity (µS/cm)	TDS ^a (mg/L)	Nitrate ^b (mg/L)	Ammonia (mg/L)	δ ¹⁵ N (‰)
<i>Primary or Secondary Standard:</i>			6.5–8.5	NA	500	10	NA	NA
8201201	9/10/2015	10.2	7.82	225.7	111	2.31	NA	NA
8204601	9/10/2015	10	7.69	248	122	1.46	NA	NA
8204701	9/10/2015	10.4	7.58	273.6	134	0.993	NA	NA
8204801	9/10/2015	9.2	7.67	248.3	122	0.601	NA	NA
8205001	9/10/2015	9.5	7.61	265.4	130	<0.18	NA	NA
8205101	9/10/2015	9	7.58	292.9	144	2.31	NA	NA
8205201	9/10/2015	11.3	7.59	244.4	119	1.86	NA	NA
8300301	6/16/2015	12.9	7.01	279.9	137	4.16	NA	NA
8300401	6/16/2015	13.5	7.01	265.1	130	3.19	NA	NA
8300501	6/16/2015	13.6	7.45	285	139	3.93	NA	NA
8301101	6/16/2015	13	7.02	268	131	1.04	NA	NA
8303001	6/16/2015	11.5	7.01	661	324	6.98	NA	NA
8404301	6/18/2015	12.9	7.03	348	170	0.715	NA	NA
8404801	6/18/2015	12.6	7.48	442	216	2.37	NA	NA
8405001	6/18/2015	12.1	7.03	380	187	1.72	NA	NA
8405801	6/18/2015	12.2	7.03	401	196	0.974	NA	NA
8406101	6/18/2015	12.9	7.03	417	204	1.47	NA	NA
8600801	6/9/2015	16.2	7.31	915	448	<0.18	2.9	NA
8601101	6/8/2015	15	7.19	2264	1109	4.82	<0.010	NA
8601401	6/9/2015	15.4	6.74	1287	630	6.86	<0.010	NA
8601801	6/9/2015	18.3	7.77	880	432	<0.18	5.3	NA
8602001	6/9/2015	14.9	6.79	2097	1028	9.22	0.31	NA
8602901	6/9/2015	19.5	7.55	1961	961	<0.18	10	NA
8603001	6/9/2015	22.7	7.14	1336	654	<0.18	9.7	NA
8651501	6/10/2015	15.3	6.72	940	460	13.2	NA	NA
8650201	6/11/2015	17.1	6.94	799	392	9.37	NA	NA
8650301	6/10/2015	15.3	6.70	2492	NA	113	NA	NA
8650501	6/10/2015	17.6	7.07	1950	956	18.7	NA	NA
8650601	6/11/2015	14.2	6.95	1138	558	4.75	NA	NA
8650701	6/10/2015	15.6	7.09	1265	620	36.2	NA	NA
8653401	6/11/2015	15.2	6.94	923	452	3.62	NA	NA
8655001	6/11/2015	14.4	6.95	886	434	5.06	NA	NA
8700501	6/23/2015	12.2	7.09	561	275	9.94	NA	NA
8700601	6/23/2015	16.2	7.05	457	224	6.85	NA	NA
8700801	6/23/2015	14.3	7.05	659	323	5.84	NA	NA
8700201	6/23/2015	15.2	7.06	604	296	8.35	NA	NA
8701401	6/23/2015	14.7	7.04	634	311	6.10	NA	NA
8701601	6/23/2015	17	7.07	515	252	6.62	NA	NA
8900401	6/15/2015	17	7.21	890	436	6.92	NA	NA
8900501	6/15/2015	17.6	7.43	717	351	3.36	NA	NA

ISDA Well ID	Sample Date	Temperature (°C)	pH ^a	Specific Conductivity (µS/cm)	TDS ^a (mg/L)	Nitrate ^b (mg/L)	Ammonia (mg/L)	δ ¹⁵ N (‰)
<i>Primary or Secondary Standard:</i>			6.5–8.5	NA	500	10	NA	NA
8900201	6/15/2015	16.3	7.41	686	336	2.72	NA	NA
8900801	6/15/2015	16.4	7.30	1497	734	47.4	NA	NA
8901801	6/15/2015	17.1	7.34	977	479	12.8	NA	NA
9500201	8/10/2015	17.8	7.33	347	170	5.94	NA	5.1
9501201	8/11/2015	13.2	7.87	181.2	89	0.816	NA	NA
9501401	8/10/2015	15	7.19	647	317	39.1	NA	13.2
9501901	8/12/2015	22.3	7.49	306	150	3.95	NA	NA
9502201	8/11/2015	14.8	7.54	272.8	134	11.3	NA	5.0
9502801	8/10/2015	13.9	7.96	244	120	<0.18	NA	NA
9504301	8/10/2015	11.8	7.32	524	257	24.4	NA	3.2
9504501	8/11/2015	16.1	7.27	154.7	76	2.80	NA	NA
9505401	8/12/2015	12.3	7.64	339	166	14.2	NA	3.4
9505501	8/12/2015	20.7	8.11	200.9	98	<0.18	NA	NA
9505701	8/11/2015	11.1	7.62	181.4	89	2.02	NA	NA
9506001	8/10/2015	12.4	7.05	2134	105	5.96	NA	2.9
9506401	8/11/2015	13	7.82	210.3	102	<0.18	NA	NA
9507001	8/10/2015	12.4	7.33	445	218	18.4	NA	4.7
9507901	8/10/2015	14.1	6.92	194.8	95	1.70	NA	NA

Notes: Bolded red numbers indicate EPA's National Primary Drinking Water Regulation standard, expressed as a maximum contaminant level (MCL), was reached or exceeded. Italicized red numbers indicate EPA's National Secondary Drinking Water Regulation standard was exceeded. These regulations are applicable for public water systems only and are used with private wells to evaluate water quality.

^a Contaminant with a National Secondary Drinking Water Regulation standard.

^b Contaminant with a National Primary Drinking Water Regulation standard.

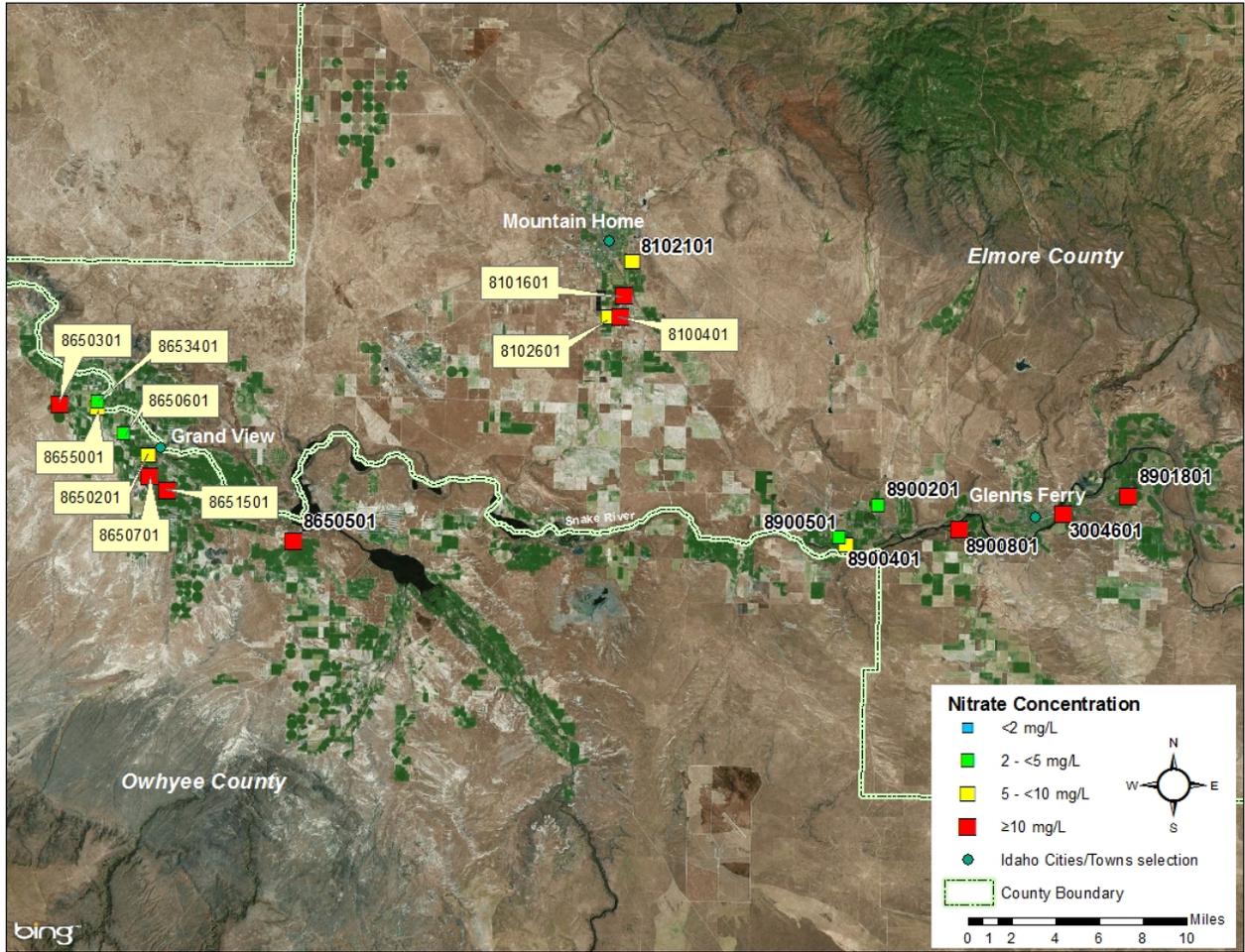


Figure C1. Elmore and Owyhee Counties nitrate concentrations, 2015 ISDA data.

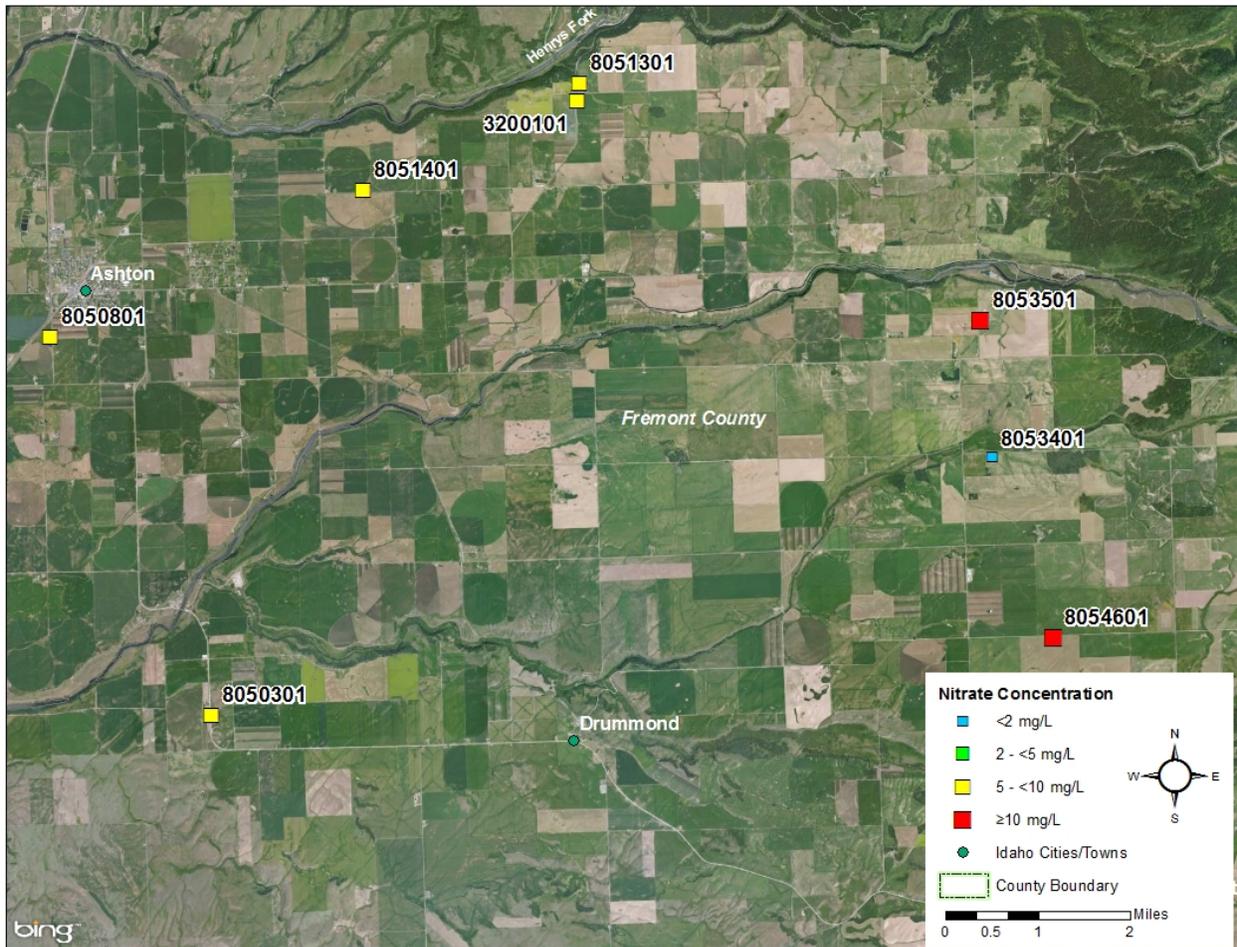


Figure C2. Fremont County nitrate concentrations, 2015 ISDA data.

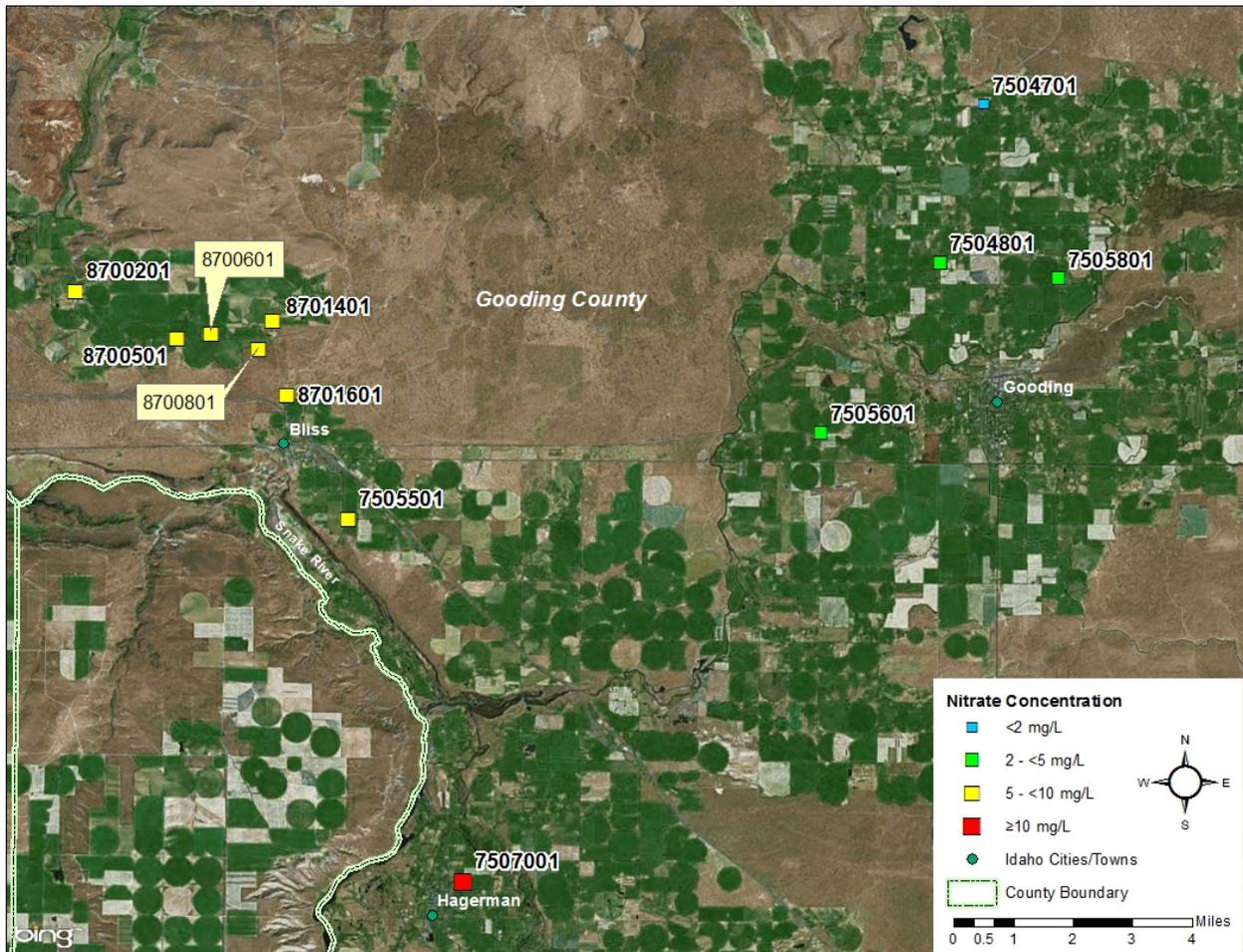


Figure C3. Gooding County nitrate concentrations, 2015 ISDA data.

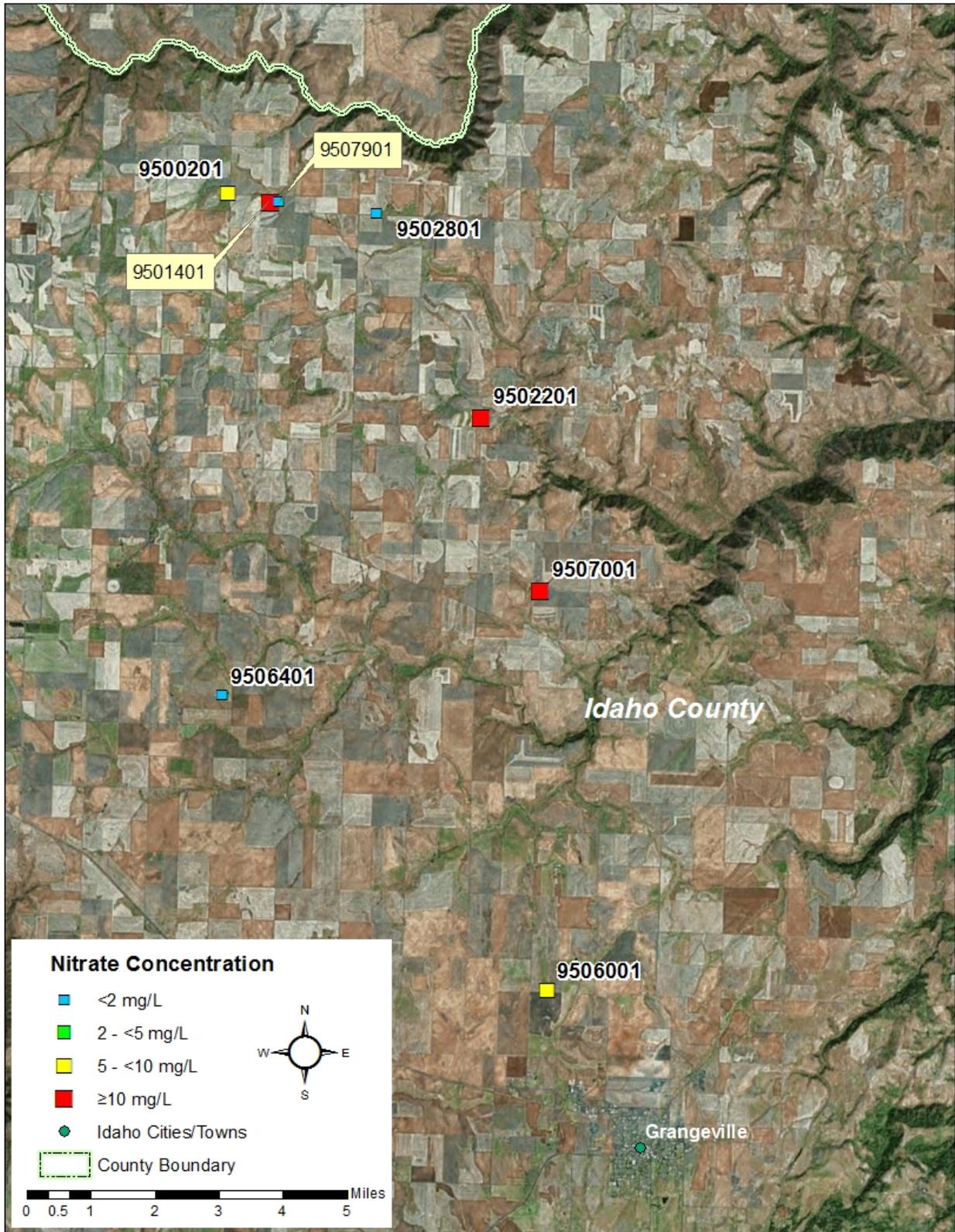


Figure C4. Idaho County nitrate concentrations, 2015 ISDA data.

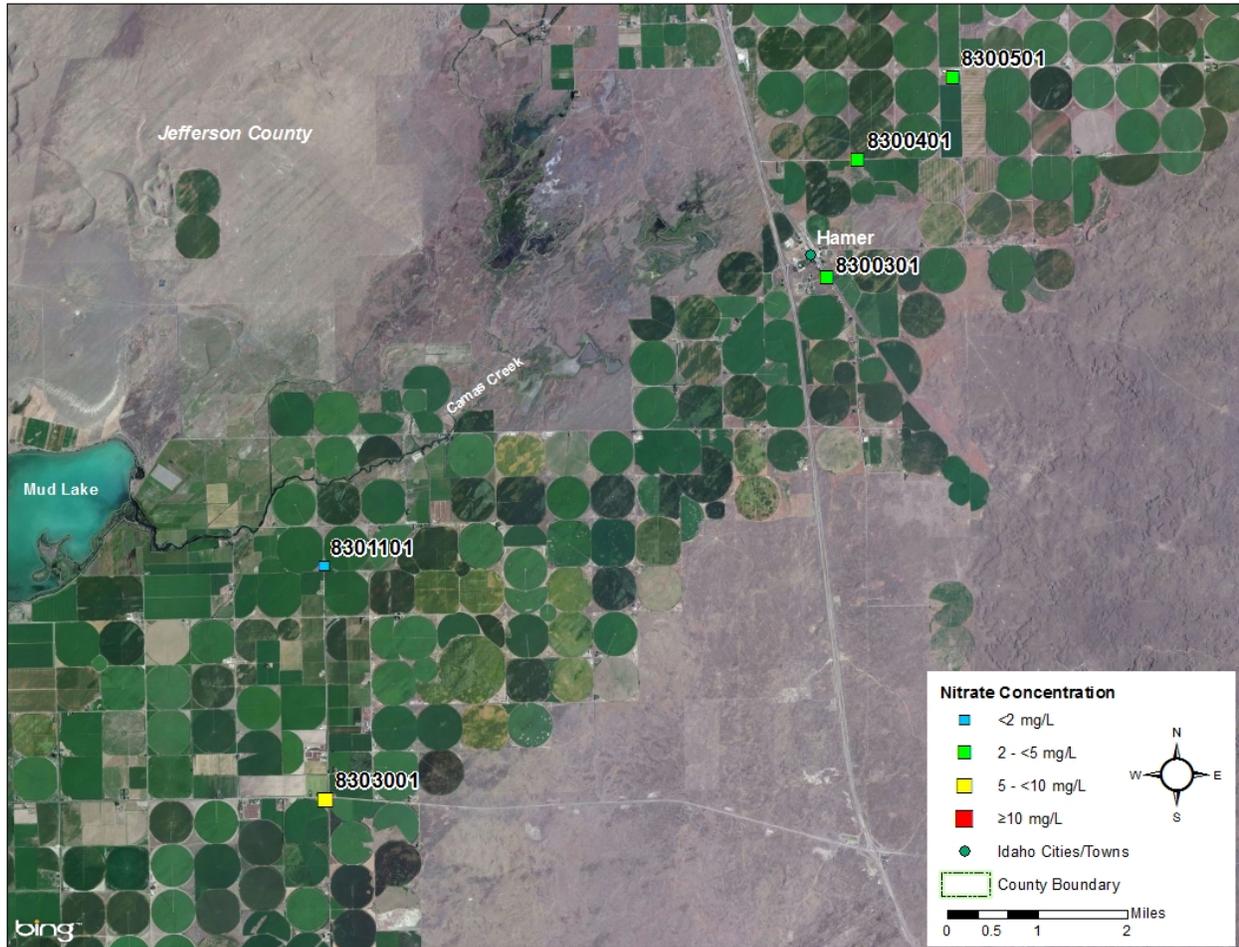


Figure C5. Jefferson County nitrate concentrations, 2015 ISDA data.

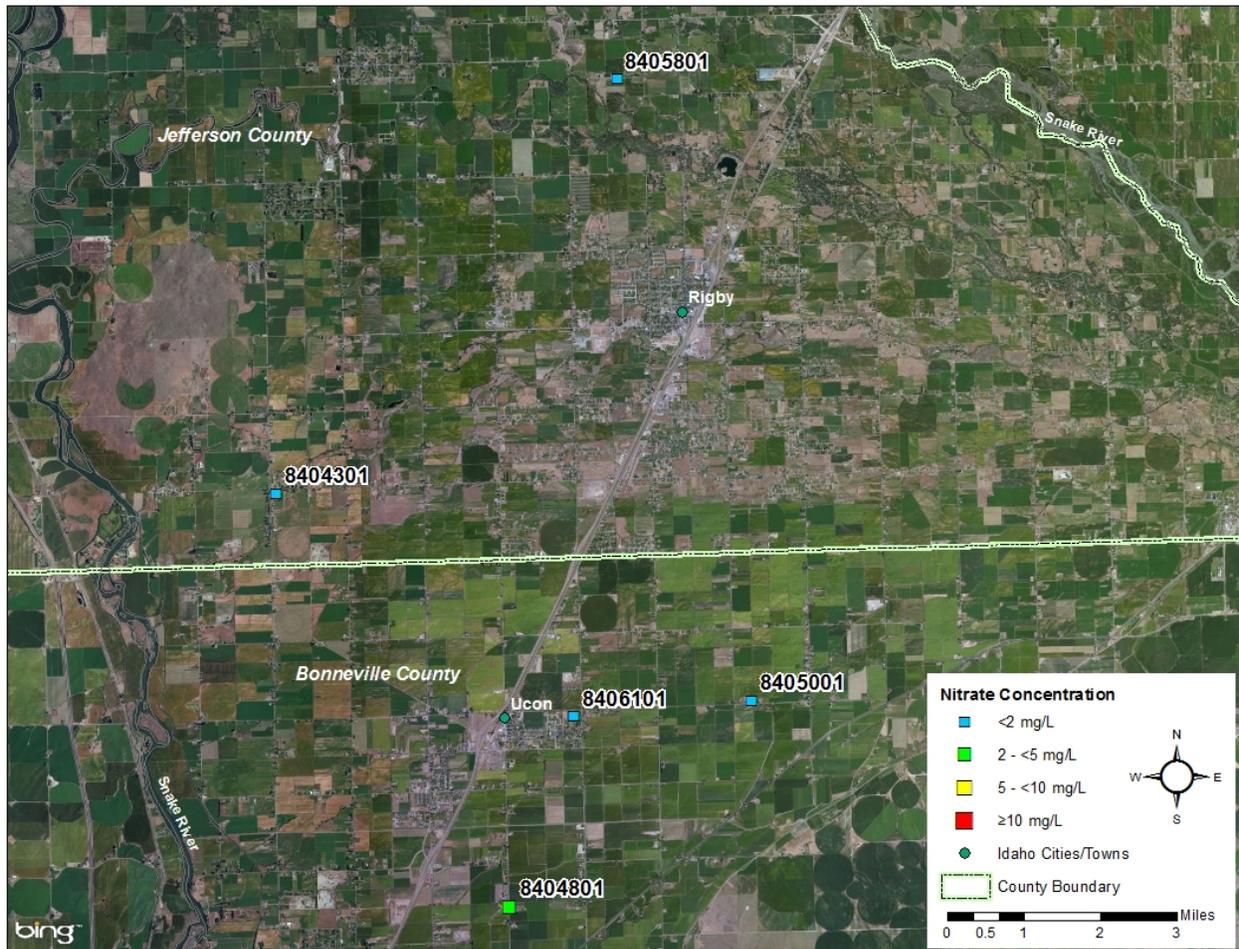


Figure C6. Jefferson and Bonneville Counties nitrate concentrations, 2015 ISDA data.

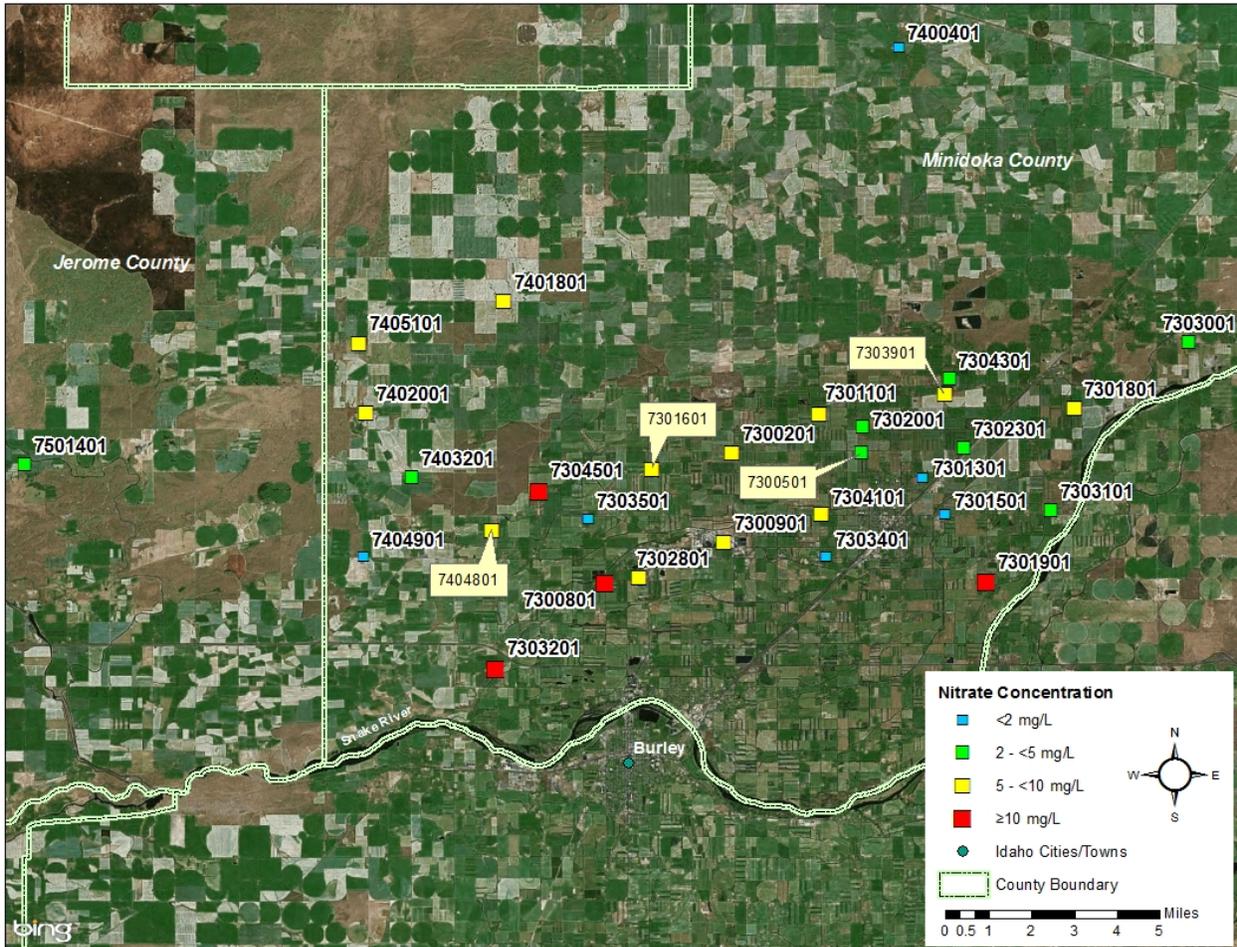


Figure C7. Jerome and Minidoka Counties nitrate concentrations, 2015 ISDA data.

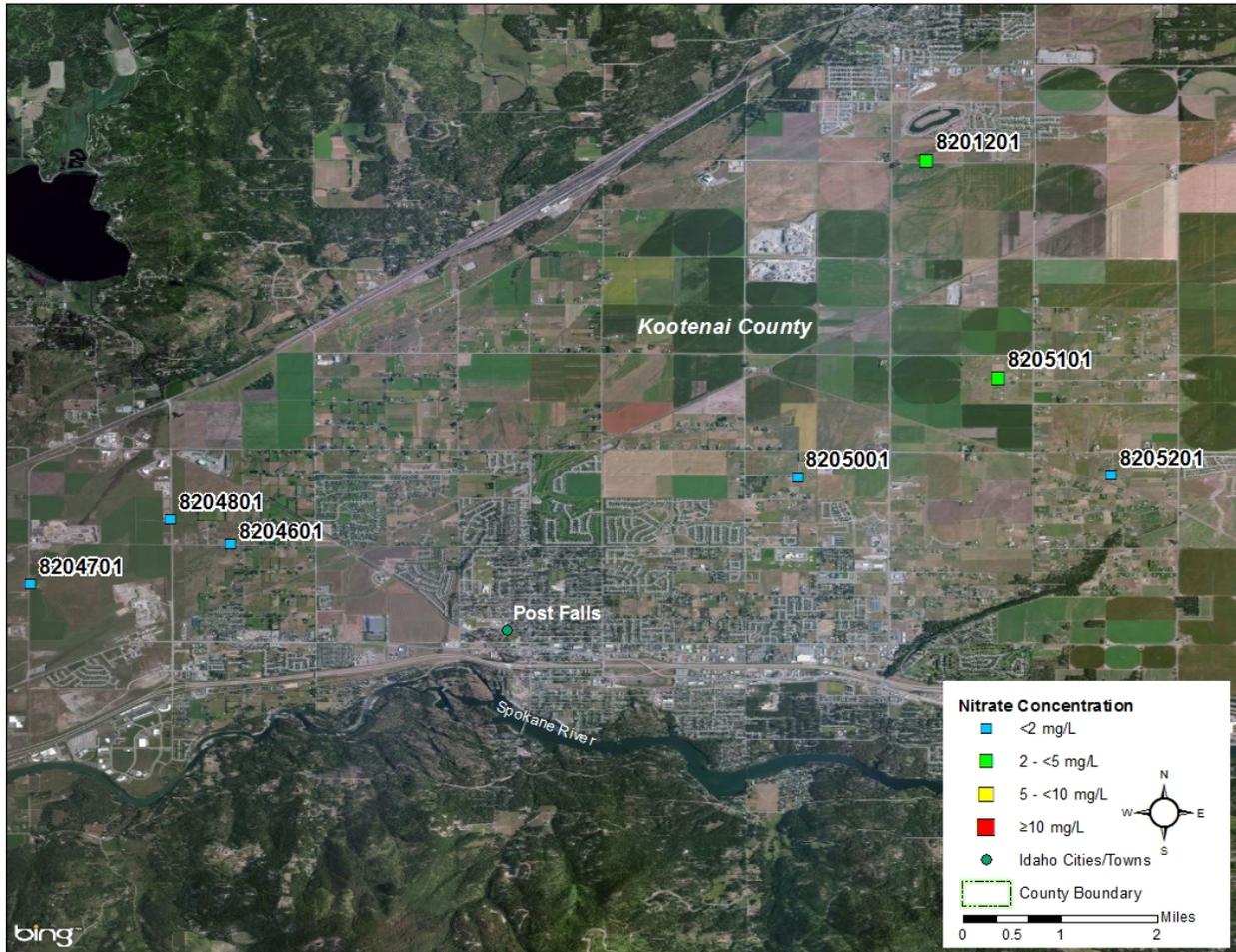


Figure C8. Kootenai County nitrate concentrations, 2015 ISDA data.

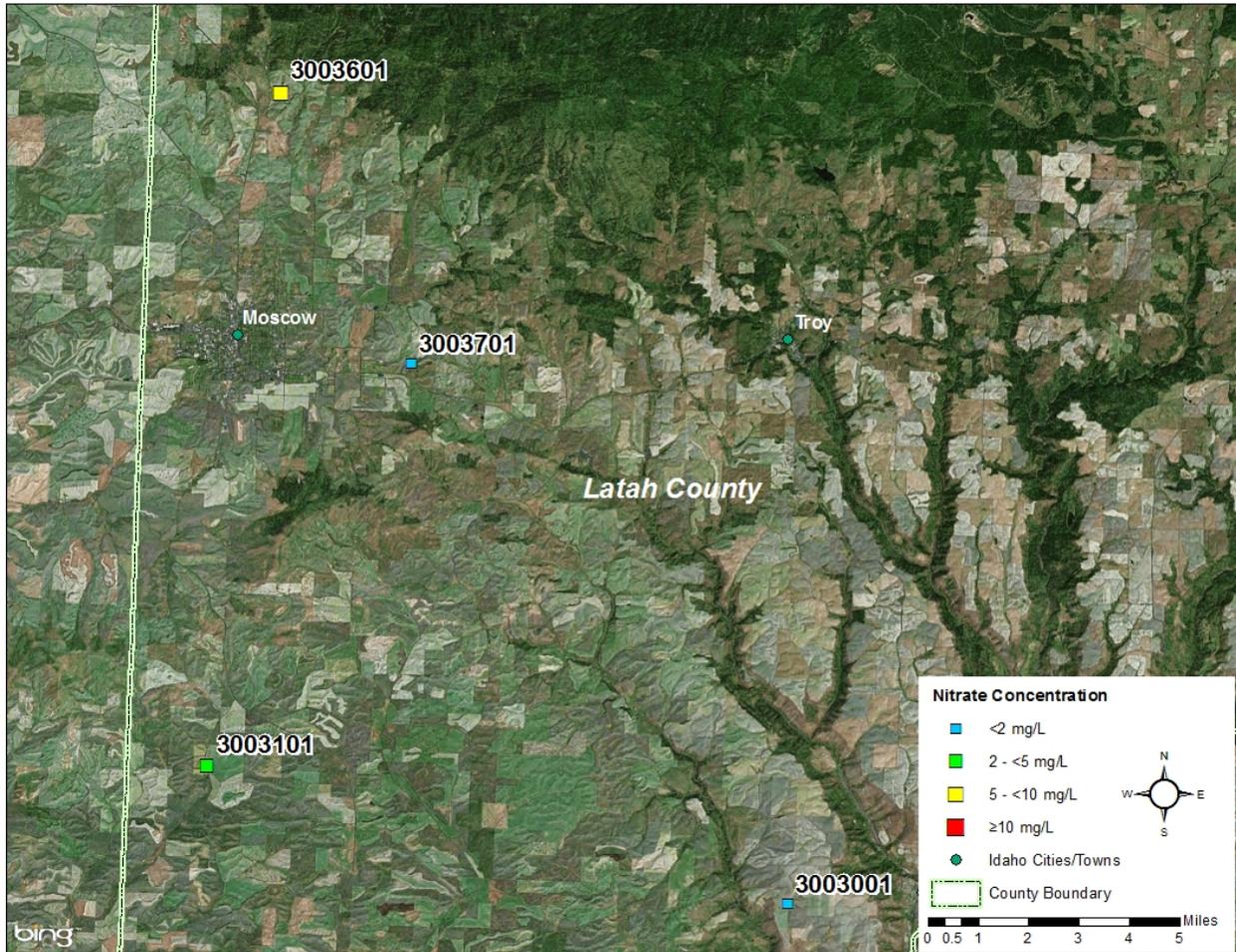


Figure C9. Latah County nitrate concentrations, 2015 ISDA data.

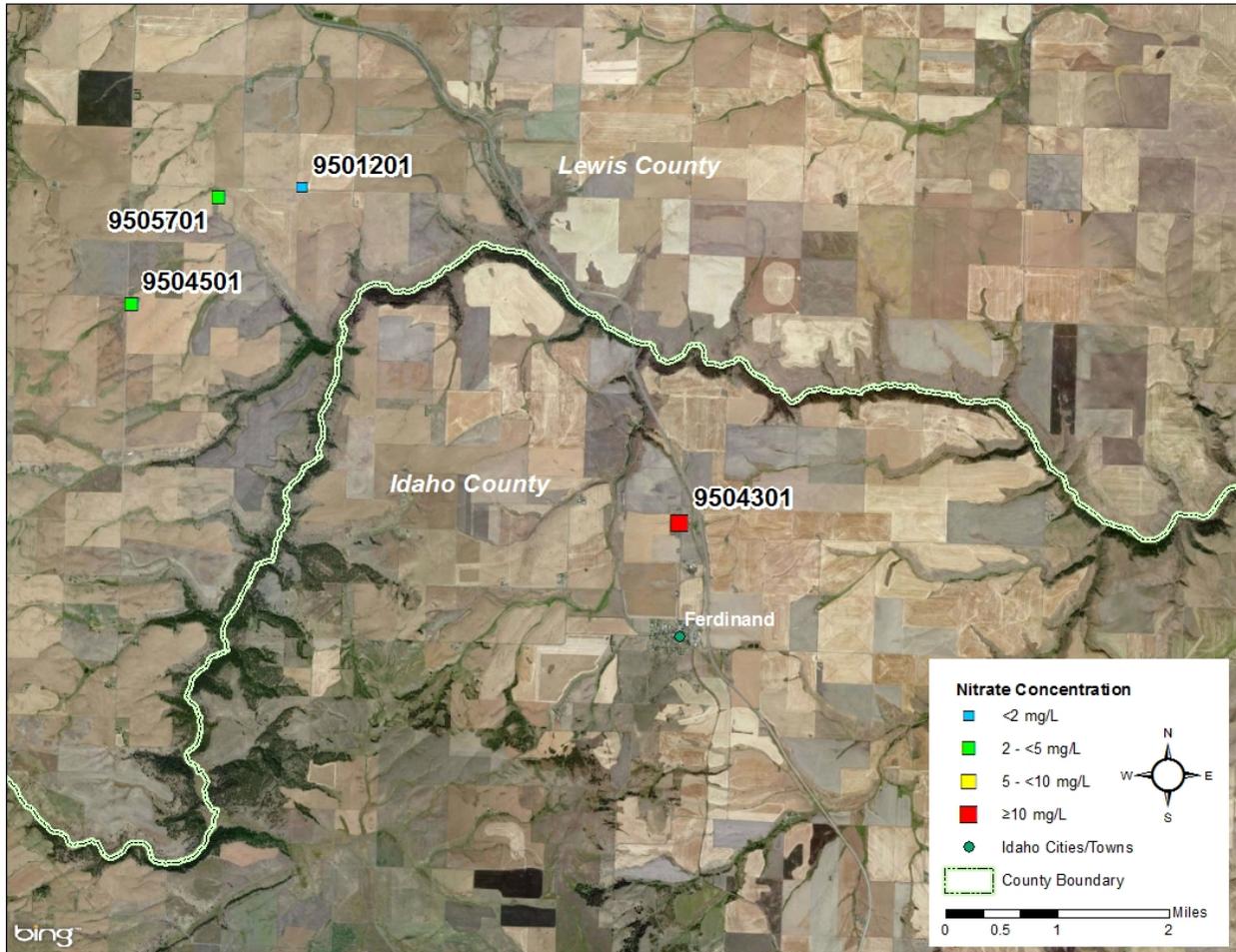


Figure C10. Lewis and Idaho Counties nitrate concentrations, 2015 ISDA data.

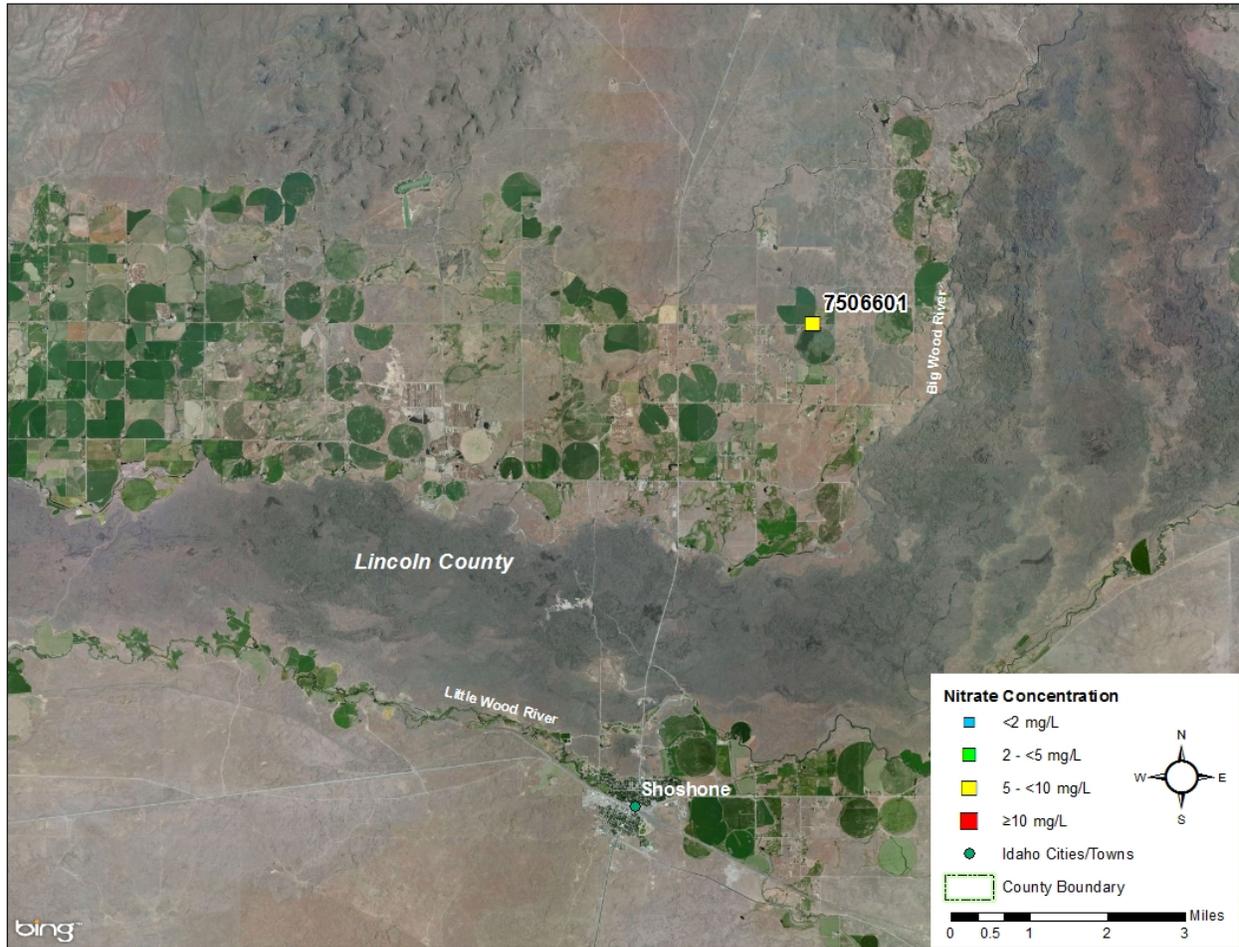


Figure C11. Lincoln County nitrate concentrations, 2015 ISDA data.

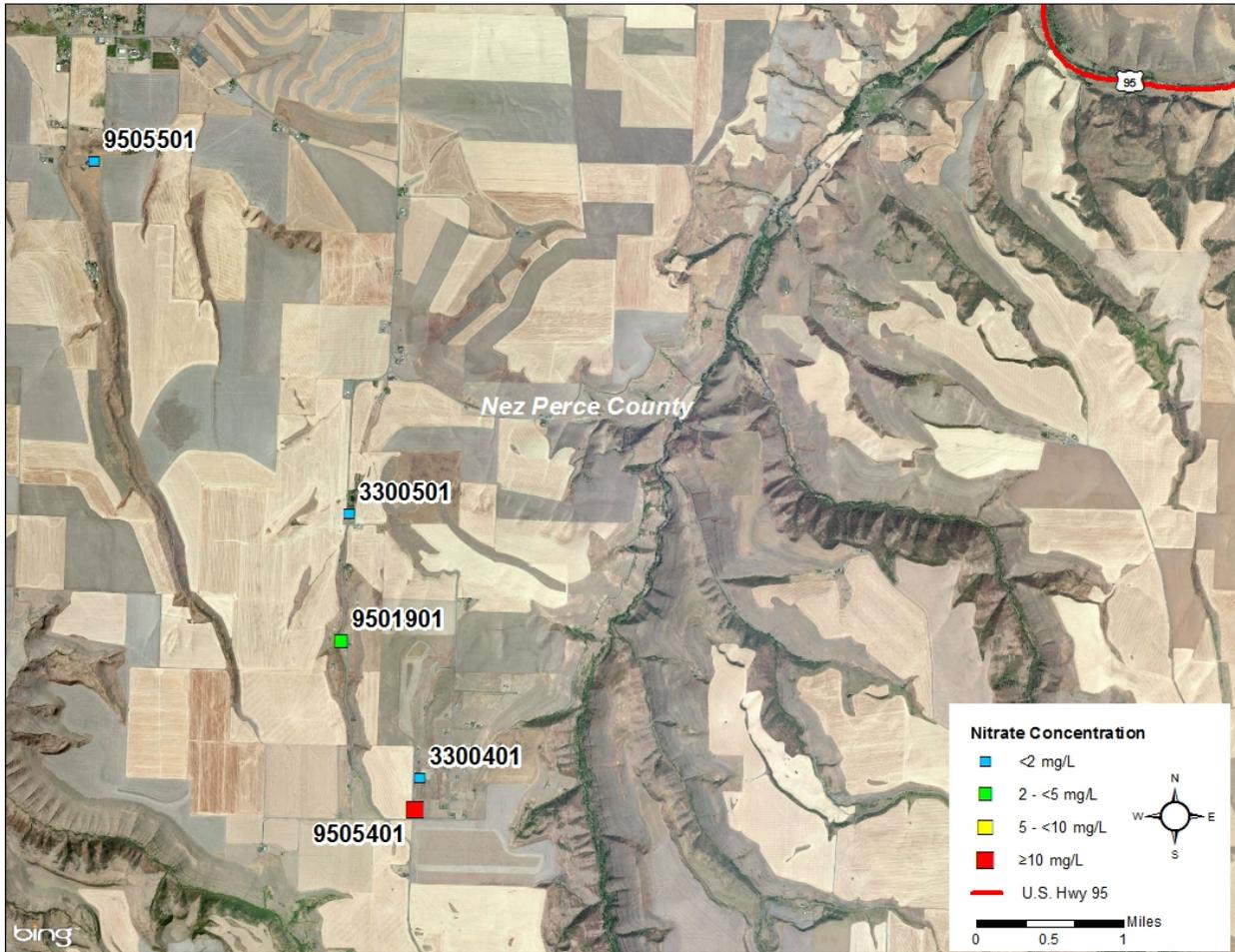


Figure C12. Nez Perce County nitrate concentrations, 2015 ISDA data.



Figure C13. Owyhee County nitrate concentrations, 2015 ISDA data.

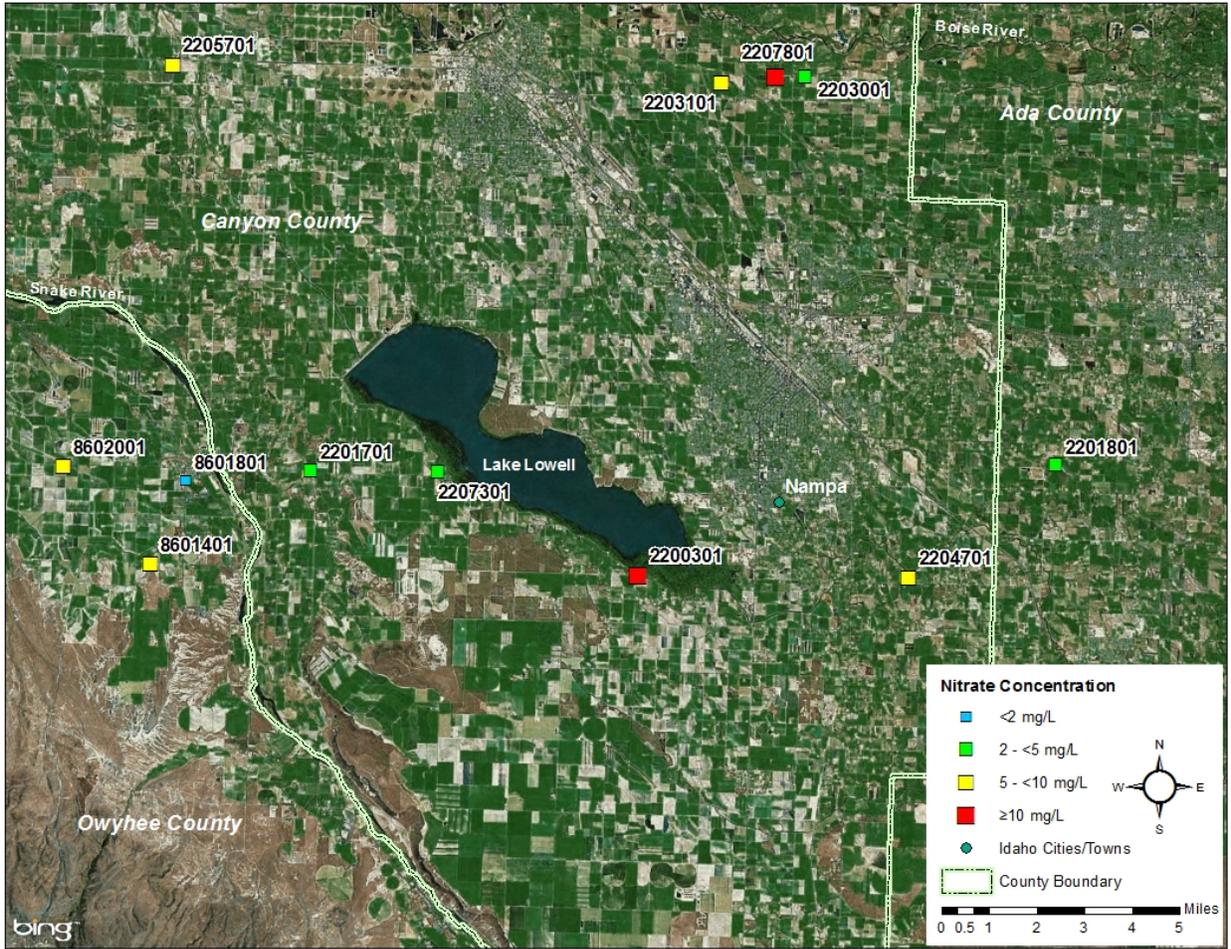


Figure C14. Owyhee, Canyon, and Ada Counties nitrate concentrations, 2015 ISDA data.

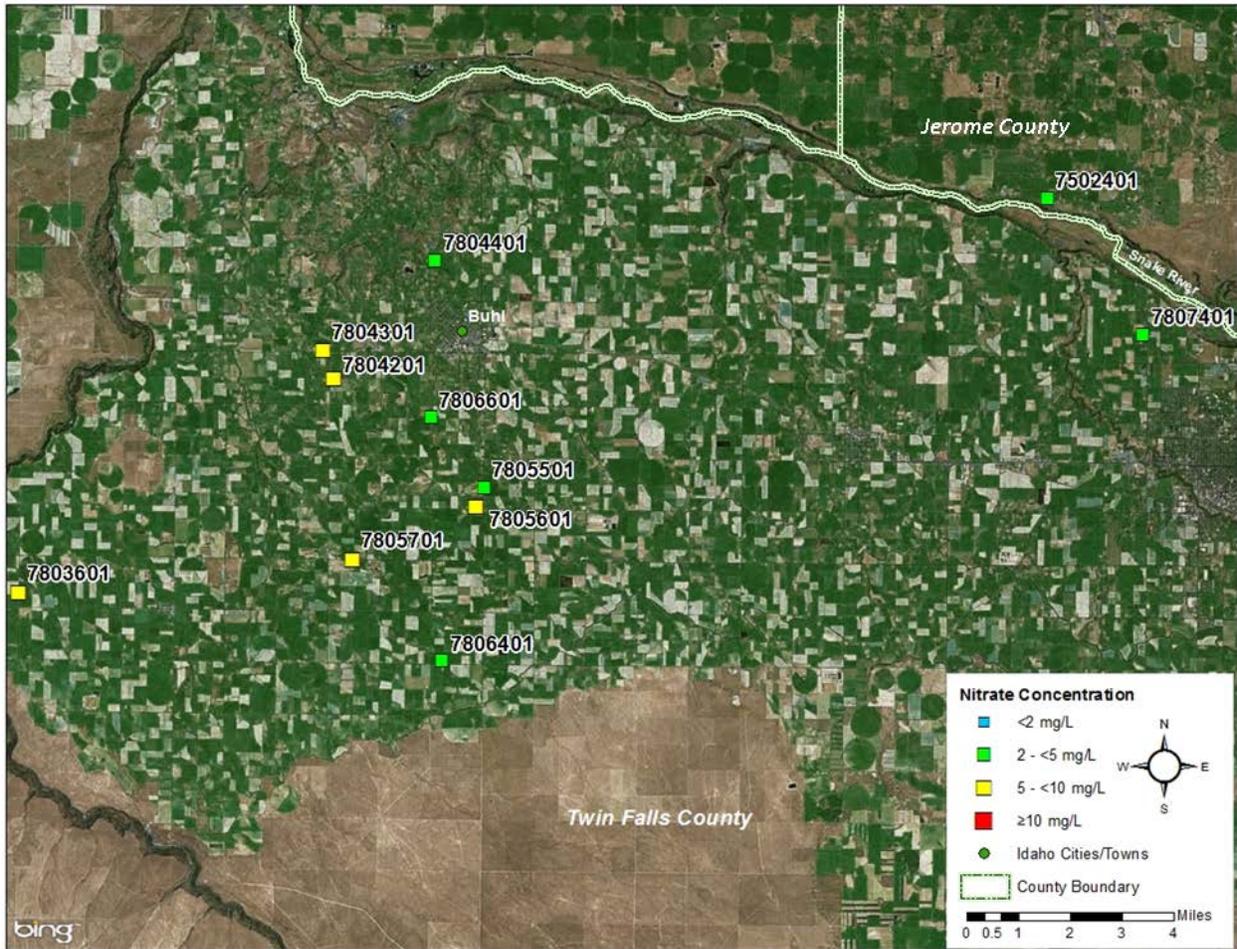


Figure C15. Twin Falls and Jerome Counties nitrate concentrations, 2015 ISDA data.

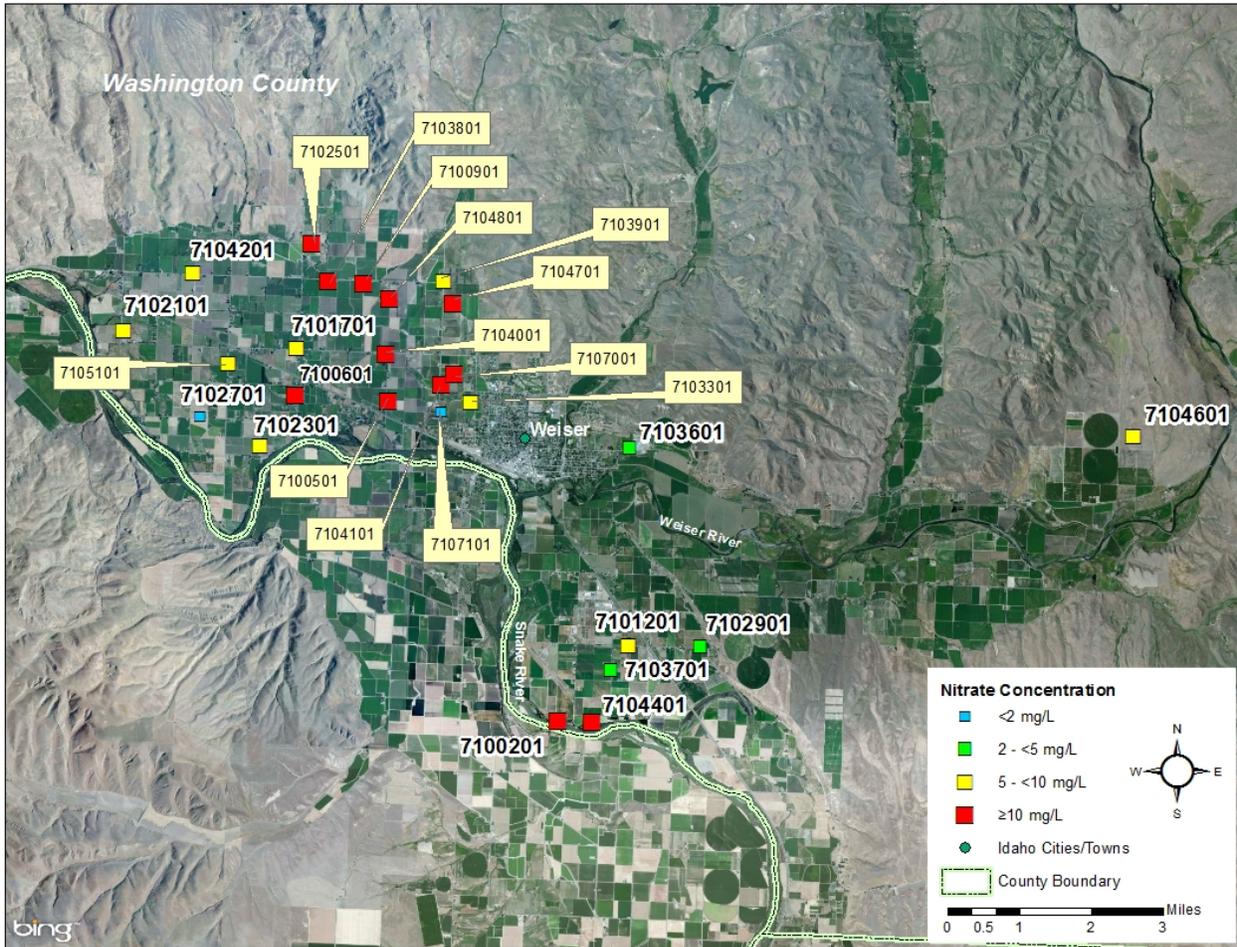


Figure C17. Washington County nitrate concentrations, 2015 ISDA data.