Statewide Groundwater Monitoring Program: Mid-Rogue Basin 2015

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Laboratory and Environmental Assessment Program
3150 NW 229th Avenue
Suite 150
Hillsboro, OR 97124
Phone: 503-693-5700
Fax: 503-693-4999
www.oregon.gov/DEQ

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Department of Environmental Quality

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This report prepared by:

Oregon Department of Environmental Quality
Laboratory & Environmental Assessment Program
3150 NW 229th Avenue
Hillsboro, OR 97124

www.oregon.gov/DEQ

Authors:
Kara Goodwin, Natural Resource Specialist
Paige Evans, Natural Resource Specialist

Contact:
Laboratory and Environmental Assessment Program
503-693-5700

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Executive Summary

Oregon's goal is "to prevent contamination of Oregon's groundwater resource while striving to conserve and restore this resource and to maintain the high quality of Oregon's groundwater resource for present and future uses (ORS 468B.155)." To understand how Oregon is doing in meeting this goal, the Statewide Groundwater Monitoring Program began collecting water quality data in 2015 to establish the status of ambient groundwater conditions, identify emerging groundwater quality problems and inform groundwater users of potential risks from contamination. To implement this work, two regional groundwater studies are conducted annually with the goal of monitoring Oregon's vulnerable aquifers over a 10-year period. Regional study areas are selected based on previously identified groundwater vulnerabilities, nitrate data collected during real estate transactions as required by statute (ORS 448.271), time elapsed since water quality data were collected, analysis of potential contamination sources and community interest to help with recruitment of volunteer participants. All studies include analysis of nitrate, arsenic, bacteria, pesticides and common ions in 60 to 100 wells. Additional analyses are added based on local risk factors and program capacity.

In 2015, the Statewide Groundwater Monitoring Program conducted a groundwater study in the mid-Rogue Basin. Objectives of the study were:

1. To collect high-quality data on nitrate, arsenic, coliform bacteria and pesticide concentrations in groundwater throughout the study area;
2. To identify areas of groundwater contamination related to these parameters;
3. To inform well water users of the results of this study and provide information regarding potential risks to human health;
4. To identify areas needing additional investigation in order to describe the extent of contamination and help focus efforts to prevent further contamination.

Outside the scope of this study and report:

- Hydrogeologic characterization of the study area and contamination
- Investigation of the sources of contamination
- Health risk assessments

The study area spanned Jackson and Josephine counties, including the communities of Grants Pass, Shady Cove, Central Point, Medford and Ashland. DEQ staff sampled 107 private, mostly domestic, wells for nitrate, arsenic, bacteria, pesticides, metals, and common ions over two sampling events in February and October 2015. These domestic wells serve as sources of drinking water, along with other household uses such as for farm animals, outdoor garden and lawn irrigation, etc.

Key findings include:

- Elevated nitrate levels [3 milligrams per liter (mg/L) or higher] in the area around Central Point and north and west of Medford. For the limited data set of wells with well logs, elevated nitrate concentrations were found only in wells with shallow water bearing zones. Four wells had nitrate concentrations above the maximum contaminant level (10 mg/L) set by the U.S. Environmental Protection Agency for public water systems
- High arsenic [above the maximum contaminant level of 10 micrograms per liter (µg/L)] was measured in six wells. Lack of well logs for many of the wells with high arsenic results limited the interpretation of this data
- Coliform bacteria detected in 43 percent of wells tested
- At least one pesticide or pesticide breakdown product in 41 of the 107 wells tested. Twenty-three wells had two or more pesticide-related chemicals detected. All pesticide detections were well below their associated screening levels. However, very little research has been done on the effect of multiple chemicals on human health. Pesticide mixtures found in wells included up to four different "parent" pesticides

- Manganese was detected in 57 of the study wells, with two of the wells above the Lifetime Health Advisory level of 300 µg/L. While low concentrations are likely due to natural geochemical processes, further investigation is necessary to determine the sources of manganese in the wells with very high concentrations
- Low concentrations of uranium and vanadium were common
- No seasonal trend was detected in nitrate or bacteria results. Pesticide detections and concentrations were slightly higher in the winter than the fall

The results of this study can be used to focus outreach and education activities that encourage private well owners to routinely test wells for nitrate, bacteria and arsenic and encourage well protection and maintenance best practices to protect the aquifer. Further analysis is needed to delineate the extent of nitrate contamination in several parts of the study area, particularly around Central Point and north and west of Medford. Long-term monitoring of nitrate and pesticides is recommended, especially in the area north and west of Medford. A network of wells should be established and monitored to detect any changes over time.

1. Background

Groundwater is a vital resource in Oregon. Over 600,000 Oregonians rely on private wells for their drinking water (Maupin et al. 2014). Public water systems, the agricultural community and industry also rely on groundwater to meet their operational needs. In addition, Oregon's rivers and streams depend on groundwater for the maintenance of adequate summer flows to sustain fish populations and for recreational opportunities. Groundwater is a critical water reserve that can be used when available surface water is inadequate to meet demands.

Oregon's goal is "to prevent contamination of Oregon's groundwater resource while striving to conserve and restore this resource and to maintain the high quality of Oregon's groundwater resource for present and future uses (ORS 468B.155)." To understand how Oregon is doing in meeting this goal, the Statewide Groundwater Monitoring Program began collecting water quality data in 2015 to establish the status of ambient groundwater conditions, identify emerging groundwater quality problems and inform groundwater users of potential risks from contamination. To implement this work, two regional groundwater studies are conducted annually with the goal of monitoring Oregon's vulnerable aquifers over a 10-year period. Regional study areas are selected based on previously identified groundwater vulnerabilities, nitrate data collected during real estate transactions as required by statute (ORS 448.271), time elapsed since water quality data were collected, analysis of potential contamination sources and community interest to help with recruitment of volunteer participants. All studies include analysis of nitrate, arsenic, bacteria, pesticides and common ions in 60 to 100 wells. Additional analyses are added based on local risk factors and program capacity.

In 2015, the Statewide Groundwater Monitoring Program collected groundwater quality data in the mid-Rogue basin. Data from the 2011 Rogue Basin Groundwater Investigation, which includes a comprehensive review of the Basin's groundwater data since the 1970s (Patton and Eldridge 2013), and the Oregon Health Authority's Real Estate Transaction Act (ORS 448.271) indicated some elevated nitrate concentrations in the region, particularly the Central Point area. Data collected by DEQ for the Rogue Basin Groundwater Investigation in 2011 showed elevated nitrate concentrations (3 mg/L or higher) in 35 percent of the wells tested (18 of 52 wells), including all the wells tested in Central Point and north and west of Medford. The 2011 study also investigated arsenic, fluoride, boron and vanadium concentrations (Patton and Eldridge 2013).

Using information learned from the 2011 study and guided by the objectives of the Statewide Groundwater Monitoring Program, the goals of the 2015 mid-Rogue basin groundwater study were:

1. To collect high-quality data on nitrate, arsenic, coliform bacteria and pesticide concentrations in groundwater throughout the study area;
2. To identify areas of groundwater contamination related to these parameters;
3. To inform well water users of the results of this study and provide information regarding potential risks to human health;
4. To identify areas needing additional investigation in order to describe the extent of contamination and help focus efforts to prevent further contamination.

Outside the scope of this study and report:

- Hydrogeologic characterization of the study area and contamination
- Investigation of the sources of contamination
- Health risk assessments

2. Study Design and Methods

2.1 Study Design

The study area included the communities of Grants Pass, Shady Cove, Central Point, Medford and Ashland. The boundary was within the Rogue River watershed and included the area surrounding Lost Creek Lake. Our study focused primarily on private, domestic wells and relied on homeowners who volunteered to have their wells tested in exchange for a complete report of the analytical results from their well. Volunteers were recruited using flyers, emails, and other announcements with the help of the Jackson County Soil and Water Conservation District, staff from the DEQ office in Medford, and others. Over 400 individuals expressed interest in having their well tested. From these 400 plus volunteers, 150 potential wells were randomly selected as candidates for sampling. Of these 150 candidate wells, 107 wells were sampled as a part of the study based on location, availability of a well log and known or suspected depth of the well. Known depths were based on a confirmed well log. Suspected depths were based on conversations with the homeowner.

Previous DEQ groundwater studies tried to only include wells with well logs and it is unknown if this introduced a bias in the dataset. Older wells are more likely to not have well logs. These wells may also be more vulnerable to contamination due to poor construction or location in areas that have a longer history of agricultural activity, a known risk factor for groundwater contamination. This study did not require all study site wells to have a well log in an effort to see if there is an increased risk of contamination in this population, which has not been included in previous studies. A full site list including information on presence or absence of a well log can be found in Appendix A. Figure 1 shows the locations of the wells selected for this study and the location of water table aquifers as described by Sweet et al. (1980). A water table aquifer, also known as an unconfined aquifer, is groundwater that is overlain by permeable material (i.e., sand) and therefore, is expected to be more vulnerable to contamination from surface activities.

DEQ collected samples during two events, each lasting three weeks. The first 60 wells were sampled between Feb. 9 and March 4, 2015. Another 47 wells, along with a resampling of 13 wells from the first event, occurred between Oct. 12 and Oct. 28, 2015. Wells were resampled to capture potential seasonal variability. Of the wells selected to be resampled, eight were selected based on results from the first event; the rest were selected based on location and the existence of a well log. All resampled wells were shallow wells (chosen as less than 100 feet below ground surface), as they are most likely to be affected by seasonal differences in precipitation or land use practices. Due to limitations of the study design and inclusion of wells without well logs, results from this study represent the conditions in the well sampled and not the broader aquifer. Additional hydrogeologic analysis is outside the scope of this report.

2.2 Methods

2.2.1 Sampling Methods

DEQ water quality monitoring staff collected and processed samples according to standard procedures found in the Manual of Methods, Sampling and Analysis Plan and Quality Assurance Project Plan. (DEQ03-LAB-0036-SOP_V3, DEQ11-LAB-0043-SAP, DEQ93-LAB-0024-QAPP). Samples were collected from an outdoor spigot closest to the well head, whenever possible, and always before any water filtration or treatment. Some samples were collected from a pressure tank or large storage reservoir when access to water directly from the well was not available. Wells were purged for at least five minutes and until field readings of conductivity, temperature and dissolved oxygen stabilized. Bacteria samples were collected last, after the sample point was disinfected with isopropyl alcohol.

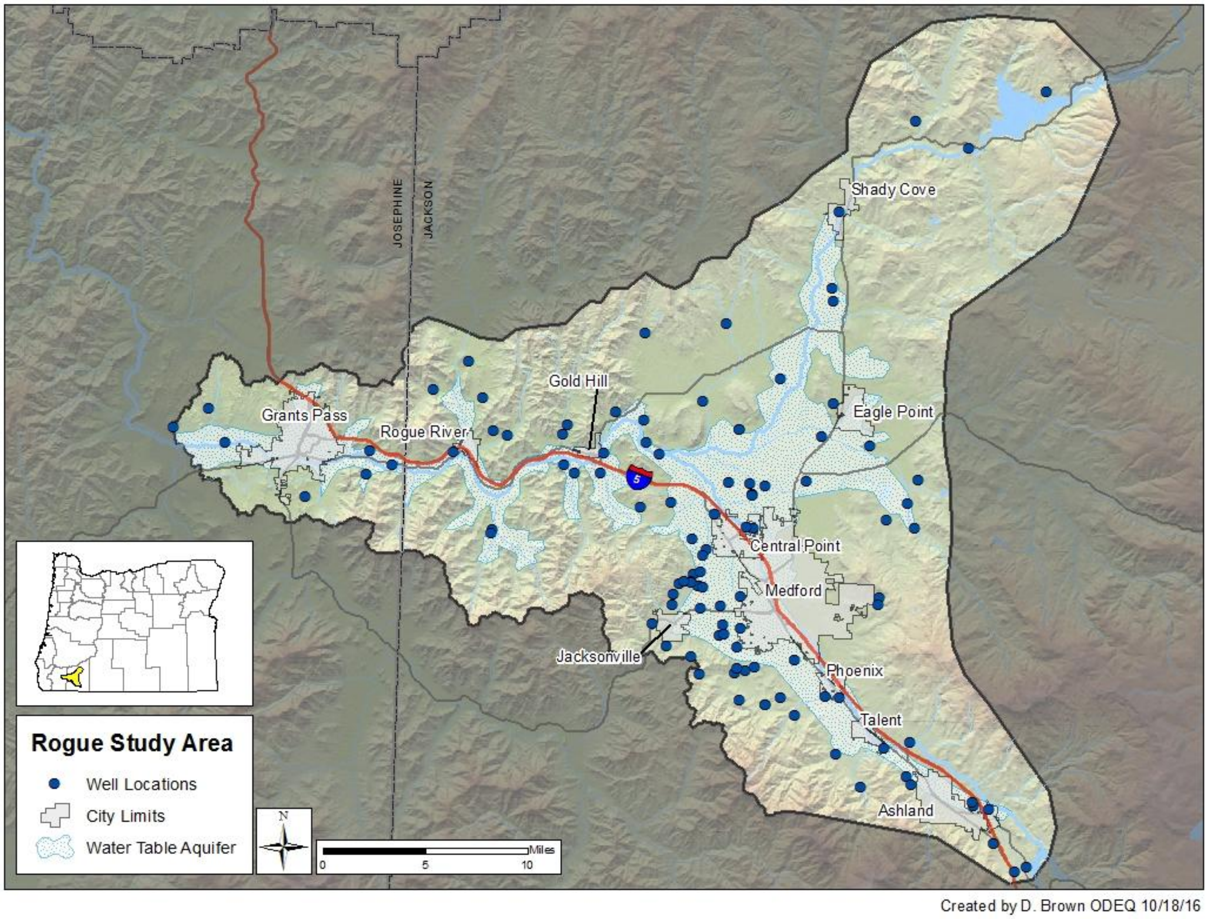


Figure 1. Study area and sample locations (Water table aquifer from Sweet et al. 1980).

Sample analyses included nitrate/nitrite as N (henceforth referred to as nitrate), total coliform bacteria, *E. coli* bacteria, current use and legacy chlorinated pesticides, total recoverable arsenic, common ions and common field parameters. A complete analyte list can be found in Appendix B and the corresponding laboratory methods can be found in the Sampling and Analysis Plan (DEQ11-LAB-0043-SAP). Due to project capacity limits, legacy chlorinated pesticides were only analyzed on samples from known or suspected shallow wells during each sampling event (n=43 wells). These pesticides are highlighted in green in Appendix B.

2.2.2 Context for Data Interpretation

The results from this study can be interpreted in two different contexts: the impacts of human activities on groundwater quality and the potential for human health impacts when the groundwater is used for drinking water. Many of the chemicals analyzed in this study are not found naturally in groundwater (e.g., pesticides), or have very low natural concentrations (e.g., nitrate). Detection of these chemicals indicates an influence from human activities such as leaching from agricultural or residential use of fertilizers and pesticides, improperly designed or maintained septic systems or poor well construction. These contaminants, along with some naturally occurring minerals such as arsenic, may be harmful to human health when present in drinking water above certain levels.

In Oregon, there are no regulatory criteria that apply to water from private, domestic wells. However, it can be useful to compare water quality results to the criteria set by EPA for public water systems. EPA sets a maximum contaminant level goal at the concentration of a contaminant below which there is no known or expected health risk. The EPA then sets the maximum contaminant level as close to the maximum contaminant goal as feasible considering treatment technologies and cost. Maximum contaminant levels are enforceable water quality criteria for public water systems (U.S. EPA 2014).

Many of the chemicals measured in this study do not have a maximum contaminant level. There are several other sources of health risk information, such as the lists of Health Advisories, Human Health Benchmarks for Pesticides, and Regional Screening Levels developed by EPA (U.S. EPA 2012, U.S. EPA 2013 and U.S. EPA 2016) and the Health-Based Screening Levels developed by the United States Geological Survey (Toccalino et al., 2014). These non-regulatory screening values are based on the available toxicological research and can be used to determine whether the concentration of a contaminant in drinking water may pose a risk to human health. In this report, results are compared to maximum contaminant level goal and maximum contaminant levels when available. If no maximum contaminant level is available, the result is compared to the lowest value of the current Health Advisories, Human Health Benchmarks for Pesticides, Regional Screening Levels, or Health-Based Screening Levels.

3. Results and Discussion

3.1 Well Characteristics

Of the 107 wells sampled in this study, 48 had a verified well log. A DEQ hydrogeologist evaluated wells logs for aquifer confinement[1], depth of water bearing interval, and potential for vertical fluid migration below the well seal (Appendix A):

- **Aquifer Confinement.** All but two of the wells with well logs suggest that the water is being withdrawn from a confined or semi-confined aquifer. Existence of a confining or semi-confining layer may protect the aquifer from surface contamination.
- **Depth of Water Bearing Interval.** Depth of the water bearing interval may be related to the presence of contamination. Contamination may come from surface activities such as fertilizer or pesticide application, which may impact shallow waters (less than 100 feet below ground surface), or dissolution of geologic minerals in deeper, and likely older, waters. Depth to top of the water bearing zone was determined for 41 wells and ranged from 23 to 890 feet below ground surface.
- **Potential for Vertical Fluid Migration.** Poorly constructed wells may allow water to travel along the borehole, introducing contaminants into deep aquifers. Thirty-nine wells have a high relative potential for vertical fluid migration below the seal based on the geologic material in which the well is located.

The differences between the wells sampled in this study include the following variables: depth the well was drilled, age of the well, well construction or alterations/deepenings, land use around the well, the geology of the land and aquifer, how frequently the well is used, distance of transport piping and piping material between well and faucet, whether an inline filter system needed to be removed to take the sample, the type of faucet the sample was collected from and the presence of and/or the size of holding tank or pressure tank connected to system.

3.2 Water Quality

The following sections discuss results for analytes that indicate contamination due to human activities, or present a potential health risk for people drinking the water. Comprehensive analytical reports may be obtained by contacting the DEQ Laboratory and Environmental Assessment Program.

[1] A confined aquifer occurs when the aquifer (for example, a permeable sand) is capped by an impermeable layer (for example, an impermeable silt). A confined aquifer does not connect with shallow groundwater. Aquifers can also be semi-confined, which means that an aquifer has limited connection with shallow groundwater. An aquifer is confined or semi-confined if the static water level in the well is higher than the water-bearing zone.

3.2.1 Nitrate

While nitrate is a natural and necessary nutrient found in soil and surface water, human activities can enrich the level of nitrate found in the environment. Nitrate enriched water can leach into aquifers from areas of fertilizer use, manure storage or application or improperly designed or maintained septic systems (Powers and Schepers, 1989). While background concentrations of nitrate in groundwater may only be up to 1 mg/L (Nolan and Hitt, 2003), this report will consider values of 3 mg/L or greater as elevated. This is consistent with the previous report (Patton and Eldridge, 2013) and represents a level sufficiently above background to indicate an impact from human activities on groundwater quality. Drinking water with high nitrate may cause serious health problems for infants, pregnant women and nursing mothers. To protect the public from these health risks, the EPA has set the maximum contaminant level for nitrate (as N) at 10 mg/L. As mentioned previously, nitrate in this study was measured as nitrate/nitrite as N. While nitrite is rarely found in groundwater at significant levels due to geochemical conditions, these results represent a conservative measurement of nitrate. More information on nitrate risks and recommendations can be found on DEQ's Fact Sheet: Nitrate in Drinking Water (http://www.deq.state.or.us/wq/pubs/factsheets/groundwater/nitratedw.pdf).

In this study, 22 of the 107 wells sampled had an elevated nitrate concentration (3 mg/L or above). Four wells were above the maximum contaminant level of 10 mg/L (Figure 2). Based on the limited number of wells where the water bearing zone could be determined, elevated nitrate concentrations were found in wells where the top of the water bearing zone was shallower than about 60 feet below ground surface (Figure 3). However, not all shallow wells had elevated nitrate.

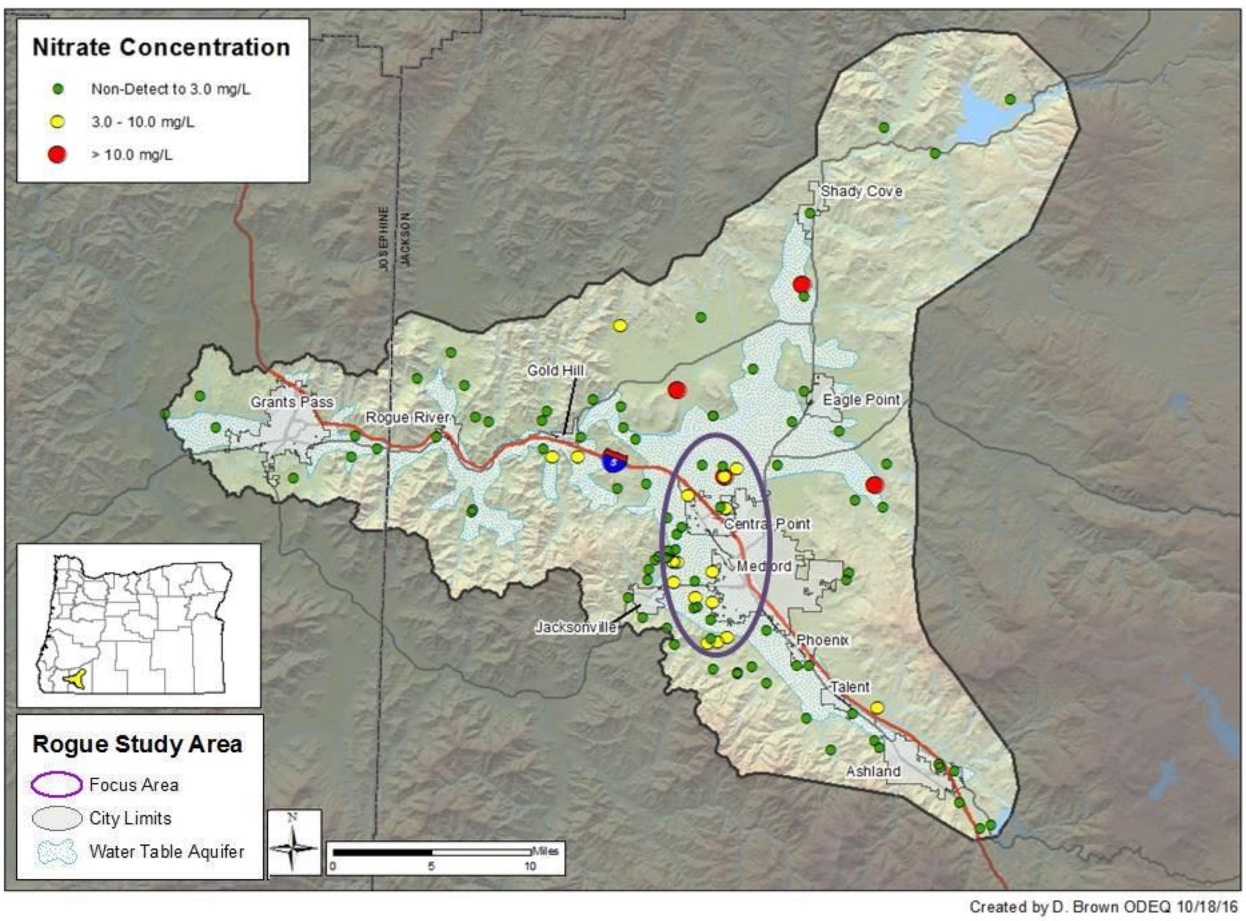


Figure 2. Nitrate concentration in sampled wells. Oval encompasses the area around Central Point and north and west of Medford where a high nitrate results were concentrated in the 2011 and 2015 studies. Results higher than 3 mg/L are considered elevated due to human activities. The maximum contaminant level for nitrate in drinking water is 10 mg/L.

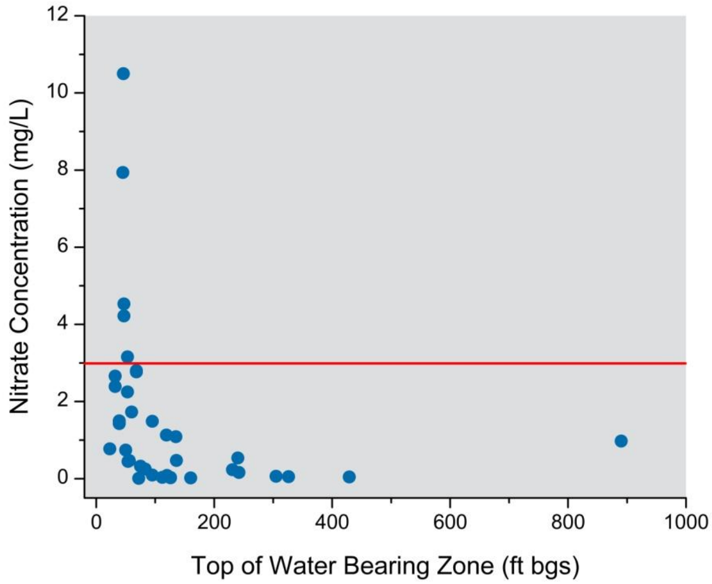


Figure 3. Nitrate concentration and depth to top of the water bearing zone for wells where well log information was available. Red line indicates a concentration of 3 mg/L, which DEQ considers to be an elevated nitrate concentration.

In the area north and west of Medford and around Central Point (circled in Figure 2), samples from 15 of 30 wells had elevated nitrate concentrations. The results in this area ranged from non-detect to above the maximum contaminant level (<0.005 mg/L to 10.1 mg/L). This indicates more variability in nitrate concentrations in this area than observed during the 2011 study in which all wells sampled in this area had elevated nitrate concentrations. However, this is still a very high occurrence of elevated nitrate concentrations in well water. One well from the 2011 study was also sampled in 2015. In July 2011, March 2015 and October 2015, the nitrate concentration in this well was 4.5, 4.22, and 4.53 mg/L indicating little to no change over this five-year period.

The four wells with results over the maximum contaminant level are spread out north and east of Central Point. Two of the wells have logs, which indicate shallow water sources. The other two do not have well logs, limiting the interpretation of the results.

3.2.2 Arsenic

Arsenic is a naturally occurring element found in the earth's crust. It is found in groundwater throughout Oregon, often associated with volcanic geology. In the past, arsenic was also used in some agricultural practices such as the insecticide lead arsenate (especially in orchards), as well as for embalming fluids prior to approximately 1945 (indicating historic cemeteries as potential sources). While it is not believed that this is a common source of arsenic in groundwater, arsenic geochemistry is complex and several factors may influence the mobility of arsenic from these sources into shallow groundwater (Welch et al, 2000). Most arsenic in groundwater is a result of dissolution of arsenic-containing minerals in soil and rock. Arsenic in drinking water is a health hazard and EPA has established a maximum contaminant level for total arsenic at 10 µg/L (parts per billion). However, the maximum contaminant level goal is zero.

Arsenic was detected in 24 of the 107 wells in this study (measured as total recoverable arsenic). Six wells had arsenic concentrations above the maximum contaminant level of 10 µg/L (Figure 4). Five of the six highest concentrations were found close to the Rogue River and Lost Creek Lake; the other high value was south of Medford (Figure 4). Arsenic concentrations in the Rogue River are low (ODEQ 2015a) and not expected to be the source of the arsenic in the groundwater. Well logs were located for only two of the six wells with arsenic above the maximum contaminant level. These wells are deep and have water-bearing zones that begin at 312 and 160 feet below ground surface (107 and 38.8 µg/L, respectively). Further investigation is necessary to understand the contributing factors for these high concentrations.

The 2011 Rogue Basin groundwater study reported arsenic to a lower level (1 µg/L) than the 2015 study (2 µg/L). To compare results from the 2011 study to the 2015 study, only results of 2 µg/L or higher are counted as detects. Seven out of 52 wells sampled in 2011 were at or above 2 µg/L (13 percent). Further analysis of well logs for both studies, which is outside the scope of this report, may help explain the difference in arsenic results between the two studies.

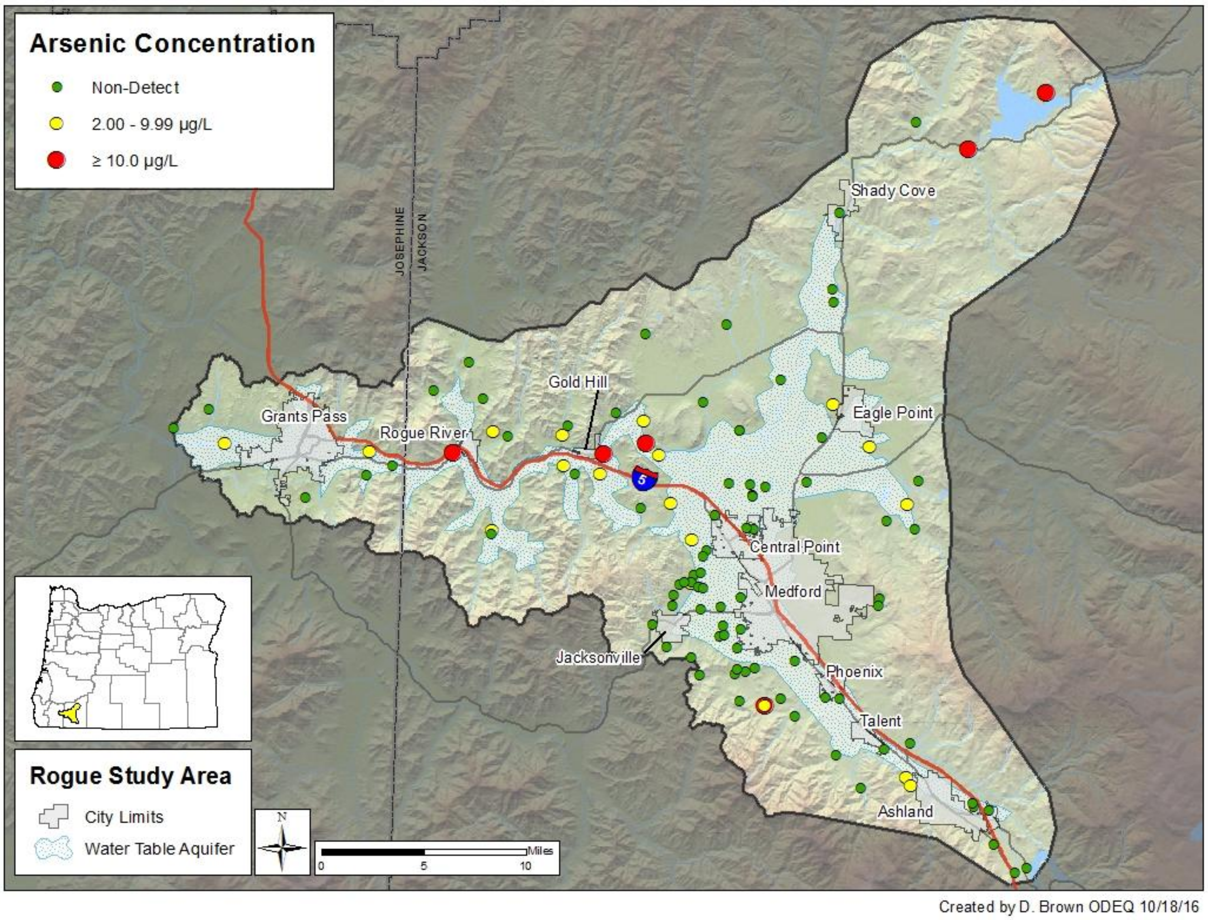


Figure 4. Arsenic concentrations in sampled wells. The maximum contaminant level goal for arsenic is zero. The maximum contaminant level for total arsenic is 10 µg/L.

3.2.3 Coliform Bacteria and *E. coli*

Coliform bacteria are a group of closely related bacteria that are typically not harmful to humans. However, coliform bacteria are a useful indicator to determine if similar, disease-causing microorganisms (e.g., bacteria, viruses) may be present in water bodies. *E.coli* is a specific class of coliform bacteria more commonly associated with illness. Presence of coliform bacteria may indicate a problem with the integrity of a well's construction allowing contamination from surface or soil sources into the well. Bacterial contamination may also affect shallow aquifers through improperly designed or maintained septic systems or leaching from areas where manure or biosolids are spread. The maximum contaminant level goal for coliform bacteria is zero.

Coliform bacteria were detected in 46 of 107 wells (43 percent), and *E. coli* was detected in eight of those wells. Detections were evenly distributed throughout the study area (Figure 5) and did not show a relationship with depth of the water bearing interval. Without further investigation, it is unknown if these results indicate structural problems with individual wells or if aquifer contamination is local or area-wide. Public health officials recommend testing well water for coliform bacteria annually and the prevalence of coliform bacteria detected in this study strongly supports that recommendation.

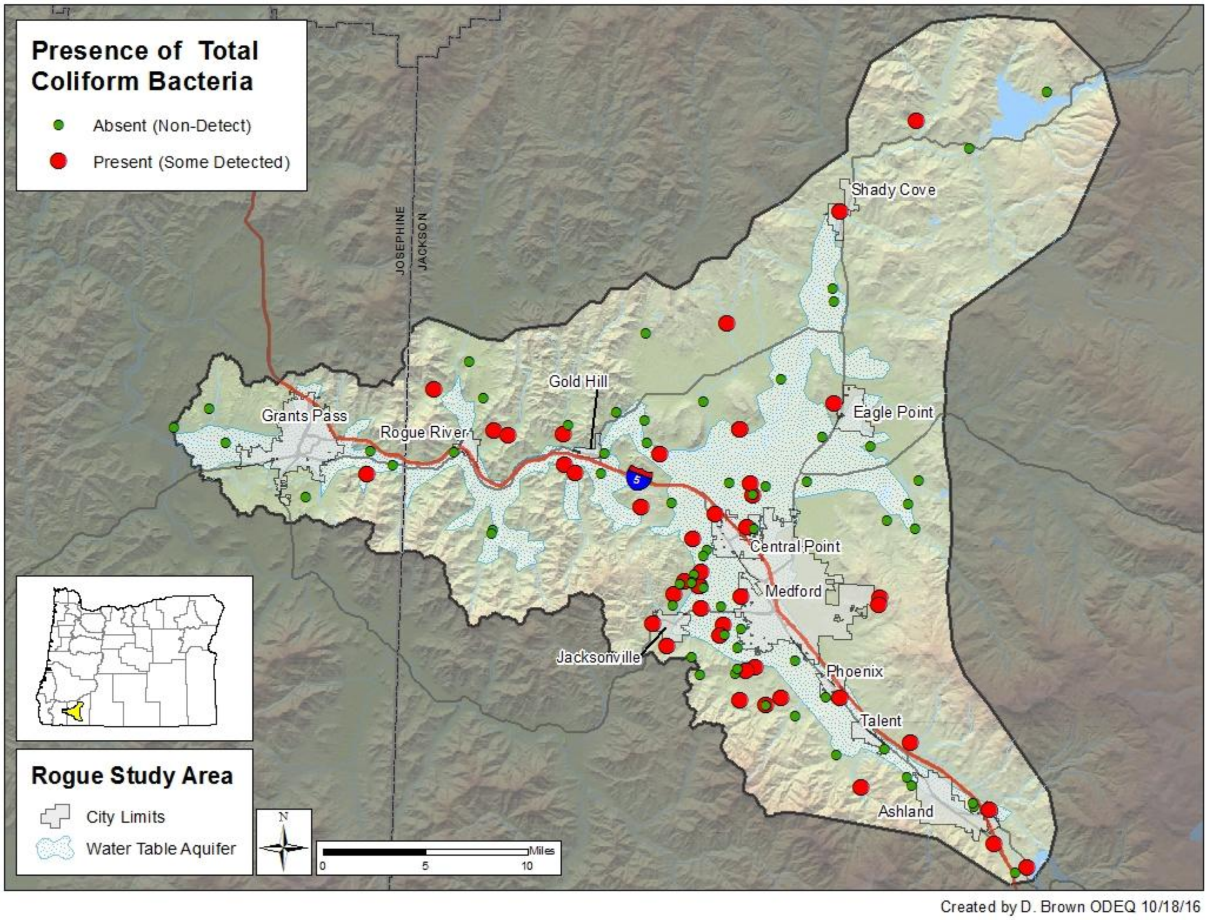


Figure 5. Bacteria results for sampled wells.

3.2.4 Pesticides

Pesticides are a broad class of chemicals that includes insecticides, herbicides and fungicides. Pesticides that are currently used and those no longer in use (legacy) are both included in the study. Legacy pesticides refer to chlorinated insecticides, such as DDT, which are banned in the United States. This study also measured several chemicals that are breakdown products of pesticides. Physical processes, such as photo-degradation by sunlight, or biological processes, such as metabolism by bacteria, can break parent pesticides down into different chemicals that may be more soluble and travel more easily into groundwater. In general, less information is known about the potential health impacts of these breakdown products than the parent pesticide. It is common to detect the breakdown product of a pesticide in a water sample, but not the parent pesticide, due to differences in solubility and other chemical properties. Pesticides were not measured in the 2011 study.

Seventeen different pesticide-related chemicals were detected in this study, representing 12 different parent pesticides (Table 1). At least one current use pesticide related chemical was detected in 37 of the 107 wells sampled in this study (Figure 6). Six wells had at least one chemical originating from a legacy pesticide detected in their water. While pesticides were detected throughout the study area, the wells in the area around Central Point and north and west of Medford had a high occurrence of pesticide detection (21 of 28 wells) (Figure 7).

The most commonly detected pesticides belong to the triazine herbicide group, which includes atrazine and simazine. Desethylatrazine and deisopropylatrazine are two of the highly soluble breakdown products of atrazine and simazine. These herbicides are widely used in agriculture and urban applications. There are several other breakdown products of these two pesticides, however they were not included in the analysis of these samples. At least one of these four chemicals was found in 24 of the study wells.

Table 1. Summary of pesticides and breakdown products detected.

	# wells detected	Max. Conc.	Units	Screening Level	Use
Current Use Pesticides					
*Total triazines**	24	259.6	ng/L	3,000[1]	
Atrazine	6	53.2	ng/L	3,000[1]	Herbicide
Simazine	12	51.3	ng/L	4,000[1]	Herbicide
Deisopropylatrazine	19	69.4	ng/L	Not Available	Breakdown product of atrazine and simazine
Desethylatrazine	12	137	ng/L	Not Available	Breakdown product of atrazine and simazine
2,4-D	2	1400	ng/L	70,000[2]	Herbicide
2,6-Dichlorobenzamide	12	692	ng/L	32,000[2]	Breakdown product of dichlobenil
Acetamiprid	1	5.96	ng/L	497,000[2]	Insecticide
DCPA acid metabolites	1	8300	ng/L	Not Available	Breakdown product of dacthal
DEET	1	45.2	ng/L	Not Available	Insect repellent
Diuron	7	57.5	ng/L	2,000[3]	Herbicide
Norflurazon	1	51.7	ng/L	105,000[2]	Herbicide
Prometon	2	9.53	ng/L	400,000[3]	Herbicide
Legacy Pesticides					
Total DDTs [#]	5	0.694	ng/L	100[3]	
2,4´-DDD	1	0.118	ng/L	Not Available	Breakdown product of banned insecticide DDT
4,4´-DDD	2	0.235	ng/L	100[3]	Breakdown product of banned insecticide DDT
4,4´-DDE	3	0.495	ng/L	100[3]	Breakdown product of banned insecticide DDT
4,4´-DDT	3	0.498	ng/L	100[3]	Banned chlorinated insecticide
Heptachlor epoxide	1	0.0803	ng/L	200[2]	Banned chlorinated insecticide

*includes atrazine, simazine, deisopropylatrazine and desethylatrazine

[#]includes 2,4'-DDD, 4.4'-DDD, 4,4'-DDE and 4,4'-DDT

[1]USEPA Maximum Contaminant Level

[2]USEPA non-regulatory Human Health Benchmark

[3]USGS Health-based Screening Level

All detected chemicals were well below any known human health screening level, often less than 1 percent of the screening value, and never more than 3 percent. Twenty-two of the wells had two or more pesticide chemicals detected (Figure 6), and 13 wells had chemicals from more than one parent pesticide detected (Figure 7). Very little research has been done on the combined effects of chemical mixtures on human health. A common practice is to add the concentration of all related chemicals (parents and their breakdown products, or chemically similar pesticides) and compare that concentration to the lowest screening level of those chemicals. This method assumes that the combined effect of the chemicals is no worse than the most toxic of the individual chemicals. Using this method, the results for total DDTs and total triazines are still far below a level that may cause any health risk (Table 1).

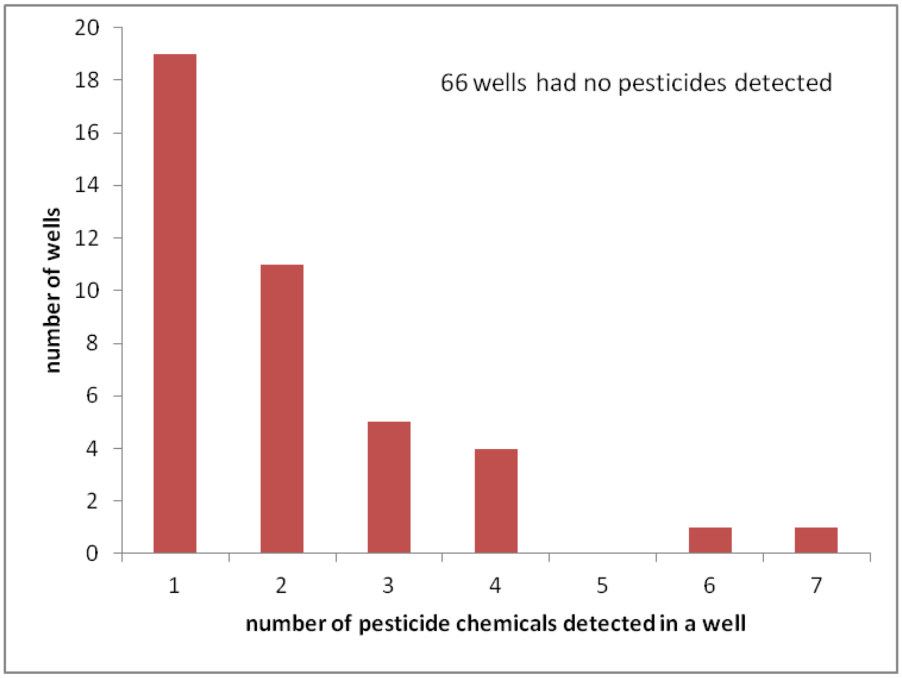
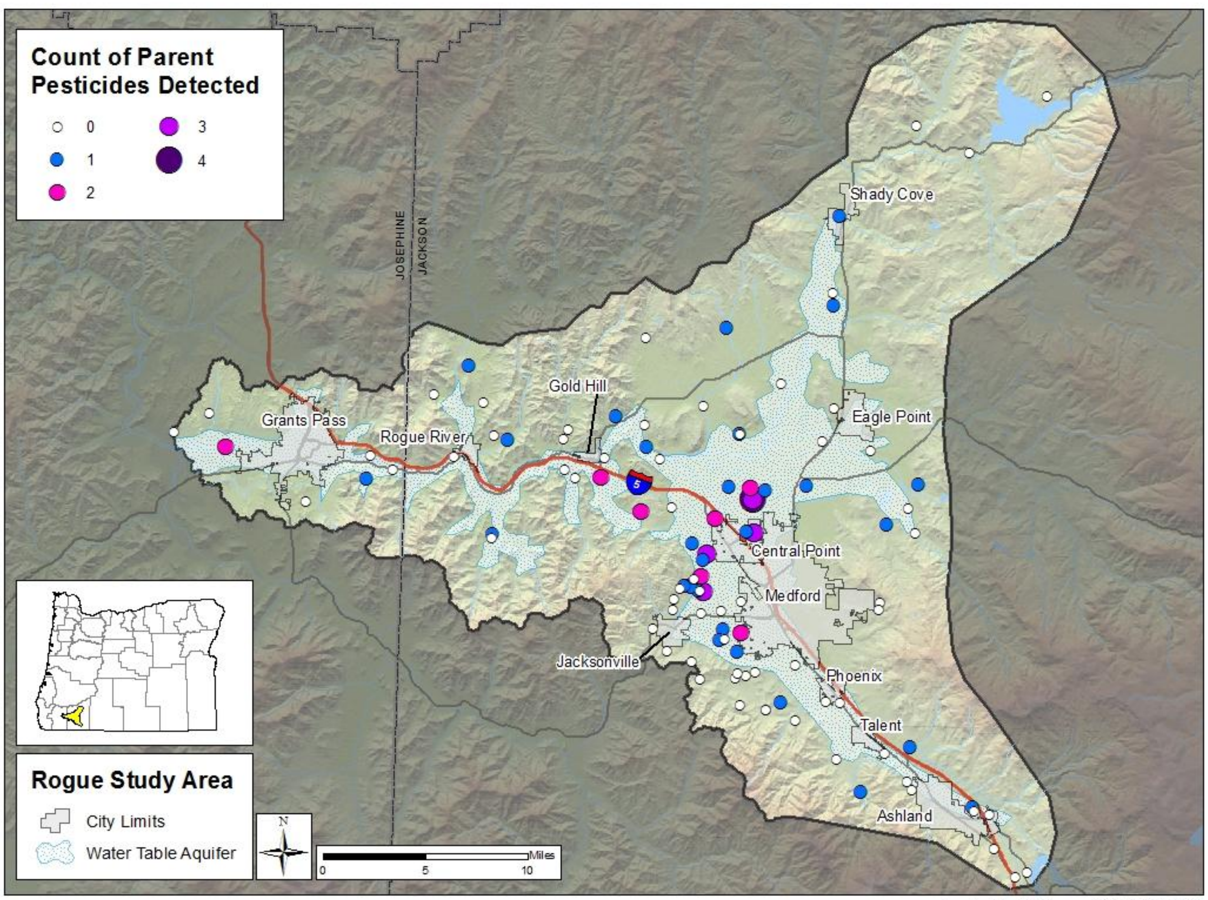


Figure 6. Histogram of total number of pesticide chemicals detected in a well.



Created by D. Brown ODEQ 10/18/16

Figure 7. Number of parent pesticides detected in sampled wells.

3.2.5 Manganese

Manganese is an element found in many soils, rocks and minerals. In areas with manganese-containing minerals, manganese may be present in the groundwater under low-oxygen conditions. At high concentrations, manganese has been associated with neurological disease. EPA has set a secondary drinking water standard for manganese at 50 µg/L to avoid discoloration, staining and a metallic taste. EPA also has calculated a Lifetime Health Advisory for manganese in drinking water at 300 µg/L. Manganese was detected in 57 of the wells sampled in this study. Fifteen wells were above the 50 µg/L secondary drinking water standard and two were above the 300 µg/L Lifetime Health Advisory (Figure 8). Similar results were found in the 2011 study. While low concentrations are likely due to natural geochemical processes, further investigation is necessary to determine the sources of manganese in the wells with very high concentrations. Water above the secondary drinking water standard would not be palatable for drinking without treatment.

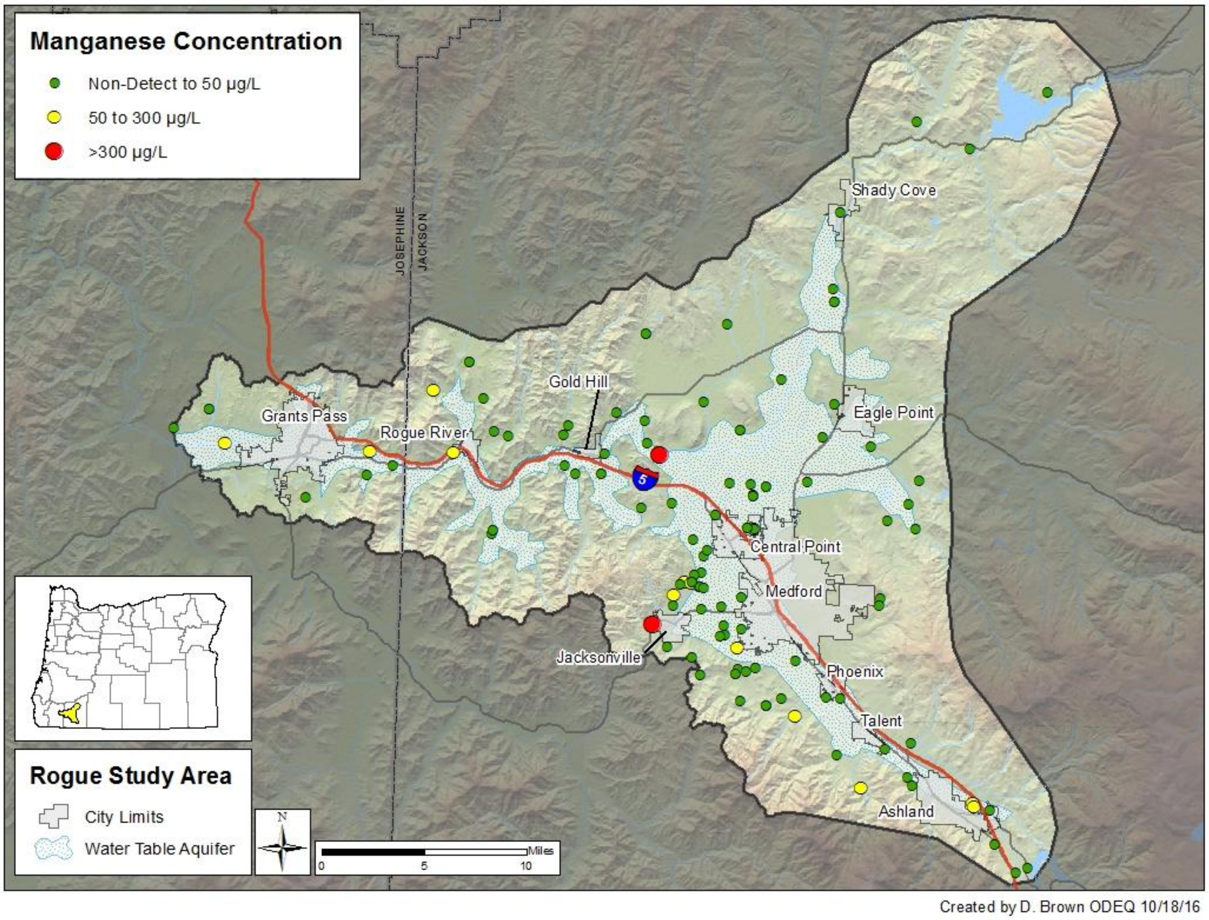


Figure 8. Manganese results in sampled wells. The secondary drinking water standard for manganese is 50 µg/L and the Lifetime Health Advisory is 300 µg/L.

3.2.6 Uranium

Uranium is a natural element found throughout the environment. Uranium in water comes mainly from rocks and soil as water passes over them. Nearly all naturally occurring uranium is non-radioactive (Oregon Department of Human Services 2007). EPA has established a maximum contaminant level of 30 µg/L for uranium in drinking water. Low concentrations of uranium were detected in 71 of the 107 wells sampled in this study. The maximum concentration measured was 8.28 µg/L, less than one-third of the maximum contaminant level. Uranium was not measured in the 2011 study.

3.2.7 Vanadium

Vanadium is found in many different minerals as well as in coal and other fossil fuels. Vanadium may be released to the environment through the combustion of fossil fuels, or through natural weathering processes of rocks and soils. There is no federal or state regulatory standard for vanadium in drinking water. However, EPA has set a Regional Screening Level for resident tap water of 86 µg/L for vanadium. Vanadium was detected in 44 of the 107 study wells. The maximum concentration measured was 31.1 µg/L, similar to the results from the 2011 DEQ study in this region.

3.3 Well log comparison

The Oregon Water Resources Department has required wells logs since 1955. The logs are completed by a well driller and provide details on well construction including a description of the geologic material drilled through and material used to case and seal the well. While the information in well logs is extremely useful in interpreting groundwater data, well logs can be difficult to locate and verify. Some of the reasons for this include:

- A well log may never have been completed.
- The location of a well is described by township, range, and section on the well log, and there may be more than one well in any given section.
- There may be mistakes, especially in the location, that cause the well log to be misfiled and difficult to find.

With the emergence of electronic record keeping and the requirements to have new well locations tagged with their GPS coordinates (since 2009), it is much easier to locate well logs for recently drilled wells. This study included wells with and without well logs. While the absence of some well logs limits the interpretation of the data, it also provides an opportunity to compare the results between these two groups and identify any potential bias that may be introduced when excluding wells without a well log from a study.

Figure 9 shows the distribution of nitrate results between wells with and without well logs. The group of wells without well logs has a higher percentage of results above 3 mg/L. However, this might reflect the geographic distribution of the wells in each group (Figure 10), with many of the wells without well logs located in the area north and west of Medford. There was no significant difference in results between the two groups (ANOVA: F = 2.35, df = 87, P = 0.13).

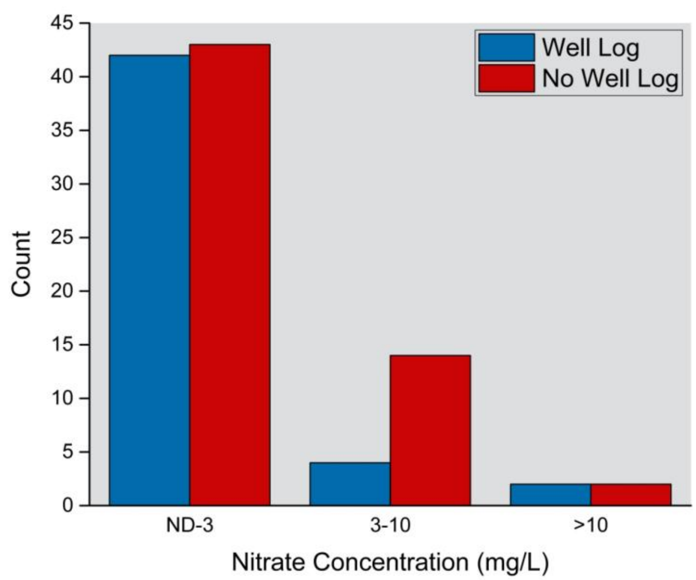


Figure 9. Comparison of the distribution of nitrate results for wells with and without well logs.

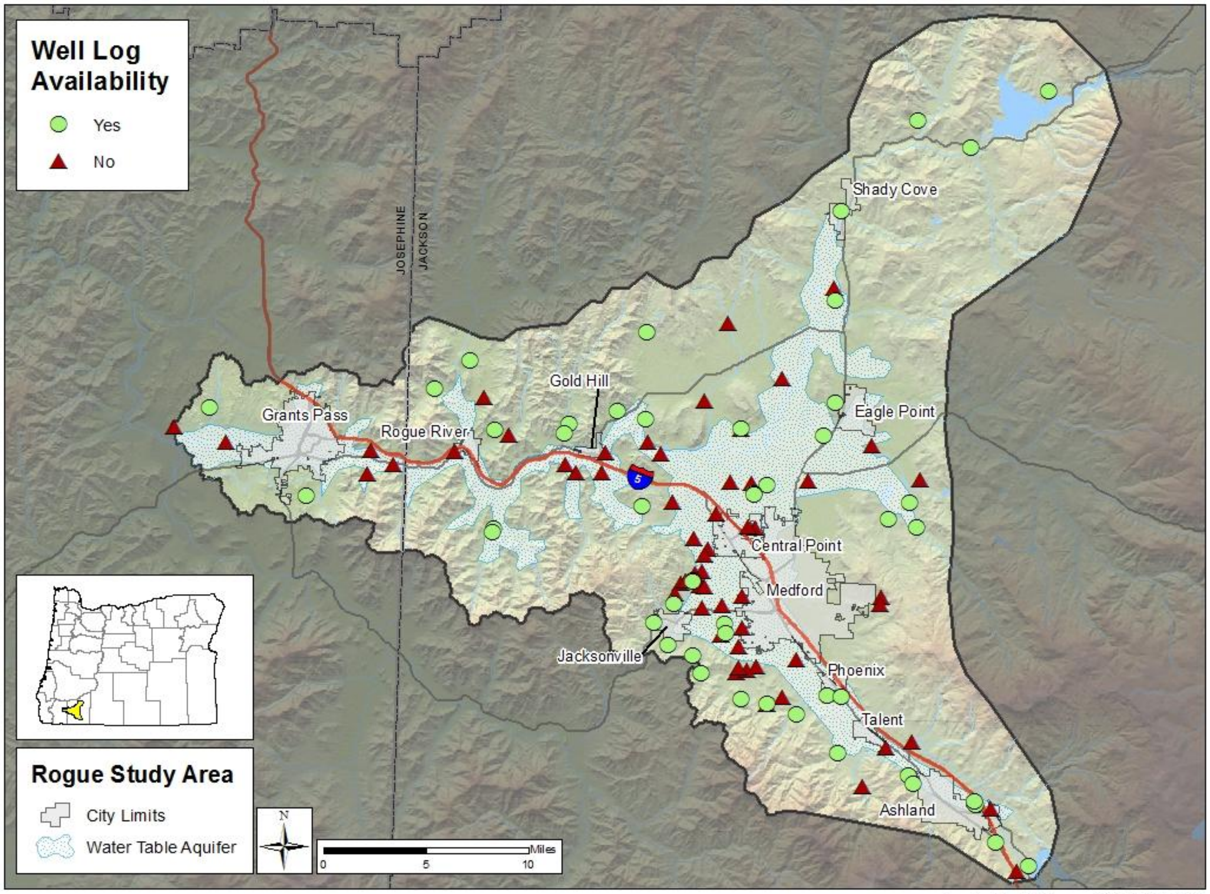


Figure 9. Distribution of wells with and without well log records.

3.4 Seasonal differences

Thirteen wells were sampled during both the winter (February-March) and fall (October) sampling events in an effort to capture the seasonal variability of results. Wells chosen for resampling were shallow and therefore most likely to be affected by seasonal changes in rainfall or land management practices.

The seasonal differences in nitrate concentration ranged from 0.66 mg/L lower to 1.41 mg/L higher during the fall than the winter with no obvious pattern (Figure 11). Bacteria results were similar between the two sampling events, despite a large rain storm just prior to the first week of the winter sample collection, which could have been a risk for contamination due to flooding. There were nine wells in the resample group with pesticide detects. All but one had more pesticide chemicals detected and/or higher concentrations in the winter sample (Figure 12). The other well had no pesticides detected in the winter and one detected in the fall. Lower results in the fall may indicate a hydrological disconnect between soils and the aquifer after a long dry summer.

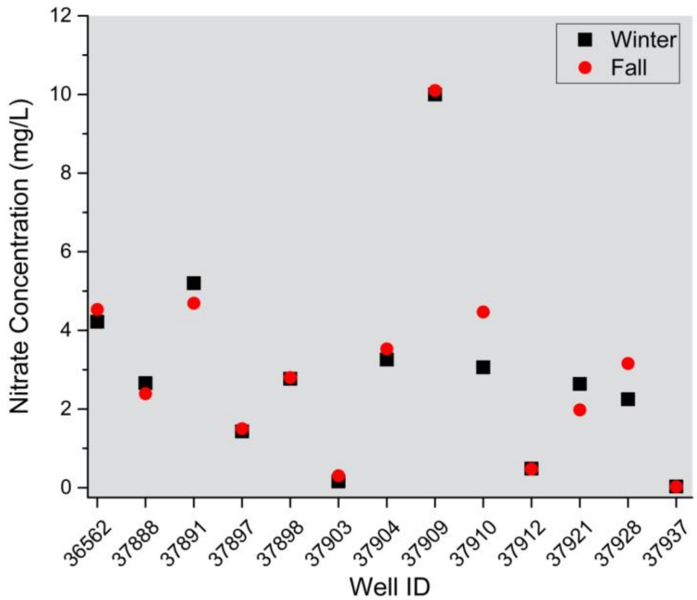


Figure 10. Nitrate concentrations for wells sampled during both events. Winter sampling occurred in February and March 2015 and fall sampling occurred in October 2015.

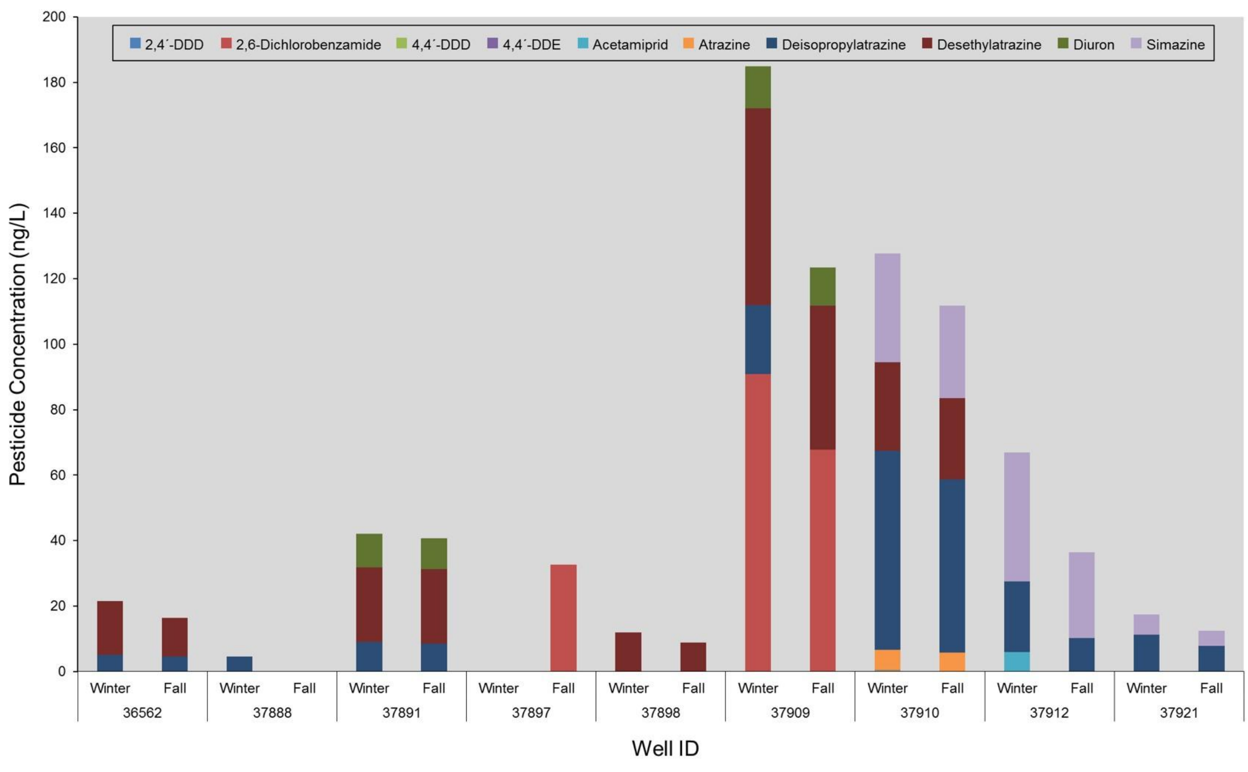


Figure 11. Pesticide results for wells sampled during both events. Winter sampling occurred in February and March 2015 and fall sampling occurred in October 2015. Wells without any detected pesticides were excluded from this figure.

4. Summary

The 2015 mid-Rogue Basin groundwater study met its objectives in the following ways:

1. *To collect high-quality data on nitrate, arsenic, coliform bacteria and pesticide concentrations in groundwater throughout the study area*
   Groundwater quality data for 107 wells within the study area are available. This represents the largest quality-controlled groundwater investigation in the area since the early 1970s (Patton and Eldridge, 2013). These data may be used in future analyses of specific groundwater issues or to support and focus outreach activities.

2. *To identify areas of groundwater contamination related to these parameters*
   Nitrate contamination was found in several areas in Jackson County, including the area around Central Point and Medford. Arsenic contamination was found in many sites along the Rogue River between Grants Pass and Gold Hill and in the area around Lost Creek Lake. Some wells around Eagle Point, Ashland and west of Phoenix and Central Point also had arsenic detections. The wells with high arsenic (>10 µg/L) were different than the wells with high nitrate (>10 mg/L). Bacterial contamination was detected throughout the study area as were low levels of pesticides.

3. *To inform well water users of the results of this study and provide information regarding potential risks to human health*
   In addition to the 46 wells with total coliform detections, there were 12 wells with other results exceeding a maximum contaminant level or other health-based benchmark. All of these well owners were notified of these results by DEQ staff and referred to local and state public health resources to discuss potential risks. While pesticides were detected in 41 wells, all results were well below any health-based benchmark and not expected to pose a health risk.

4. *To identify areas needing additional investigation in order to describe the extent of contamination and help focus efforts to prevent further contamination.*
   This study confirmed the presence of nitrate-contaminated groundwater in the area around Central Point and north and west of Medford. Several wells outside this area also had high nitrate and warrant further investigation to determine the extent of the contamination. Hydrogeologic analyses and investigations into the sources of contamination were outside the scope of this study.

5. Recommendations

Aquifer contamination is a long-lasting problem and steps should be taken to reduce any further negative impacts from human activity. Additional analysis of data from this study, as well as data from previous studies and the Oregon Health Authority’s Real Estate Transaction Act (ORS 448.271) data, can further refine the extent of aquifer contamination and contribute to identifying the sources of nitrate, pesticide and bacterial contamination. With this information, strategies can be developed to help prevent further degradation of aquifer water quality.

Long-term monitoring of nitrate and pesticides is recommended, especially in the area north and west of Medford. While the concentrations measured in this study are mostly below the health-based benchmarks, these levels may rise over time. A network of wells should be established and monitored to detect any changes over time.

Since there is no regulatory oversight for private wells, and many private well owners are currently unaware of the quality of their drinking water, results from this study can be used to focus public health outreach in areas where contamination exits. Local, county or state public health outreach should encourage homeowners to get their wells tested annually for nitrate and bacteria and to test it at least once for arsenic. Overall results of this study and the on-going statewide monitoring program can be used to better understand the threats to and quality of the groundwater resources of Oregon.

There are many resources available to help domestic well owners in Oregon. As part of the recommendations of this Mid-Rogue Basin Groundwater Report, the following list of resources is provided to well owners:

- The *Oregon Domestic Well Safety Program* (www.healthoregon.org/wells) focuses on improving local and state capacity to assess and manage risks associated with private wells. DWSP partners with local health departments and water information providers to further promote domestic well safety.

- The Oregon Water Resources Department and Oregon Health Authority publish a brochure, "Water Well Owner's Handbook: A guide to water wells in Oregon" which provides general information on groundwater, water wells, well construction, operation, maintenance and abandonment information (http://www.oregon.gov/owrd/PUBS/docs/Well_Water_Handbook.pdf).

- DEQ's Drinking Water Protection Program has developed many tools for public water systems that can be readily used for domestic wells:
    - Basic Tips for Keeping Drinking Water Clean and Safe http://www.deq.state.or.us/wq/pubs/factsheets/drinkingwater/BasicTips12WQ005.pdf
    - Groundwater Basics for Drinking Water Protection http://www.deq.state.or.us/wq/pubs/factsheets/drinkingwater/GroundwaterBasics.pdf
    - Other technical assistance fact sheets http://www.deq.state.or.us/wq/dwp/assistance.htm

6. References

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Appendix A – Complete Site List

Pages A-1 through A-5

Well ID	Rogue Basin Groundwater Study Site ID	Latitude	Longitude	Well Log Availability	Well log	Top of Water Bearing Zone (ft bgs)	Bottom of Water Bearing Zone (ft bgs)	Well Vertical Migration Potential	2016 Sampling Season
36562	RV-066	42.41329	-122.88377	Yes	JACK-52545	47	58	High	Winter/Fall
37886	RV-115	42.39579	-123.32271	Yes	JOSE-1342	50	66	High	Winter
37888	RV-117	42.54566	-122.82348	Yes	JACK-61885	32	35	Unknown	Winter/Fall
37890	RV-119	42.45246	-123.07396	Yes	JACK-58069	95	120	High	Winter
37896	RV-125	42.47438	-123.20331	Yes	JACK-9662	44	65	Moderate	Winter
37897	RV-126	42.49518	-123.17072	Yes	JACK-5369	39	65	High	Winter/Fall
37898	RV-127	42.37667	-123.14353	Yes	JACK-14229	68	83	Moderate	Winter/Fall
37899	RV-128	42.19132	-122.67604	Yes	JACK-20357	Unknown	Unknown	High	Winter
37900	RV-129	42.22537	-122.80850	Yes	JACK-15542	23	90	High	Winter
37902	RV-131	42.26528	-122.82027	Yes	JACK_14885	92	105	High	Winter
37906	RV-135	42.31466	-122.92061	Yes	JACK_13878	Unknown	47	Moderate	Winter
37908	RV-137	42.40721	-122.89555	Yes	JACK-7347	45	60	Low	Winter
37909	RV-138	42.40692	-122.89611	Yes	JACK-7384	Unknown	40	Low	Winter/Fall
37912	RV-141	42.34457	-122.95149	Yes	JACK-34989	Unknown	70	High	Winter/Fall
37917	RV-146	42.40358	-122.74671	Yes	JACK-54897	46	80	High	Winter
37919	RV-148	42.44642	-123.14475	Yes	JACK53151 (new), JACK-59259 (deepening)	326	500	High	Winter
37924	RV-153	42.67455	-122.74916	Yes	JACK_56916	126	200	High	Winter
37925	RV-154	42.65671	-122.69785	Yes	JACK18822, JACK-30911	160	300	Moderate	Winter
37926	RV-155	42.69854	-122.62464	Yes	JACK_51045	312	345	High	Winter

Well ID	Rogue Basin Groundwater Study Site ID	Latitude	Longitude	Well Log Availability	Well log	Top of Water Bearing Zone (ft bgs)	Bottom of Water Bearing Zone (ft bgs)	Well Vertical Migration Potential	2016 Sampling Season
37928	RV-157	42.51938	-123.00336	Yes	JACK4516 (new), JACK-4515 (deepening)	53	320	High	Winter/Fall
37929	RV-158	42.46257	-123.02839	Yes	JACK8136 (new), JACK-57391 (deepening)	83	760	High	Winter
37932	RV-161	42.27867	-122.94113	Yes	JACK-33311	305	320	High	Winter
37933	RV-162	42.26118	-122.90271	Yes	JACK16689, JACK16649, JACK16647, JACK16646	Unknown	405	Moderate	Winter
37937	RV-166	42.45601	-123.41768	Yes	JOSE-19047	126	150	High	Winter/Fall
37942	RV-171	42.45301	-122.90990	Yes	JACK_58138	72	147	High	Winter
37944	RV-173	42.25178	-122.84951	Yes	JACK_15162	135	700	High	Winter
37946	RV-175	42.37457	-123.14457	Yes	JACK55759	135	700	High	Fall
37947	RV-176	42.60885	-122.81976	Yes	JACK792 (new) JACK705 (deepening)	135	700	High	Fall
37949	RV-178	42.45795	-123.00151	Yes	JACK-8249	50	437	High	Fall
37952	RV-181	42.34397	-122.95193	Yes	JACK-33003	105	120	High	Fall
37955	RV-184	42.14886	-122.62436	Yes	JACK-20770	56	360	High	Fall
37956	RV-185	42.16480	-122.65635	Yes	JACK-22560	136	150	High	Fall
37958	RV-187	42.19339	-122.67748	Yes	JACK 20348 (new) JACK 20347 (Recon) JACK-54646 (Deepening)	Unknown	121	High	Fall

Well ID	Rogue Basin Groundwater Study Site ID	Latitude	Longitude	Well Log Availability	Well log	Top of Water Bearing Zone (ft bgs)	Bottom of Water Bearing Zone (ft bgs)	Well Vertical Migration Potential	2016 Sampling Season
37959	RV-188	42.26537	-122.80742	Yes	JACK-14849	231	280	High	Fall
37960	RV-189	42.44578	-123.07894	Yes	JACK-8339	119	140	High	Fall
37964	RV-193	42.31353	-122.98793	Yes	JACK-33846	242	540	High	Fall
37965	RV-194	42.29836	-122.97329	Yes	JACK-53696	429	460	High	Fall
37966	RV-195	42.29083	-122.94920	Yes	JACK-58067	95	300	High	Fall
37969	RV-198	42.30745	-122.91922	Yes	JACK-31052	147	200	High	Fall
37972	RV-201	42.21011	-122.74113	Yes	JACK-54627	890	940	High	Fall
37973	RV-202	42.20476	-122.73684	Yes	JACK-33887	240	517	High	Fall
37974	RV-203	42.25847	-122.87768	Yes	JACK-34025	54	205	High	Fall
37975	RV-204	42.38690	-122.73924	Yes	JACK-19617	180	226	High	Fall
37976	RV-205	42.39165	-122.76652	Yes	JACK6794 (new), JACK 6791 (reseal)	120	218	High	Fall
37978	RV-207	42.47319	-122.82103	Yes	JACK-1236	Unknown	340	Unknown	Fall
37979	RV-208	42.44993	-122.83152	Yes	JACK-61259	75	200	High	Fall
37984	RV-213	42.32733	-122.96965	Yes	JACK51097	112	420	High	Fall
37987	RV-216	42.39581	-123.00265	Yes	JACK-30605	60	142	High	Fall
37887	RV-116	42.55458	-122.82446	No	Not Found				Winter
37889	RV-118	42.47182	-122.94557	No	Not Found				Winter
37891	RV-120	42.41890	-123.04168	No	Not Found				Winter/Fall
37892	RV-121	42.45292	-122.90980	No	Not Found				Winter
37893	RV-122	42.43350	-122.98536	No	Not Found				Winter
37894	RV-123	42.41559	-122.91914	No	Not Found				Winter
37895	RV-124	42.37465	-122.95165	No	Not Found				Winter
37901	RV-130	42.23020	-122.76358	No	Not Found				Winter
37903	RV-132	42.25878	-122.87758	No	Not Found				Winter/Fall
37904	RV-133	42.28036	-122.90752	No	Not Found				Winter/Fall

Well ID	Rogue Basin Groundwater Study Site ID	Latitude	Longitude	Well Log Availability	Well log	Top of Water Bearing Zone (ft bgs)	Bottom of Water Bearing Zone (ft bgs)	Well Vertical Migration Potential	2016 Sampling Season
37905	RV-134	42.31195	-122.90386	No	Not Found				Winter
37907	RV-136	42.42043	-122.73733	No	Not Found				Winter
37910	RV-139	42.38341	-122.89416	No	Not Found				Winter/Fall
37911	RV-140	42.34957	-122.95033	No	Not Found				Winter
37913	RV-142	42.34142	-122.94413	No	Not Found				Winter
37914	RV-143	42.34147	-122.94445	No	Not Found				Winter
37915	RV-144	42.34081	-122.94046	No	Not Found				Winter
37916	RV-145	42.23501	-122.73888	No	Not Found				Winter
37918	RV-147	42.42444	-123.07617	No	Not Found				Winter
37920	RV-149	42.43082	-123.18254	No	Not Found				Winter
37921	RV-150	42.38419	-122.90037	No	Not Found				Winter/Fall
37922	RV-151	42.34266	-122.96300	No	Not Found				Winter
37923	RV-152	42.35121	-122.94341	No	Not Found				Winter
37927	RV-156	42.48942	-122.87155	No	Not Found				Winter
37930	RV-159	42.43378	-123.03918	No	Not Found				Winter
37931	RV-160	42.33699	-122.77163	No	Not Found				Winter
37934	RV-163	42.14540	-122.63529	No	Not Found				Winter
37935	RV-164	42.20210	-122.78416	No	Not Found				Winter
37936	RV-165	42.32557	-122.94256	No	Not Found				Winter
37938	RV-167	42.43178	-123.40113	No	Not Found				Winter
37939	RV-168	42.41308	-123.26567	No	Not Found				Winter
37940	RV-169	42.42936	-123.26248	No	Not Found				Winter
37941	RV-170	42.42018	-123.24031	No	Not Found				Winter
37943	RV-172	42.47017	-123.15648	No	Not Found				Winter
37945	RV-174	42.44171	-123.45117	No	Not Found				Fall
37948	RV-177	42.52742	-122.92488	No	Not Found				Fall
37950	RV-179	42.26364	-122.86354	No	Not Found				Fall

Well ID	Rogue Basin Groundwater Study Site ID	Latitude	Longitude	Well Log Availability	Well log	Top of Water Bearing Zone (ft bgs)	Bottom of Water Bearing Zone (ft bgs)	Well Vertical Migration Potential	2016 Sampling Season
37951	RV-180	42.28537	-122.88877	No	Not Found				Fall
37953	RV-182	42.36749	-122.93785	No	Not Found				Fall
37954	RV-183	42.36279	-122.94164	No	Not Found				Fall
37957	RV-186	42.18883	-122.66199	No	Not Found				Fall
37961	RV-190	42.44374	-123.13120	No	Not Found				Fall
37962	RV-191	42.33489	-122.90451	No	Not Found				Fall
37963	RV-192	42.32727	-122.92267	No	Not Found				Fall
37967	RV-196	42.29836	-122.90619	No	Not Found				Fall
37968	RV-197	42.30701	-122.92284	No	Not Found				Fall
37970	RV-199	42.28203	-122.89821	No	Not Found				Fall
37971	RV-200	42.28393	-122.90561	No	Not Found				Fall
37977	RV-206	42.44390	-122.78437	No	Not Found				Fall
37980	RV-209	42.41729	-122.84485	No	Not Found				Fall
37981	RV-210	42.29113	-122.85042	No	Not Found				Fall
37982	RV-211	42.34471	-122.95890	No	Not Found				Fall
37983	RV-212	42.33531	-122.96870	No	Not Found				Fall
37985	RV-214	42.41854	-123.06617	No	Not Found				Fall
37986	RV-215	42.44223	-122.99817	No	Not Found				Fall
37988	RV-217	42.40026	-122.97330	No	Not Found				Fall
37989	RV-218	42.39215	-122.93124	No	Not Found				Fall
37990	RV-219	42.41446	-122.89887	No	Not Found				Fall
37991	RV-220	42.33169	-122.77267	No	Not Found				Fall

Appendix B – Full Analyte List

Pages B-1 through B-3

List contains all compounds analyzed during the sampling period	Pesticides analyzed in a limited number of samples as discussed in section 2.2.1
Analyte group, *Analyte sub-group*, Analyte name	
Bacteria	**Current Use Pesticides, cont'd**
Total Coliform	*Herbicides*
E. Coli	Chlorpropham
Consumer Product Constituents	Cyanazine
DEET	Cycloate
Current Use Pesticides	Dacthal (DCPA)
Fungicides	DCPA acid metabolites
Chloroneb	Deisopropylatrazine
Chlorothalonil	Desethylatrazine
Etridiazole	Dichlobenil
Fenarimol	Dichloroprop
Pentachlorophenol	Dimethenamid
Propiconazole	Dinoseb
Pyraclostrobin	Diphenamid
Triadimefon	Diuron
Tricyclazole	EPTC
Herbicides	Fluometuron
2,4,5-T	Fluridone
2,4-D	Hexazinone
2,4-DB	Imazapyr
2,6-Dichlorobenzamide	Linuron
Acetochlor	MCPA
Acifluorfen	MCPP
Alachlor	Metolachlor
Ametryn	Metribuzin
Aminocarb	Metsulfuron Methyl
Atrazine	Molinate
Bromacil	Napropamide
Butachlor	Neburon
Butylate	Norflurazon

List contains all compounds analyzed during the sampling period	Pesticides analyzed in a limited number of samples as discussed in section 2.2.1
Analyte group, *Analyte sub-group*, Analyte name	
Current Use Pesticides, cont'd	**Current Use Pesticides, cont'd**
Herbicides	*Insecticides*
Pendimethalin	Fenamiphos
Picloram	Fenvalerate+Esfenvalerate
Pendimethalin	Imidacloprid
Picloram	Malathion
Prometon	Methiocarb
Prometryn	Methomyl
Pronamide	Methyl paraoxon
Propachlor	Mevinphos
Propazine	Mexacarbate
Siduron	MGK 264
Simazine	Mirex
Simetryn	Oxamyl
Sulfometuron-methyl	Parathion-ethyl
Tebuthiuron	Parathion-methyl
Terbacil	Permethrin
Terbutryn (Prebane)	Pyriproxyfen
Terbutylazine	Terbufos
Triclopyr	Tetrachlorvinphos (Stirophos)
Trifluralin	**Industrial Chemicals or Intermediates**
Vernolate	3,5-Dichlorobenzoic acid
Insecticides	**Legacy Pesticides**
Acetamiprid	2,4,5-TP (Silvex)
Azinphos-methyl (Guthion)	Aldrin
Baygon (Propoxur)	Chlorobenzilate
Bifenthrin	cis-Nonachlor
Carbaryl	Dieldrin
Carbofuran	Endosulfan I
Chlorpyrifos	Endosulfan II
Diazinon	Endosulfan sulfate
Dicamba	Endrin
Dichlorvos	Endrin aldehyde
Dimethoate	Endrin ketone
Ethoprop	Endrin+cis-Nonachlor

List contains all compounds analyzed during the sampling period	Pesticides analyzed in a limited number of samples as discussed in section 2.2.1 (shaded green)
Analyte group, *Analyte sub-group*, Analyte name	
Legacy Pesticides, cont'd	**Metals (Total Recoverable)**
Heptachlor	Aluminum
Heptachlor epoxide	Arsenic
Hexachlorobenzene	Calcium
Methoxychlor	Iron
BHC-Technical (HCH)	Magnesium
alpha-BHC	Manganese
beta-BHC	Potassium
delta-BHC	Sodium
gamma-BHC (Lindane)	Uranium
Chlordane	Vanadium
alpha-Chlordane	**Standard Parameters**
cis-Chlordane	Hardness as CaCO3, Total recoverable
gamma-Chlordane+trans-Nonachlor	Alkalinity, Total as CaCO3
Oxychlordane	Chloride
trans-Chlordane	Nitrate/Nitrite as N
trans-Nonachlor	Oxidation Reduction Potential
Total DDT	Phosphate, Total as P
2,4´-DDD	Sulfate
2,4´-DDE	Total Solids
2,4´-DDT	**Field Parameters**
4,4´-DDD	Conductivity
4,4´-DDE	Dissolved Oxygen
4,4´-DDT	pH
	Temperature