Statewide Groundwater Quality Monitoring Program: Walla Walla Basin 2020

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Executive Summary

The stated objective of Oregon statute ORS 468B.155 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.” To understand how Oregon is doing in meeting this goal, the Statewide Groundwater Monitoring Program began collecting water quality data in 2015. The goals of the Program are to establish the status of ambient groundwater conditions, identify emerging groundwater quality problems and inform groundwater users of potential risks from contamination. 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 2016, the Statewide Groundwater Monitoring Program conducted a groundwater study in the Walla Walla Basin. Objectives of the study were:

1. To collect high-quality data on nitrate, arsenic, coliform bacteria, pesticides and perchlorate 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.
5. To help establish long-term trending data and describe changes over time.

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

Study Area Description:
This study is located in the Walla Walla River Basin and is centered around the city of Milton-Freewater. This area is known for its agriculture and is dominated by fruit orchards and vineyards. It has a relatively arid climate. The geology consists of a shallow alluvial aquifer in the central basin and extends downward, and to a greater geographic extent, to layered basalt aquifers as the lands rise to the south and to the east of Milton-Freewater. The city is sustained by municipal water that pulls from the Walla Walla River and from local groundwater sources. There are distributed private wells at varying depths for domestic and irrigation uses throughout the basin. Aquifer Recharge projects are active in the basin to improve low-flow conditions of hydraulically connected streams and to stabilize the shallow alluvial aquifers.

Key findings include:
Nitrate detections were widespread but not at levels concerning to health (the health-based threshold for drinking water is 10 mg/l). Twenty percent of wells had elevated nitrate above levels expected to be found in uncontaminated groundwater (3mg/L). Those wells were spread out within the basin’s central valley with a few wells up at higher elevations. One irrigation well in the valley has levels slightly above the maximum contaminant level for drinking water. Elevated levels of nitrate indicate anthropogenic sources of contamination and it is recommended that wells throughout the Walla Walla Basin continue to be monitored for nitrate.

There was no arsenic detected in any of the wells sampled in this study.

Thirty-seven percent of wells sampled were contaminated with total coliform bacteria, and 3 of those wells also had *E. coli* present. Bacteria is unlikely to be detected at any level in groundwater unless contamination is present due to surface water or soil infiltration. 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.

Twenty different pesticide-related chemicals were detected in this study, representing twelve different parent pesticides. There were no pesticides detected at levels above health benchmarks of concern. The most commonly detected pesticide was desethylatrazine, a breakdown product of atrazine, showing up in 30 wells. The maximum detection of total atrazines (parent compound plus breakdown products) detected in any well was below the EPA established maximum contaminant level of 3 µg/L (equal to 3,000 ng/L). DCPA metabolites were detected in 3 wells. DCPA metabolites are breakdown products of the herbicide dacthal. Elevated dacthal concentrations were detected in 2012 in a groundwater public water supply at a point on the state line. Sixty-two percent of the wells sampled had no pesticide detections at all.

Although DEQ has analyzed for perchlorate in the Lower Umatilla Basin Groundwater Management Area since 2009, this study marks the first time that DEQ has analyzed groundwater samples for perchlorate in the Statewide Groundwater Monitoring Program. Perchlorate was detected in 7 wells, with a maximum concentration on 1.64 µg/L. The Agency for Toxic Substances and Disease Registry (ATSDR) has calculated an Environmental Media Evaluation Guide (EMEG) of 7 µg/L for children. Drinking water with less than this concentration is unlikely to pose a health threat.

Lead was detected at trace levels in 69 of the 100 wells sampled in this study. Three wells exceeded the EPA established drinking water maximum contaminant level of 0.015 mg/L. DEQ notified well owners with exceedance and connected them with Oregon Health Authority's lead expert. Well owners concerned about lead concentrations were instructed to contact their county environmental health department to investigate the possible lead sources and about retesting their water.

Sixteen wells from a DEQ 1999 study were resampled in 2016, and comparisons were made between common analytes sampled in both events. Nitrate was detected in all the samples in both studies, with two wells in both studies having elevated levels (>7 mg/L). Bacteria was detected in 6 wells in 2016 that did not have detections 1999. Atrazine detections increased from 1999 to 2016 in a few wells. There were no significant trends in the changes in concentrations of metals between the two studies except for iron which increased significantly in several wells.

The results of this study can be used to inform the people of Oregon about the current condition of the state's groundwater aquifers, which are an increasingly important natural resource for private and public use, at large and small scales. These results can also 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. Regular monitoring of shallow wells in the central basin's alluvial aquifer should include nitrate and bacteria. Long-term monitoring of current use pesticides, including atrazines and dacthal, is encouraged. It is recommended that a network of wells be established and monitored to detect any changes over time. Continued monitoring could be established locally, or, with continued funding, the Statewide Groundwater Monitoring Program would be able to consider addition of wells within this basin to be included in the agency's long-term monitoring network.

1. Background

1.1 Statewide Groundwater Quality Monitoring Program

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 all 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 overarching goal for groundwater quality 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 Quality Monitoring Program began collecting water quality data in 2015 to determine the status of ambient groundwater conditions, identify emerging groundwater quality concerns and inform groundwater users of potential risks from contamination[1].

To implement this work, the DEQ conducts regional groundwater studies annually with the goal of monitoring Oregon's vulnerable aquifers over a 10-year period. The program selects areas regionally, 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 well user participants. All studies include analysis of nitrate, arsenic, bacteria, pesticides, metals and common ions in 60 to 100 wells. Additional analyses are added based on local risk factors and program capacity.

1.2 Study Area Description

1.2.1 Study Area Boundary

In the late winter and fall of 2016, the Oregon DEQ collected and analyzed water samples in the Walla Walla River Basin in Northeastern Oregon. The river basin boundary south of the Oregon state border is depicted in Figure 1. The city of Milton-Freewater lays in the valley and the agricultural town of Umapine lays in the western part of the study area. The study boundary extends south into the uplands, to the city of Weston, and into the Blue Mountains to the east where the headwaters of the Walla Walla River reside. The hydrological unit of the river basin boundary (HUC8) was selected in order to capture a wide geographic area with varying opportunities to sample shallow and deep wells.

[1] The 2013-15 Oregon Legislative Session passed a Policy Option Package directing the DEQ to "monitor groundwater for contaminants of concern, including nitrates and pesticides, in two geographic regions per year. Groundwater quality throughout the state would be characterized over a ten year period. The data and information developed will be used to determine: areas of the state that are especially vulnerable to groundwater contamination; long term trends in groundwater quality; status of ambient groundwater quality; emerging groundwater quality problems; and to inform groundwater users of potential risks from contamination".

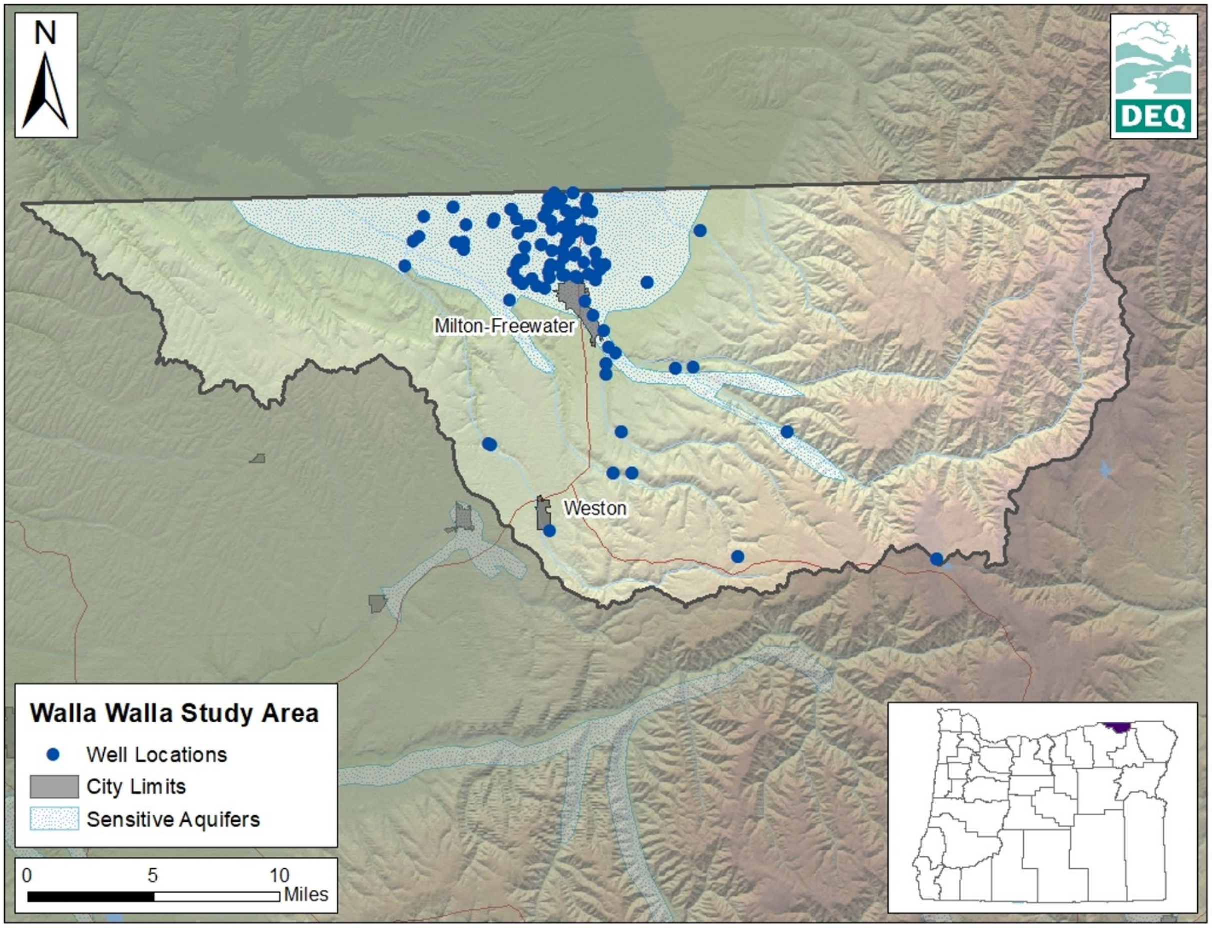

Figure 1. Study area and well locations (Water table aquifer from Sweet et al. 1980).

1.2.2 Geology

Well logs and geologic reports indicate that relatively recent sedimentary deposits from 200 to 250 feet thick, overlie volcanic rocks of the Columbia River Basalt Group. The topmost unit consists of interbedded alluvial deposits of gravel, sand, silt, and clay. The thickness of this upper unit ranges from 80 to 100 feet. These deposits are the result of coalescing alluvial fan sediments, derived from Mill Creek and the Walla Walla River. Underlying these deposits are fine-grained lacustrine deposits, with local beds of coarser deposits, also known as the Touchet Beds. These lacustrine deposits overlie fine-grained wind-blown loess deposits of the Palouse and Ringold Formations. Underlying the Palouse Formation are the rocks of the Columbia River Basalt Group (Newcomb, 1965). The Walla Walla syncline, developed within the basalt bedrock, forms the basin structure. Bounding the basin on its flanks are anticlinal structures of the Blue Mountains, Horse Heaven Hills, and Divide (Newcomb, 1965).

1.2.3 Hydrogeology

In the topographically higher locations in the northern part of the Walla Walla basin, north and east of Walla Walla, Washington (not in the study area), and in the southern part of the Walla Walla basin, just to the north and west of Milton-Freewater the shallow aquifer is composed chiefly of coarse gravel which transmits water quite readily. In the areas where coarse gravels are common, water from the main streams and numerous canals percolates into the gravel aquifer. Downslope from these two areas, water is transmitted less readily because the materials become finer grained, and layers of clay and silt occur locally in the aquifer. As the water in the aquifer moves toward the center of the valley, into lower altitudes, it encounters these finer-grained materials which cannot transmit water as quickly as the coarse materials supplying them. In these areas, the water is forced to discharge from the aquifer as springs (MacNish et.al 1973). MacNish estimated the total amount of water flowing through the aquifer, including pumpage from all of the irrigation wells tapping this aquifer, and the total spring flow, was at least 75,000 acre-feet per year. In Oregon, these springs emerge primarily downgradient (and downstream) from the City of Milton-Freewater, and flow into the mainstem Walla Walla River in Washington State.

In general, the soils in the basin are porous and permeable, which results in high drainage rates. Most of the agricultural land in the study area has a distribution system where irrigation water is taken from the Walla Walla River south of Milton-Freewater, and redistributed throughout the valley in a system of unlined ditches. These factors tend to result in rather large amounts of recharge to the aquifer. Overall, the aquifers receive recharge from precipitation, stream leakage, canal leakage, and excess irrigation water, through porous and permeable soil layers. Some evidence from static water level measurements and conductivity measurements in the early 1990's indicate that the aquifers do not support base flow to the Walla Walla River and that, in fact, the river is discharging into the shallow aquifers in the valley (Oregon Health Division, 1991). In Milton-Freewater, groundwater and surface water have been so depleted by anthropogenic withdrawals, that until recent years the River was entirely de-watered in its lower few miles, just upstream from the Oregon-Washington border, in a significant part of the growing season (late summer and early fall). Agreements with irrigators have led to a partial return (25 CFS) to enable flow continuity in the mainstem throughout the year (D. Butcher, DEQ Basin Coordinator, personal communication, Nov 2020).

1.2.4 Land use

The land use in the valley is primarily agricultural, dominated by fruit orchards and grape vineyards. Sources of contamination therefore may include any fertilizers and pesticides used for fruit crops. Land application of wastewater for fertilization may be another source of contamination including nitrate, bacteria and consumer use sewage related products. Although septic tanks may be considered a source of contamination in rural areas, it was not considered a major concern in this area due to the size of residential lots lessening the density of septic tanks and leachfields in this area. There are two landfills in the county, one for Milton-Freewater and another for the city of Athena which is just to the south of the 2016 study area boundary. A consideration of specific contaminants can be found below in Section 2.1.3

1.2.5 Climate

The climate in this study area is arid. Milton-Freewater has an average annual rainfall of 16.5 inches and 6 inches of annual snowfall (usclimatedate.com) Annual high and low temperatures are 65 and 44 degrees, respectively. February and March has some of the highest precipitation and September has some of the lowest. The wells sampled in 2016 for this study were sampled in January to February and also in September.

1.2.6 Previous DEQ Monitoring

DEQ conducted a groundwater quality study in 1999 in the Milton-Freewater area. The impetus for the study was based off the 1989 Oregon Groundwater Protection Act, ORS 468B.190, calling for the cooperation between the DEQ, OWRD and OSU to conduct an "ongoing statewide monitoring and assessment program of the quality of the groundwater sources of this state" (State of Oregon, 1989). Milton-Freewater was identified as an area that needed further evaluation based on high profile water quantity and quality issues. The 1999 study area included 16 square miles north of the city of Milton-Freewater, where thirty wells were selected and vetted based on the depth to aquifer tapped, as well as the integrity of proper construction and maintenance based on an available well drilling report and visual observation of the wells. "Wells were discounted from potential use if improper practices were observed near the well head which might produce results reflecting very local activities and not results typical of regional water quality." (ORDEQ, 1999). The analyte list for the 1999 study included physical/chemical parameters, common ions, metals, nutrients, pesticides, bacteria, and volatile organic compounds. A summary of detections found in that study include a widespread occurrence of nitrate, more concentrated in areas in the northwestern portion of the study area dominated by sprinkler irrigation rather than the southern and eastern areas where flood irrigation through ditches is common. A few pesticides were detected but not at levels that indicated any groundwater quality problems. Bacteria was detected at low levels in 4 of the 30 wells sampled but those results were not confirmed in a resampling in October of 1999. Section 3.5 will discuss some of the comparisons between the wells first sampled in April 1999 and then resampled in this new study in 2016.

1.2.7 Other DEQ monitoring in the area

DEQ currently has a Pesticide Stewardship Partnership (PSP) as well as a Toxics Monitoring Program which collect samples in the Milton-Freewater area. The PSP program collects surface water samples annually from spring through fall at four to five locations throughout the valley. There has been an overall decrease in pesticide detections in these samples, from over 140 detections in 2010 to less than 40 in 2019. The priority pesticides of concern in the basin are chlorpyrifos (e.g. Lorsban®) and carbaryl (e.g. Sevin®) whose concentrations have fluctuated with no long-term sustained trend. However, 2019 and early 2020 data show that chlorpyrifos detections notably decreased, with only two detections in 2019 and none in 2020. Historically, other detections of pesticides of concern-include diuron (e.g. Karmex®) and malathion. Levels and occurrence of those two pesticides have been reduced significantly since 2013. The pesticides of concern have primarily been detected in “distributaries” to the Little Walla Walla River that provide irrigation water for fruit growing lands near Milton-Freewater (K. Masterson, DEQ Toxics Coordinator, personal communication, Sept 2020).

DEQ’s Toxics Monitoring Program has collected surface water and sediment samples at 4 locations in the basin. Current use and legacy pesticides found in trace levels in surface waters include 4,4′-DDT, alpha-chlordane, glyphosate and its component metabolite aminomethylphosphonic acid (AMPA). Current use pesticide chlorpyrifos and legacy pesticides 2,4′-DDD, 2,4′-DDE, 2,4′-DDT, 4,4′-DDD, 4,4′-DDE ,4,4′-DDT, aldrin, alpha-BHC, alpha-chlordane, beta-BHC, chlorpyrifos, cis-nonachlor, and delta-BHC, were all detected at trace levels in sediment. Dioxins/Furans and PCBs have also been found in sediments samples (DEQ data pull September 2020).

DEQ’s groundwater sampling in the nearby Lower Umatilla Basin Groundwater Management Area (LUB GWMA), which was established based on a history of elevated nitrate concentrations, has also detected low-level and widespread perchlorate contamination with some samples at potentially harmful concentrations (ORDEQ, 2003).

1.2.8 Real Estate Transaction Domestic Well Testing

Since 1989, Oregon statute (ORS 448.271) requires that groundwater wells that are used for domestic purposes be sampled for nitrate, arsenic and bacteria when a house is sold or transferred. The Oregon Health Authority houses this data. Real Estate Transaction data in the shallow aquifers near Milton-Freewater show the presence of coliform bacteria, low detections of arsenic and lead, and elevated detections of nitrate (>7mg/L) in four private domestic wells (data pull from OHA DWTA-RET database on October 7, 2020).

1.2.9 Municipal Drinking Water

There are 17 public water systems using groundwater wells in the study area. These systems serve approximately 9,100 people. All of these systems have had recent alerts for total coliform and/or *E. coli*. Four of them had violations exceeding Maximum Contaminant Levels. Two groundwater systems have had alerts (>5mg/L) for elevated nitrate. The DEQ Agricultural Water Quality Management Area Plan has assessed these drinking water source areas, and have concluded that these contaminants are often related to animal and cropland agriculture. “All of the public water systems have agricultural land uses (irrigated crops, pasture, and/or livestock) within their source areas, although intensity of use varies”… and all “rate as high to moderate susceptibility for land use impacts to drinking water sources based on Source Water Assessments, aquifer characteristics, and well locations and construction." (ORDEQ, 2019). In addition, there was elevated dacthal concentrations (double the Health Advisory Levels) detected in 2012 in a groundwater public water supply at a point on the Washington-Oregon state line, east of the Walla Walla River (G. Bahr WA Dept. of Ag., personal communication April 2016).

1.2.10 Walla Walla Basin Watershed Council Monitoring and Aquifer Recharge

DEQ worked closely with the Walla Walla Basin Watershed Council (WWBWC) to recruit volunteers for this study and gain access to monitoring wells to sample. The WWBWC, in conjunction with the Washington Department of Ecology, monitors water levels in approximately 115 wells across the entire basin and have documented long-term water quantity declines in the alluvial aquifers. The Watershed Council is involved in a local aquifer recharge project that is intended, not for storage and recover (ASR), but to improve low-flow conditions in hydraulically connected streams and to stabilize the alluvial aquifer. Since 2004, the number of aquifer recharge projects that the watershed council operates in the valley has increased from four to twelve. These sites vary from a system of irrigation ditches, open recharge ponds, to subsurface infiltration galleries. Recharge season starts in mid-November and goes until mid-May. This subsurface water infiltration has the potential to dilute physical and chemical constituents found in groundwater aquifers during drier times of year when water levels decline. Alternatively, depending on the type of surface water application (ie. flood irrigation ditches or sprinkler irrigation), infiltration of surface contaminants such as nitrate, herbicides, or pesticides may leach more readily through to shallow aquifers. So far, previous groundwater quality monitoring efforts at Aquifer Recharge sites have shown no degradation is occurring and, in many cases, improvements to groundwater quality are evident (WWBWC, 2020).

1.2.11 Other Continued Monitoring

Since this sampling in 2016, DEQ has continued surface water and sediment sampling through the Pesticide Stewardship Partnership Program and the Toxics Monitoring Program. The Oregon Water Resources Department has joined in partnership with the United States Geological Survey (USGS) and the Washington Department of Ecology to conduct a basinwide aquifer study in this area in 2020 and the years following. They will be collaborating on a study measuring current static water levels in a network on 200 wells. These measurements as well as flow measurements, isotope sampling and specific conductivity measurements will help to provide a more detailed description of how the groundwater and surface water in this area may be interacting (J. Woody, OWRD hydrogeologist, personal communication, July 2020).

1.3 Study Objectives

Informed by previous investigations and guided by the objectives of the Statewide Groundwater Monitoring Program, the goals of the 2016 Walla Walla basin groundwater study were:

1. To collect high-quality data on nitrate, arsenic, coliform bacteria, pesticides and perchlorate 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.
5. To help establish long-term trending data and describe changes over time.

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

2.1.1 Study Area Selection

The Walla Walla Basin Study area was selected based on a consideration of available water quality data. The central Walla Walla Basin valley contains a shallow and vulnerable aquifer (Sweet, 1980) making it a priority area for Oregon's Statewide Groundwater Quality Monitoring Program. Although the Walla Walla Basin extends into lower Washington State, this study area focused only on the part of the basin south of the Oregon State border. Other factors considered while selecting this area for study include current available data from Real Estate Transactions, results from a previous 1999 DEQ study, results from ongoing DEQ monitoring efforts for Toxic contaminants in the Walla Walla Basin and DEQ's sampling in the nearby Lower Umatilla Basin Groundwater Management Area, detections of contaminants in Municipal Public Water Systems (PWS) that rely on groundwater in this area, Environmental Justice considerations including minority populations, linguistically isolated populations, and transient community water systems, and the ongoing Aquifer Recharge projects in the Walla Walla Basin that directly affect the quantity and quality of groundwater aquifers.

2.1.2 Sample Selection

The 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 Walla Walla Basin Watershed Council (WWBWC) and Oregon State University (OSU) Extension. DEQ staff also reached out to residents who owned wells that were sampled as a part of DEQ 1999 study in the Basin. Sixteen wells that had previously been sampled in 1999 were able to be sampled again based on the current well user cooperation. In addition, five wells in this study are also part of the WWBWC network, at which water level data is collected continuously at 15 minute intervals and specific conductance is collected quarterly. That data is available here: http://wwbwc.org/monitoring/groundwater.html

The current Statewide Groundwater Quality Monitoring program, including the 2016 study in the Walla Walla Basin, was designed to not exclude wells that may be older or have poorer well construction, and may lack a well drilling document, also known as a well log. These wells were excluded from DEQ's previous 1999 study. Many of these older wells are still in use by private domestic well users. Local activities as well as compromised well heads are indicators of vulnerable aquifers as well as a local public health concern for those groundwater consumers. Although there may not be information about the depth, well construction, or hydrogeologic layers from wells that do not have available well logs, water quality data collected may still reveal if a contamination problem exists that needs further attention. Section 3.1 has a more detailed discussion of well logs, well characteristics of our sample selection, and discusses any water quality correlations associated with the presence or lack of a well log.

New volunteers were recruited until a sample selection of 100 wells was reached that could be feasibly sampled and that were diversified enough in the basin to be representative (Figure 1). Sample selection was limited to the availability of well users who volunteered, the accessibility of their well and the location of an untreated access point. Wells without a working pump could be included when the well head was available for the use of a submersible pump.

The arid climate, dominant agricultural land use and aquifer recharge practice prompted a sampling schedule that would capture any seasonal differences. Twenty wells were sampled in both the winter and fall of 2016. These wells were selected based on the availability and cooperation of the well users who volunteered as well as attention to any detections that were discovered after the winter sampling. Some wells could only be sampled once as the accessibility of some agricultural well pumps are not in operation during colder months of the year, or the well user did not give permission for a resample.

Any personal data collected from participants during this study has not been attached to the final results. The location of individual wells and an existing well log, if available, is all that identifies the water quality results with a particular well.

2.1.3 Analyte Selection

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, perchlorate, 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 (DEQ15-LAB-0046-SAP).

In addition to the standard analytes sampled by this program, perchlorate was added to the analyte list. Perchlorate is commonly used as an oxidizer in munitions, is used in the manufacturing of nitrate fertilizers, and also may occur naturally in arid regions. Due the location of the Umatilla Chemical Depot to the southwest of this study area, the potential use of nitrate fertilizers on agricultural land, and the natural arid climate of northeastern Oregon, perchlorate was analyzed for in all groundwater samples.

For this study, legacy pesticides are analyzed with methods EPA 1699, EPA8270D and SM6640[2]. High resolution analysis of legacy chlorinated pesticides (Method EPA 1699) were not analyzed for in the second sampling event in September 2016. This change was due to laboratory analytical capacity schedules.

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 (DEQ03-LAB-0036-SOP_V3), Sampling and Analysis Plan (DEQ16-LAB-0008-SAP), and Quality Assurance Project Plan (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. Some wells were sampled with a submersible pump when an active pump was not available. Wells with active pumps were purged for at least five minutes and until field readings of conductivity, temperature and dissolved oxygen stabilized. Wells sampled with a submersible pump were purged three well casing volumes to ensure that stagnant water was removed, and the sample was collected from replenished groundwater. Bacteria samples were collected last, after the sample point was disinfected with isopropyl alcohol.

Confirmation that the spigot sampled was directly connected to the well head intended was determined by best available information. It was either visually clear that the spigot was plumbed to the wellhead, or the well user or well owner confirmed verbally or with written instruction that the spigot was connected to the wellhead.

2.2.2 Context for Data Interpretation

The results from this study may 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.

[2] EPA Method 1699 determines organochlorine and legacy pesticides by high resolution gas chromatography/high resolution mass spectrometry (HRGC/HRMS) using isotope dilution and internal standard quantitation techniques. EPA 8270D is a general purpose method to determine semivolatile organic compounds by gas chromatography/mass spectrometry (GC/MS). SM6640 determines chlorinated phenoxy acid herbicides by gas chromatography/electron capture detection (GC/ECD).

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 and elements such as arsenic, may be harmful to human health when present in drinking water above certain levels.

Well water was tested for lead. To measure the quality of the water coming from the groundwater aquifer, rather than the water sitting in the pipes, sampling procedures included a 5-10 minute flushing period before a sample was collected. If there is concern about lead contamination from plumbing, wells should be retested using the "first flush" method.

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 2012).

Many of the chemicals measured in this study do not have a maximum contaminant level. In these cases, 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; 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 (MCLG) and maximum contaminant levels (MCL) 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

3.1.1 Well Log Availability

Understanding well characteristics is often dependent on the availability of a document that describes how the well was drilled, often referred to as a well log. The Oregon Water Resources Department has required wells logs to be submitted by well drillers since 1955. The logs provide details on well construction including a description of the geologic material drilled through and material used to case and seal the well. While understanding the depth of the well, its casing, and seal is essential to understanding what aquifer the well accesses, well logs can be difficult to locate or correlate to wells located on the ground. Some of the reasons for this include:

- A well log may never have been completed or filed with OWRD.
- The location of a well is described by township, range, and section on the well log, and there may be dozens of wells in any given section.
- There may be mistakes, especially in the location, that cause the well log to be misfiled and difficult to find.
- Location of a well on the ground is not enough to tie it to a well log; generally depth, diameter and other details are needed to identify the correct well log.

With the emergence of electronic record keeping and the requirements to have new well locations tagged with a metal plate and L#ID (since 1995), as well as latitude and longitude coordinates for exempt wells (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.

Of the 100 wells sampled in this study, 21 wells have a verified well log confirmed by a picture taken during sample collection of a well tag on the well casing itself, or have been confirmed by location and description in the Oregon Water Resources Groundwater Well Information System (GWIS). These include associated wells in the OWRD's Milton-Freewater well network (J. Woody, OWRD hydrogeologist, personal communication, July 2020). True confidence in a correlated well log is only established when a well tag is registered with the OWRD and located in the GWIS. Another 39 wells in this study have been associated with well logs based on other related data collected by DEQ staff during communications and visits with current well owners and well users. Confidence established in these correlated well logs was based off of current well owner's personal knowledge of the well sampled and other wells that may exist on their property. This knowledge includes: the current owner or family member drilled the well themselves; the current owner received well documents from a previous owner who drilled the well; the current owner knew the name of the previous owner and well document was found with a location description that closely as possible matches the location of the well sampled, in this case it is helpful if the owner can confirm that there are no other wells on their property that match the description in the identified well drilling report. For the 39 wells where there is a reasonable confidence in a match, data interpretation is limited, however, those well logs are used in this report to classify wells based on depth, aquifer geology and year that the well was drilled.

Measuring the size of well casings and the depth to the bottom of a well during a physical well visit is another way to confirm a possible well log correlation, however this study did not include those measurements due to frequent inaccessibility of the well head and a desire to avoid potential introduction of contaminants to the well itself. Depths of wells were only measured when a submersible pump was needed for sampling.

Forty wells sampled did not have a well drilling report found. These wells are useful in summarizing water quality and detections of contaminants in the basin. They cannot be useful to interpret the conditions of shallow or deep aquifers in the basin, but can only be characterized by their geographical location within the basin. Unlike previous studies which have excluded wells where well logs were not available, this study's inclusion of these 40 wells may reveal potential contamination issues with older wells, without logs, that may be vulnerable due to age or due to well construction standards at the time of drilling.

Of the 60 well logs evaluated, a few characteristics were particularly helpful to understand the aquifers sampled and the potential aquifer confinement[3]. These characteristics include the depths of the wells, the depth and lithography of the screened portion of the wells, the age of the well and/or the presence of a seal, and the depth where first water was found. An example of how this data is documented in a well log is included in Appendix D. Appendix A is a site list which includes some relevant information from the 60 well logs.

[3] 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.

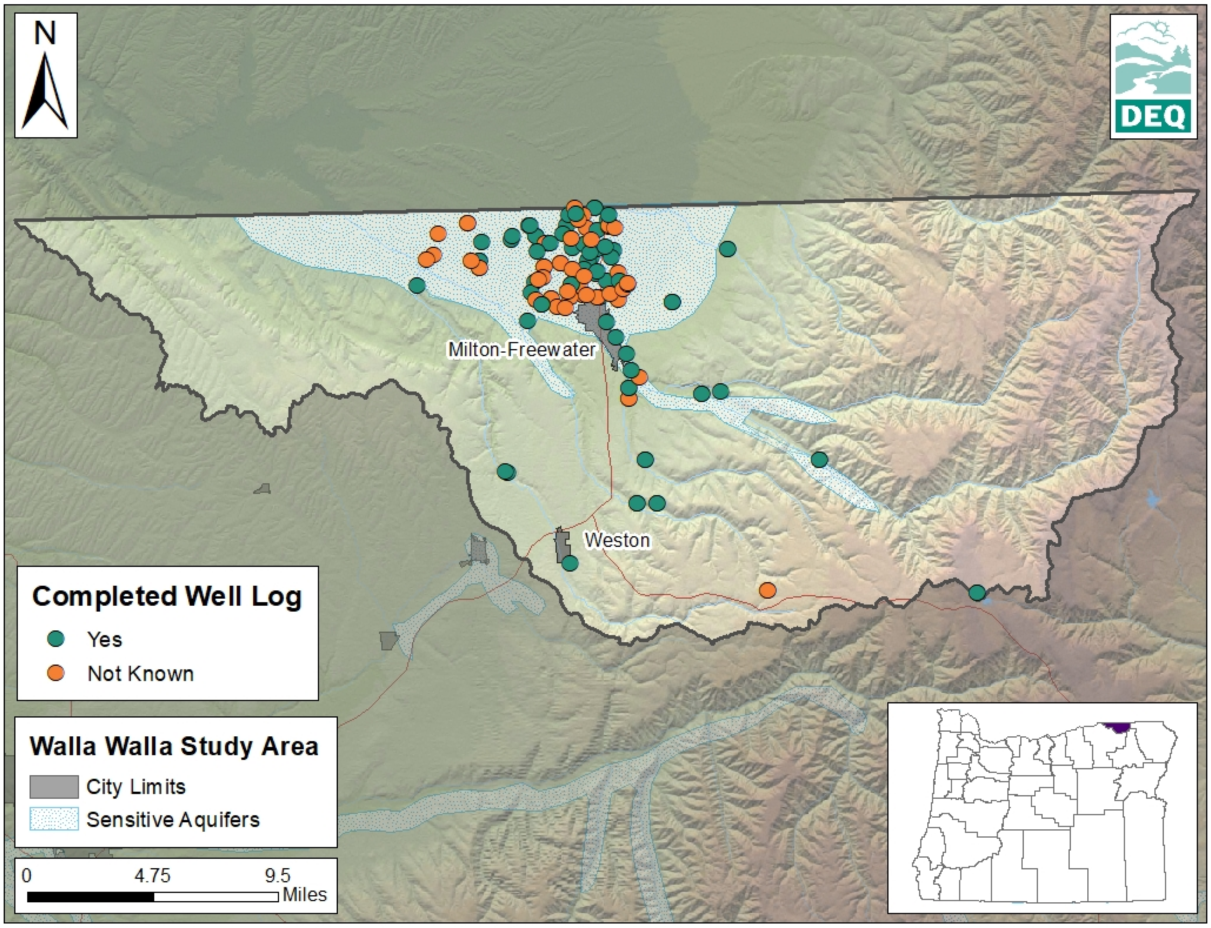

Figure 2. Distribution of wells with and without well log records.

3.1.2 Characteristics of Wells Sampled

Of the 60 wells that we have well log characteristics for, thirty-nine were sampled initially in the winter of 2016, fourteen of which were resampled in the fall. Twenty-one wells were sampled in the fall only. The depths of these 60 wells range from 40 – 1056 feet below ground surface (ft bgs). Forty-three wells were drilled into aquifers with a water bearing zone in a shallow alluvial gravel, sand, and cobble geology. Many of those wells are semi-confined by a layer of clay or other impermeable geology, although a few are clearly unconfined and may be subject to land surface contamination. Seventeen wells are drilled into confining, deeper basalt geologies. Three wells were drilled prior to 1955, and the well logs from the five oldest wells show that no well seal was installed (dating 1910-1964) the deepest of which was drilled 200 ft and drawing water from a 55 ft gravel aquifer. Section 3.3 discusses how any water quality detections found may be correlated with these well characteristics.

Other than the differences in the ways the wells were drilled and their locations, other differences between the wells sampled in this study include: land use around the well, 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, the presence of and/or the size of holding tank or pressure tank connected to system, and whether the well had an active working pump or if the well was sampled using a submersible pump.

3.1.3 Well Log Bias

Due to aging wells, a lack of a proper well seal, or poorer construction standards, wells without well logs may be more vulnerable to surface contamination such as nitrate and bacteria. This study aimed to look at whether the selections of wells sampled without a well log were, in fact, more vulnerable to contamination. Figures 3 and 4 show comparisons of nitrate and bacteria detections between wells with and without wells logs. Statistical analyses of these detections found no significant difference in nitrate ($F_{1,108} = 0.838$, ns) or bacteria ($F_{1,40} = 3.026$, $p > .05$) concentrations between the two groups of wells. Section 3.2 will look closer at water quality detections in all wells sampled.

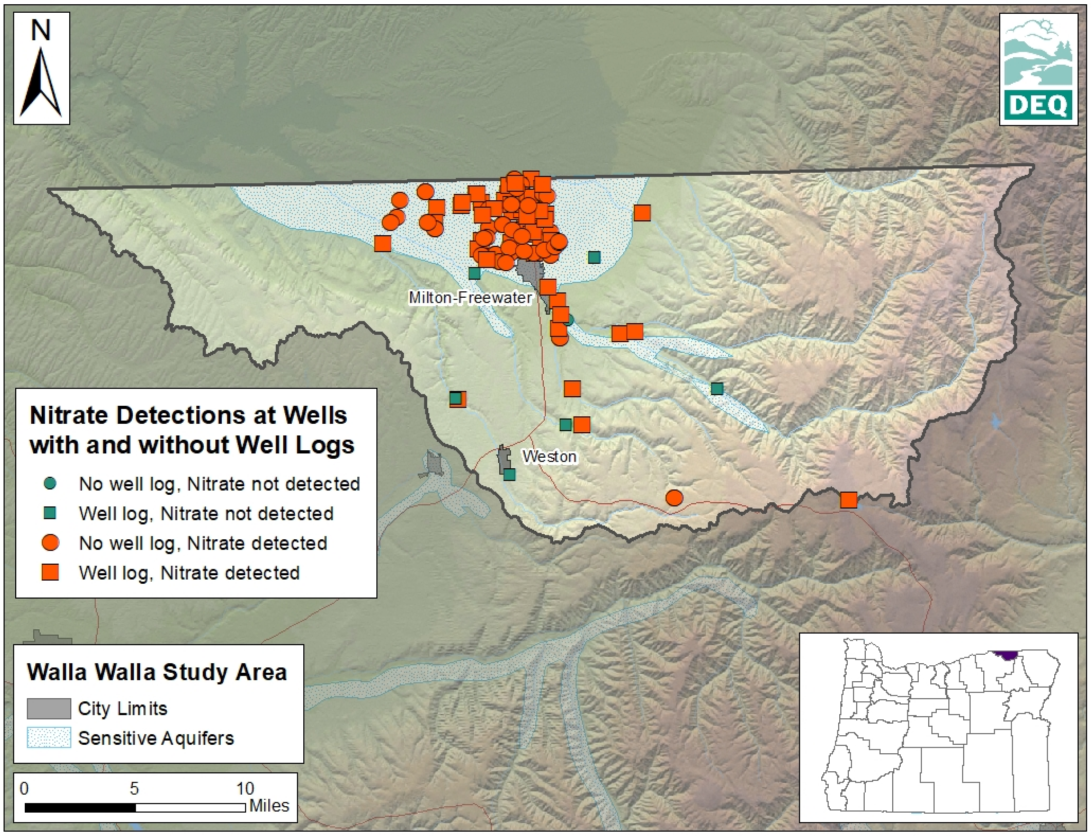

Figure 3. Comparison of the distribution of nitrate results for wells with and without well logs.

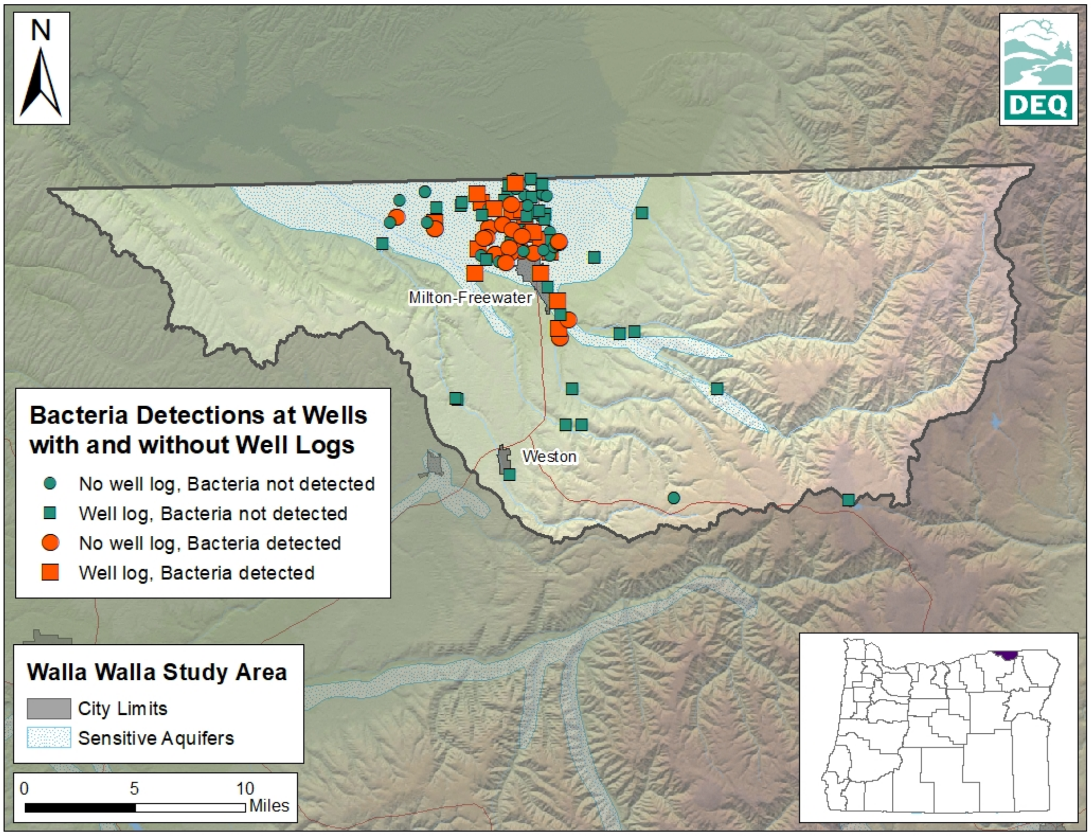

Figure 4. Comparison of the distribution of bacteria (total coliform) results for wells with and without well logs.

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 through the Ambient Water Quality Monitoring System data portal, by contacting the DEQ Laboratory and Environmental Assessment Division.

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, which is consistent with USGS interpretations. This 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 at 10 mg/L. Twenty wells had nitrate concentrations above what are considered natural levels (higher than 3 mg/L). Only one well was above the maximum contaminant level (10mg/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 (https://www.oregon.gov/deq/FilterDocs/nitratedw.pdf Or https://www.oregon.gov/deq/FilterDocs/NitrateSpanishVersion.pdf)

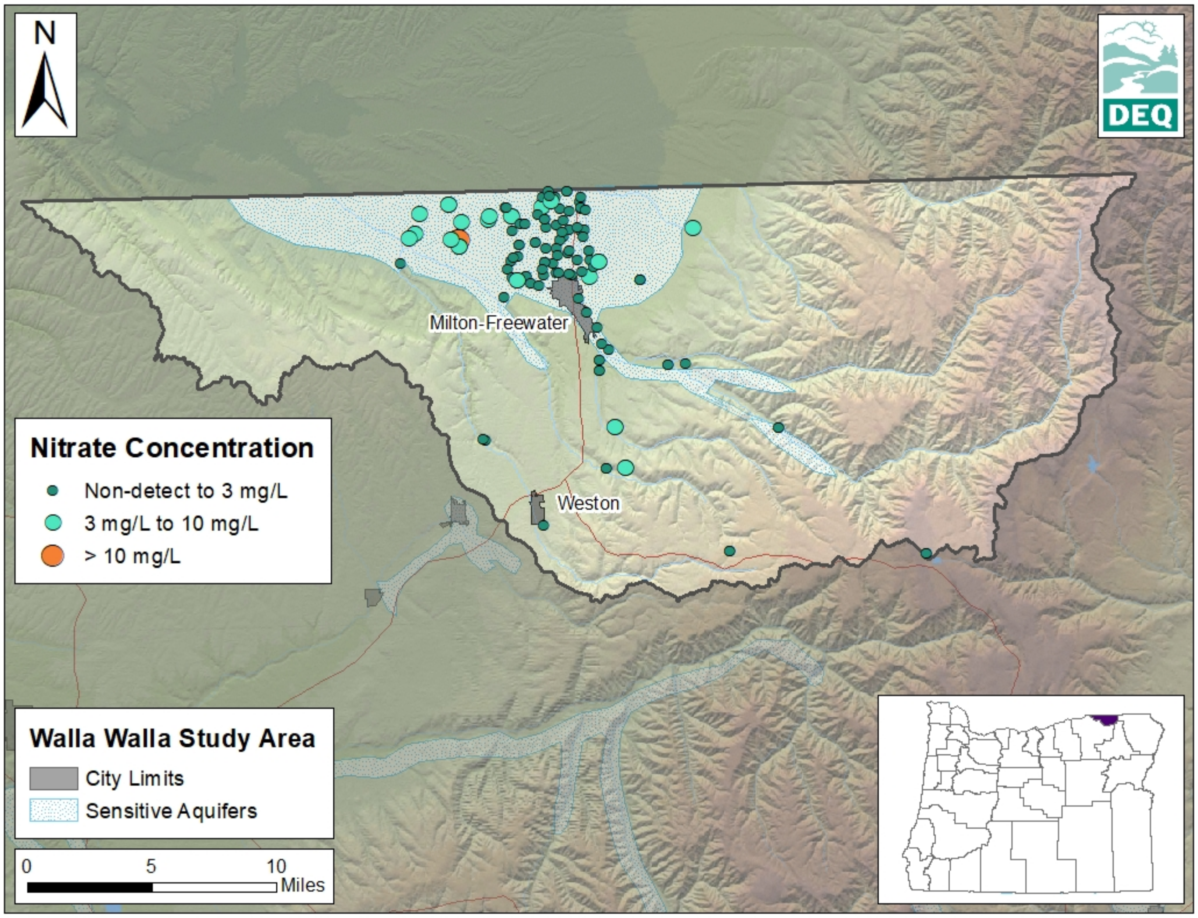

Figure 5. Nitrate concentrations detected in sampled wells. Results higher than 3 mg/L are considered elevated due to human activities. The maximum contaminant level (MCL) for nitrate in drinking water is 10 mg/L.

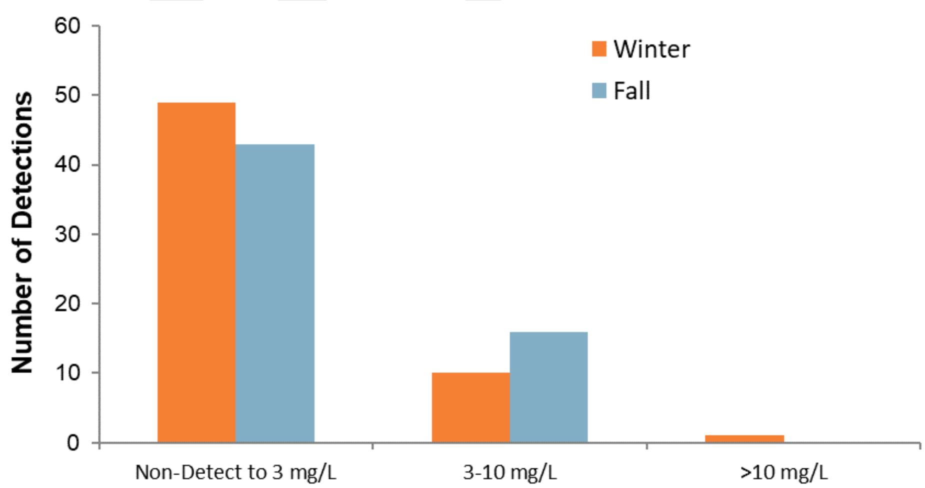

Figure 6. Nitrate concentration in number of sampled wells. Results higher than 3 mg/L are considered elevated due to human activities. The maximum contaminant level (MCL) for nitrate in drinking water is 10 mg/L.

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. Past uses included agricultural application, especially in orchards, as an insecticide and as embalming fluids prior to 1945, indicating historic cemeteries as potential sources of arsenic. 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 not detected during either sampling effort for this study.

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 37 of 100 wells, and *E. coli* was detected in 3 of those wells. There was no significant difference between detections of bacteria in the winter vs the fall. Detections were primarily in the central valley within the shallow alluvial aquifer (Figure 7). 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.

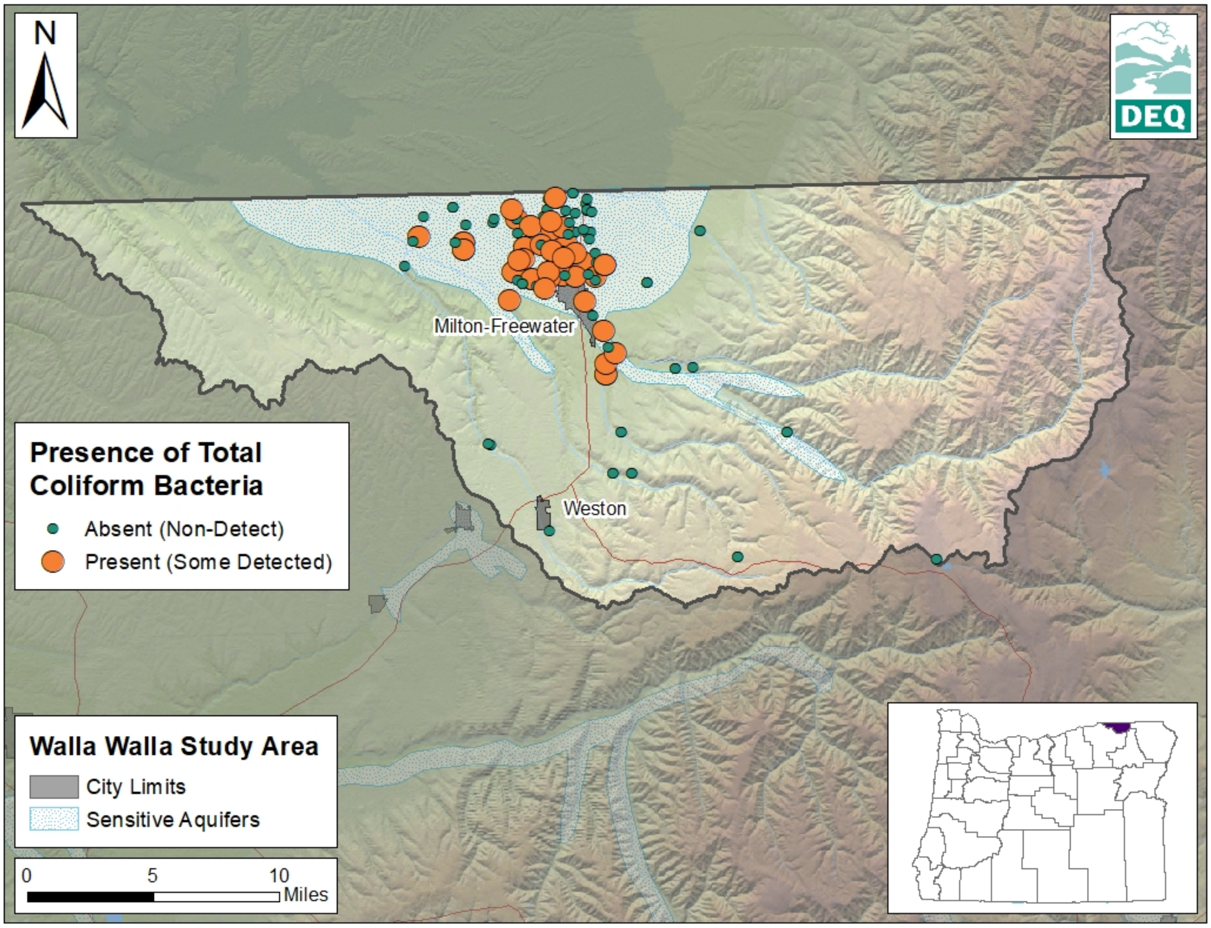

Figure 7. Total coliform bacteria detected in sampled wells.

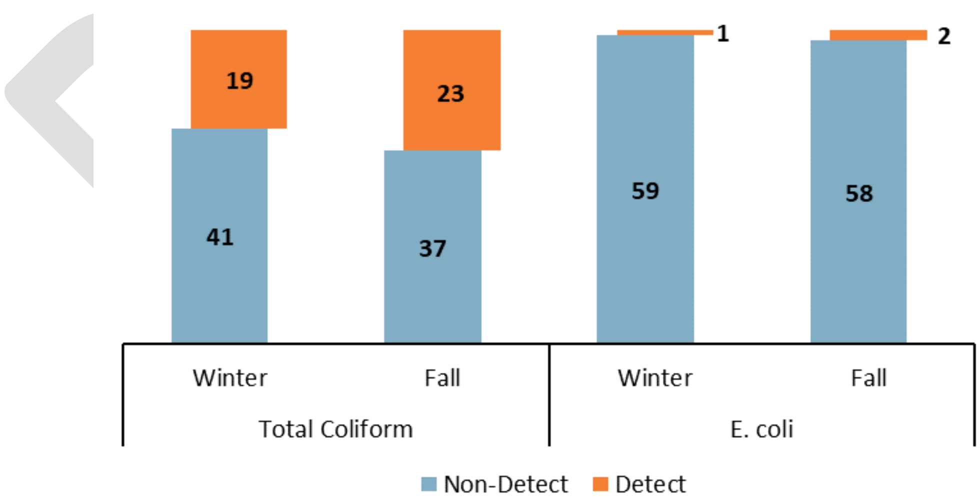

Figure 8. Total coliform and *E. coli* results for all samples collected in 2016.

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.

Twenty different pesticide-related chemicals were detected in this study, representing twelve different parent pesticides (Table 1). At least one current use pesticide related chemical was detected in 36 of the 100 wells sampled in this study. Three wells had at least one chemical originating from a legacy pesticide detected in their water. Sixty samples were analyzed for legacy pesticide using EPA's high resolution method 1699 as well as methods EPA 8270D and SM6640 in the winter and the sixty wells sampled in fall were analyzed with methods EPA 8270D and SM6640 only. The high resolution method 1699 used in the winter sampling event detected degradates of DDT in two wells at concentrations far below any health screening level[4], and were not reanalyzed in the fall.

The most commonly detected pesticide was desethylatrazine, a breakdown product of atrazine, found in 31 wells. Atrazine is an herbicide used to control grasses and broadleaf weeds on corn (field and sweet), sorghum, wheat, conifer forests, Christmas tree farms, sod farms, golf courses and lawns. Atrazine is also used in Oregon on range grasses to establish permanent grass cover on range and pasture land. Atrazine is known to disrupt normal hormone signaling in the body and can be harmful to health. The maximum detection of total atrazines detected in any well was 57.45 ng/L. The EPA has established a maximum contaminant level (MCL) of 3 µg/L (equal to 3,000 ng/L) for atrazine in drinking water. The detections of atrazine and all of its breakdown products were well below this MCL.

[4] 4,4′-DDE, 4,4′-DDT, 4,4′-DDD, 2,4′-DDT were detected with the maximum combined concentration in either well totaling .3482 ng/L. Health screening levels are 100 ng/L.

Table 1. Summary of pesticides and breakdown products detected.

	# Wells Detected	Max. Conc.	Units	Screening Level	Use
Current Use Pesticides					
Total Atrazines [#]	35	57.45	ng/L		
Atrazine	7	7.13	ng/L	3000[1]	Herbicide
Deisopropylatrazine	8	9.8	ng/L	12000[2]	Breakdown product of atrazine
Desethylatrazine	31	39.2	ng/L	12000[2]	Breakdown product of atrazine
Simazine	7	9.51	ng/L	4000[1]	Herbicide
Carbaryl	1	12.6	ng/L	40000[3]	Insecticide
DCPA acid metabolites	3	3500	ng/L	20000[3%]	Breakdown product of the herbicide dacthal
Diuron	1	5.01	ng/L	20000[3]	Herbicide
Metribuzin	1	7.67	ng/L	8000[3]	Herbicide
Metsulfuron-methyl	2	8.95	ng/L	1600000[2]	Herbicide
Norflurazon	1	182	ng/L	96000[2]	Herbicide
Legacy Pesticides					
*Total DDTs**	2	0.3482	ng/L	100[3]	
2,4´-DDT	1	0.0776	ng/L	100[3]	Insecticide
4,4´-DDD	1	0.0816	ng/L	100[3]	Breakdown product of banned insecticide DDT
4,4´-DDE	1	0.0746	ng/L	100[3]	Breakdown product of banned insecticide DDT
4,4´-DDT	1	0.189	ng/L	100[3]	Insecticide
Total Chlordanes [§]	1	3.507	ng/L	2000[1]	
alpha-Chlordane	1	1.64	ng/L	2000[1]	Insecticide
cis-Nonachlor	1	0.107	ng/L	Not available	Breakdown product of the insecticide chlordane
gamma-Chlordane+trans-Nonachlor	1	1.76	ng/L	Not available	Insecticide
Endosulfan II	1	1.79	ng/L	40000[2]	Insecticide
Endrin+cis-Nonachlor	1	0.219	ng/L	Not available	Insecticide
Heptachlor epoxide	1	1.39	ng/L	200[1]	Breakdown product of the insecticide heptachlor

[#]includes atrazine, deisopropylatrazine, desethylatrazine and simazine

*includes 2,4'-DDT, 4,4'-DDD, 4,4'-DDE and 4,4'-DDT

[§]includes alpha-Chlordane, cis-Nonachlor and gamma-Chlordane+trans-Nonachlor

[%]screening level established for dacthal

[1]USEPA Maximum Contaminant Level

[2]USEPA non-regulatory Human Health Benchmark

[3]USGS Health-based Screening Level

The pesticide with the highest concentration level was DCPA acid metabolites which is a breakdown product of the pre-emergent herbicide dacthal. These breakdown products are more water-soluble than the parent chemical and readily leach into groundwater. There have been very few studies on the toxicity of these breakdown products, however the available data indicate that they are no more toxic than the parent chemical. The EPA has classified dacthal as a possible human carcinogen. To protect against a one in a million risk of cancer, the USGS has calculated a Health-based Screening Level for dacthal at 20 µg/L. This chemical was detected in three wells with a maximum concentration of 3500 ng/L (3.5 µg/L). Although not a health concern, its presence in this basin should be noted, as dacthal was also detected in a public water drinking well on the state border in 2012. The Walla Walla Basin Watershed Council as well as the Washington Department of Agriculture were informed of these detections of DCPA.

All detected pesticide related chemicals were well below any known human health screening level, and (if excluding DCPA) was never more than 0.4% (Total DDTs) of any screening level. Fifteen of the wells had two or more pesticide chemicals detected (Figure 9), and five wells had chemicals from more than one parent pesticide detected (Figure 10). 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 atrazines and total DDTs and are still far below a level that may cause any health risk (Table 1).

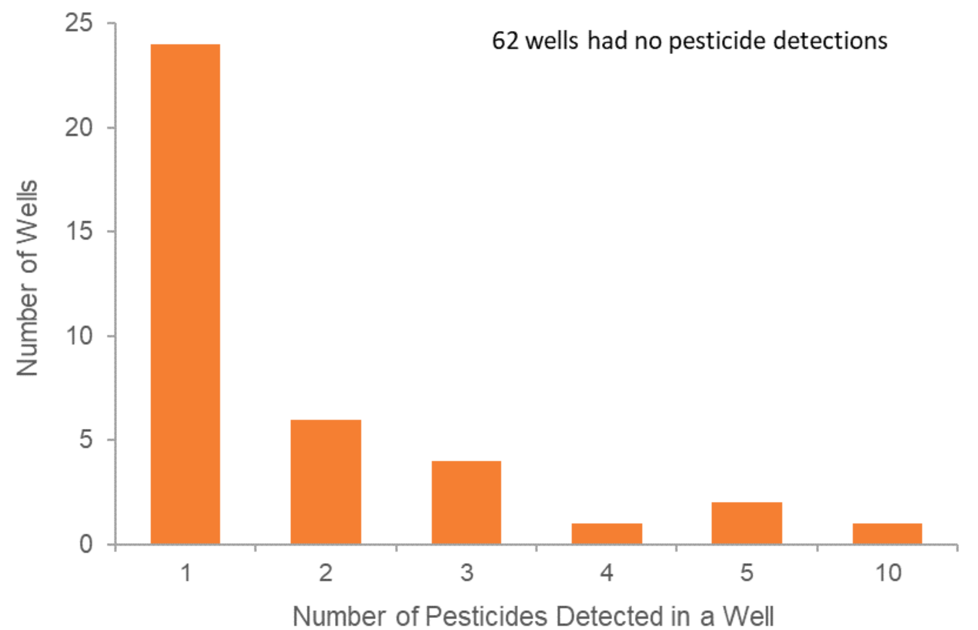

Figure 9. Histogram of total number of pesticides detected in individual wells.

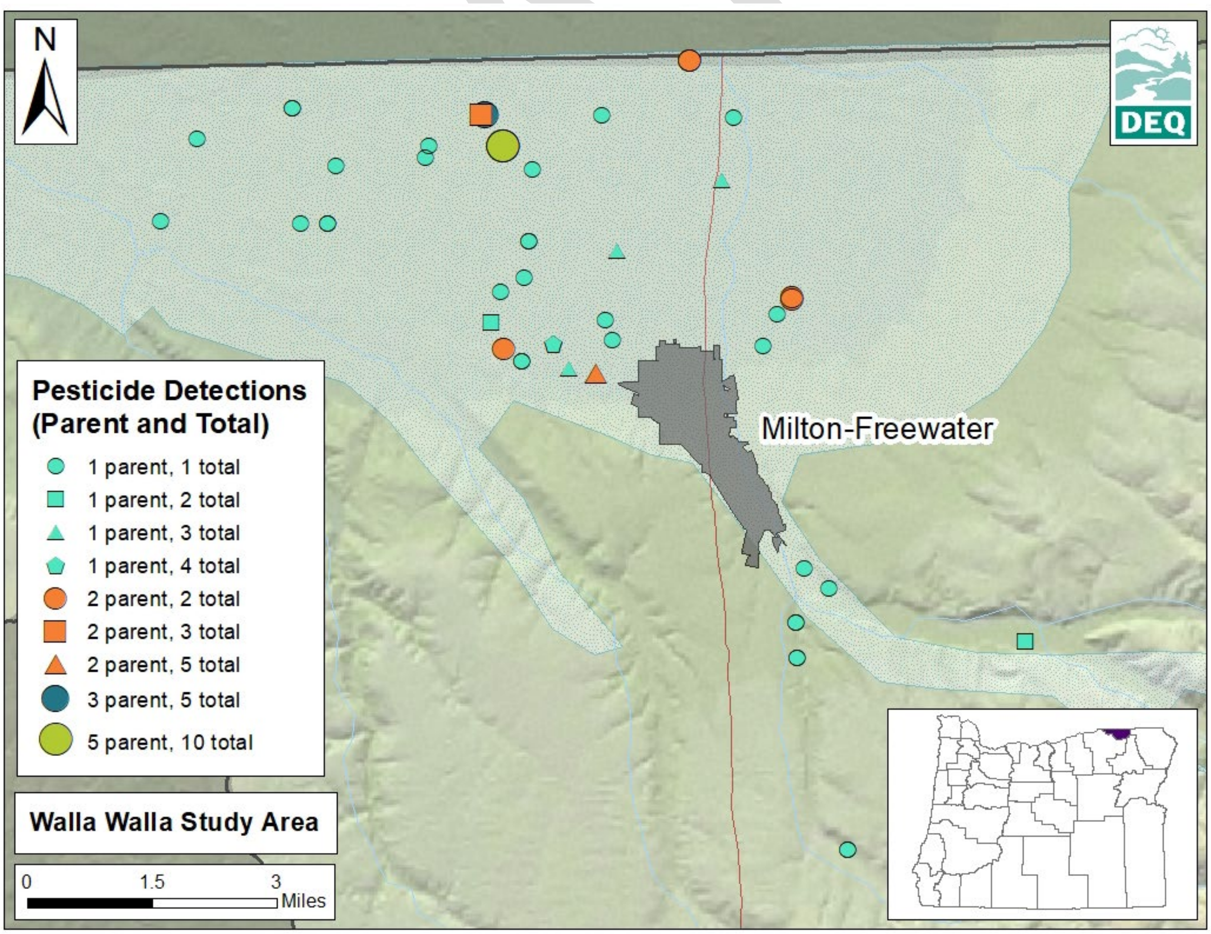

Figure 10. Number of parent and total pesticides detected in sampled wells. This map does not include wells where no pesticides were detected.

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 47 of the wells sampled in this study. Forty-five wells were detected at level below the 50 µg/L secondary drinking water standard and two were above 50 µg/L. No wells were above the 300 µg/L Lifetime Health Advisory (Figure 9). Low concentrations are likely due to natural geochemical processes, however, these detections were not significantly different between wells in shallow aquifers compared to deeper aquifers. Water above the secondary drinking water standard is usually not palatable for drinking without treatment, but it does not have concerning health effects.

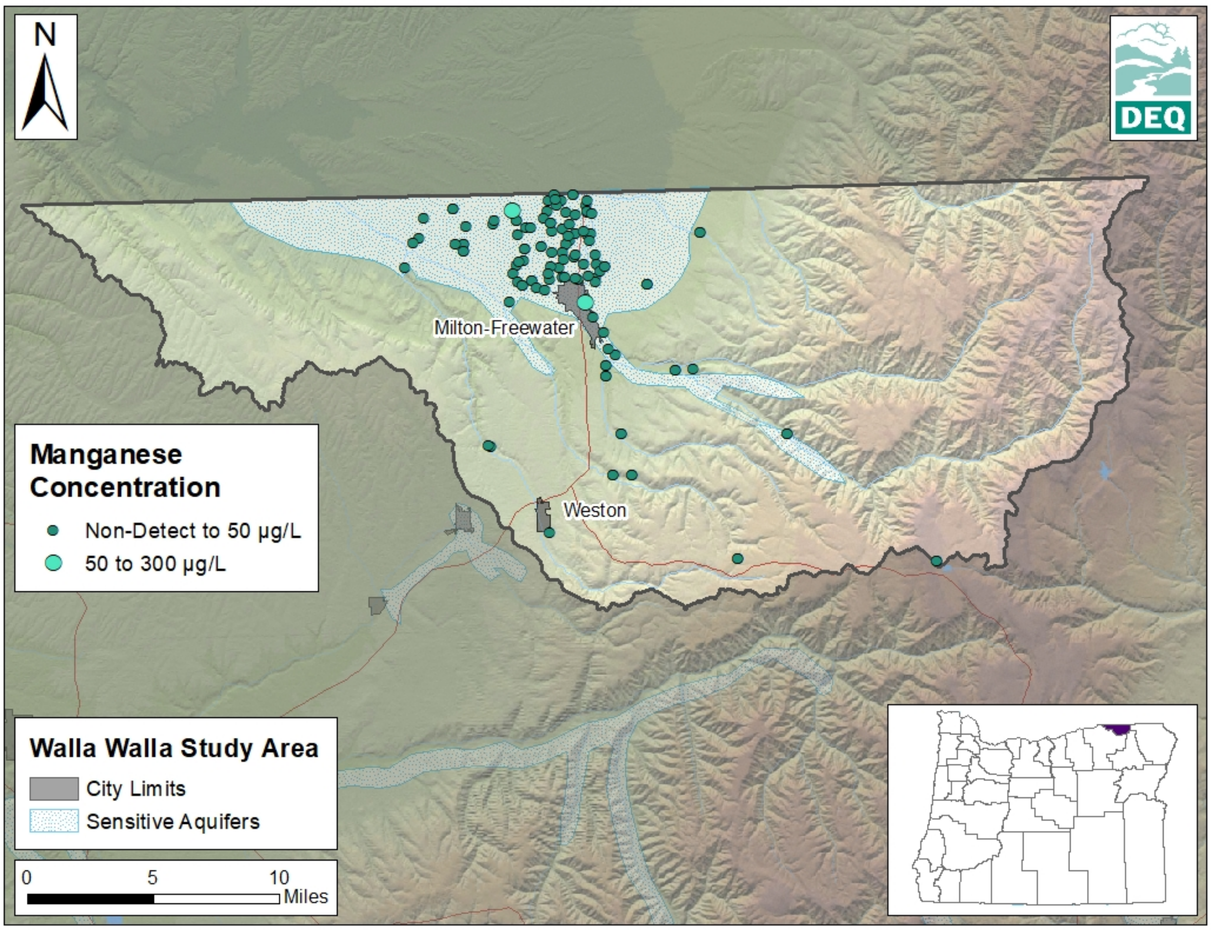

Figure 11. Manganese results in sampled wells. The secondary drinking water standard for manganese is 50 µg/L and the Lifetime Health Advisory is 300 µg/L.

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 48 of the 100 wells sampled in this study. The maximum concentration measured was 11.5 µg/L, well below the maximum contaminant level.

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 90 of the 100 study wells. The maximum concentration measured was 29.5 µg/L, which is one third of the Regional Screening Level.

3.2.8 Perchlorate

One of the goals for this Statewide Groundwater Monitoring Program was to investigate emerging groundwater quality problems. Perchlorate is commonly used as an oxidizer in munitions, is used in the manufacturing of nitrate fertilizers, and also may occur naturally in arid regions. This study marks the first time that DEQ has analyzed groundwater samples for perchlorate under the statewide groundwater monitoring program. Perchlorate was detected in seven wells, with a maximum concentration on 1.64 µg/L. The Agency for Toxic Substances and Disease Registry (ATSDR) has calculated an Environmental Media Evaluation Guide (EMEG) of 7 µg/L for children. Drinking water with less than this concentration is unlikely to pose a health threat.

3.2.9 Lead

Lead, like manganese and arsenic, can end up in aquifers due to the erosion of natural deposits, however, the most common source of lead in drinking water is from the corrosion of household plumbing systems. Lead is typically tested using the “first flush” method, which collects water that had been sitting in the pipes. For this study, however, DEQ staff flushed each well for 5-10 minutes prior to sampling to ensure that samples indicated background lead levels present in the groundwater rather than water sitting in the pipes. Lead was detected in 69 of the 100 wells sampled in this study. Three wells exceeded the EPA established maximum contaminant level of 0.015 mg/L (Figure 12). Well owners with exceedances were connected with Oregon Health Authority’s lead expert, and well owners concerned about lead concentrations were instructed to contact their county environmental health department to investigate the possible lead sources and about retesting their water.

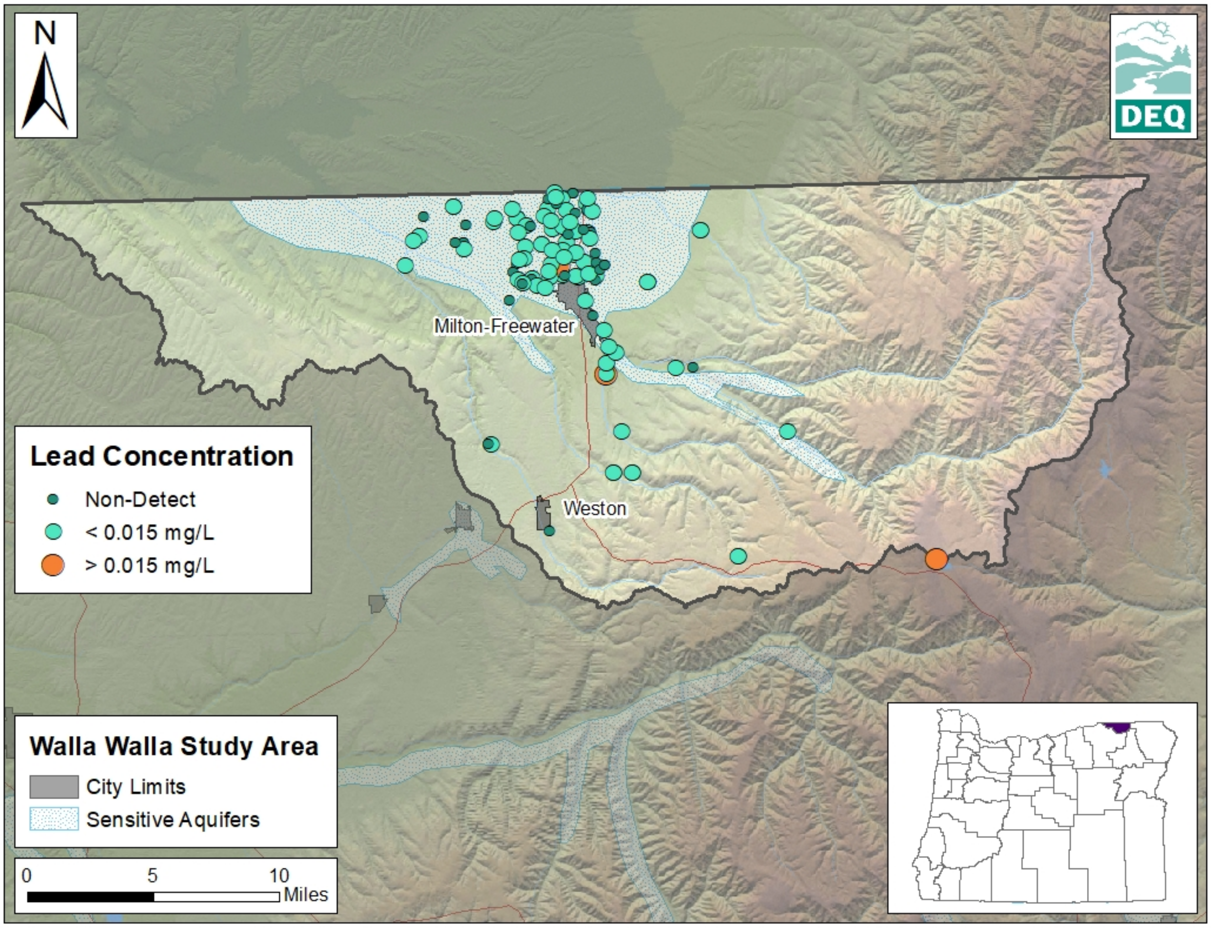

Figure 12. Lead results in sampled wells. The EPA maximum contaminant level is 0.015 mg/L.

3.3 Seasonal differences

Twenty wells were sampled during both the winter (January and February 2016) and fall (September 2016) sampling events in an effort to capture the seasonal variability of results. Resampled wells were chosen based on availability for sampling and geographic distribution within the study area. When analyzing for contaminants that leach through shallow soils and are seasonally applied such as nitrate and pesticides, there were no statistically significant difference between the wells sampled in the winter and the fall (Figures 13 and 14) (nitrate: ($F_{1,33}$ = 0.719, ns), pesticides ($F_{1,18}$ = 0.243, ns)

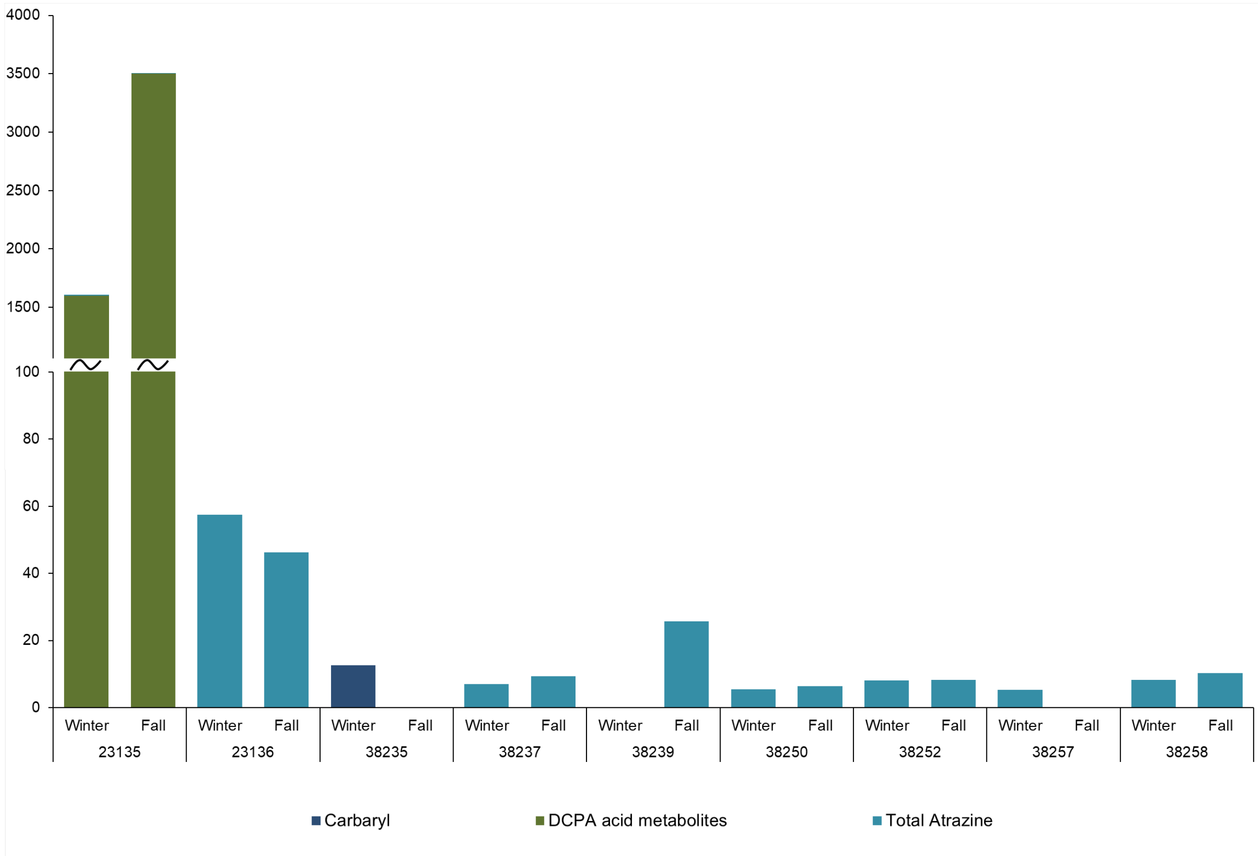

Figure 13. Pesticide concentrations for wells sampled during both the Winter and Fall 2016 sampling events. Wells without detected pesticides were excluded from this figure. 9 out of 20 well had pesticides detected in either winter or fall. Analysis for pesticides using the high resolution EPA 1699 method was only used in the Winter and is not included in this figure since there is no comparison for that method in the second sampling event.

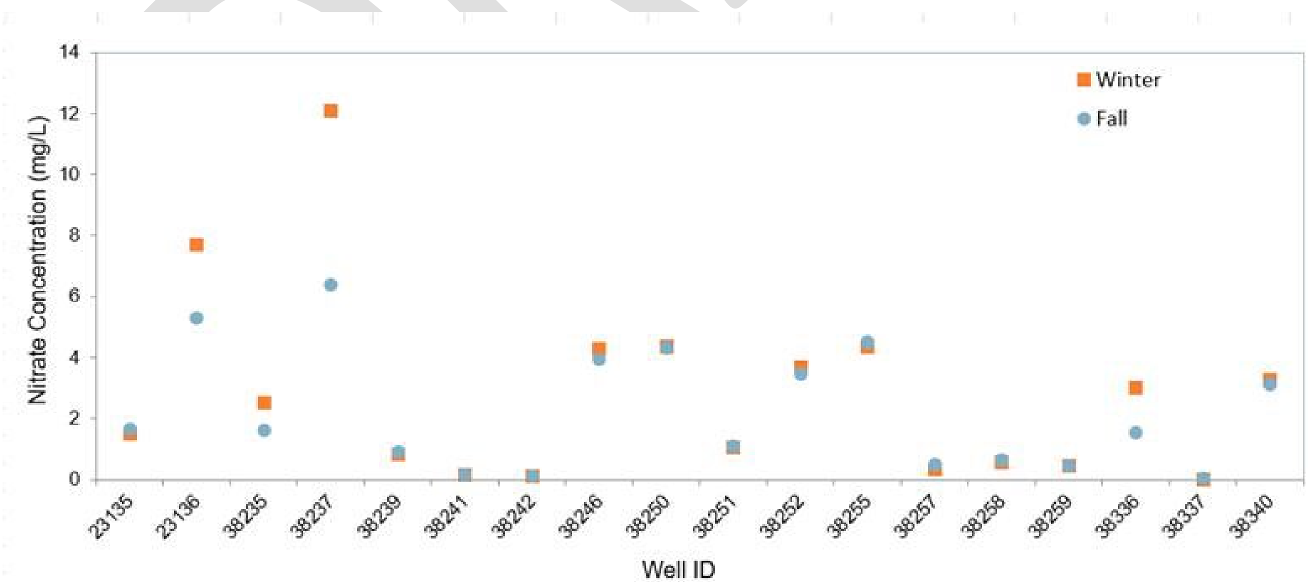

Figure 14. Nitrate concentrations in wells sampled during both the winter and fall 2016 sampling events. 18 out of the 20 resampled wells had nitrate detected in either winter or fall. The five digit numbers represent the DEQ sampling station ID of individual wells.

3.4 Comparing 1999 to 2016

Of the 100 wells sampled in this study, 16 were included in the 1999 DEQ study. The following sections compare the detections of common analytes between the two studies, and is depicted in Table 2.

Table 2. Comparison of analyte concentrations between the 1999 and 2016 studies. Green indicates decreased concentrations, red indicates increased concentrations, and yellow indicates concentrations that remained the same. Bold/darker color indicates concentrations that were not detected in one of the studies. White or blank cells indicates non-detects in both studies[5].

Well Name	Aluminum (ug/L)	Arsenic (ug/L)	Calcium (mg/L)	Iron (ug/L)	Lead (ug/L)	Magnesium (mg/L)	Manganese (ug/L)	Potassium (mg/L)	Sodium (mg/L)	Vanadium (ug/L)	Nitrate (mg/L)	Total Atrazine (ng/L)	Bacteria (MPN/100 mL)
22722			-10.90	-105.00		-3.61	-1.09	-1.43	-1.53	2.04	0.90	6.94	
22725	115.00		-0.94	79.00		0.36	6.40	0.02	0.65	1.16	0.03		
23128	107.00		-0.26	11.00	2.88	-0.25	-0.65	-0.17	0.19	1.28	-0.32		2.00
23129	75.90		0.40	52.50	1.04	0.03		-0.31	0.38	1.16	-0.95	-11.00	
23130	50.00		-1.88	763.00	0.38	0.80	3.97	0.22	0.63	2.31	0.49		10.00
23131	35.70		-1.39	120.00	0.21	0.46		0.27	0.52	2.93	0.14		46.00
23134			-0.65	44.90	0.20	0.07	2.21	-0.12	0.21	-1.25	-0.07		
23135		-0.01	0.10	-11.40		-0.68		-0.33	1.10	-1.73	0.02	5.81	
23136		-0.02	6.50	-7.50	-3.37	-4.30		-1.37	-2.80	-1.50	1.09	-52.55	2419.00
23138		-0.01	-12.30	-12.20	1.12	2.60		0.25	0.70	-7.30	0.45		
23140		-0.01	-1.50	849.80	2.36	-0.39	33.20	-0.15	-0.04	-2.60	-0.04		6.00
23141	46.70		-0.58	-30.00	0.30	0.06	-0.74	-0.02	0.33	-0.86	-0.04		
23142			-4.20	-8.80	-3.10	1.04		0.16	0.17	1.52	0.23		
23148		-0.02	1.40	653.40	1.74	-1.60		0.07	2.30	-1.60	-0.51	15.50	
23149	25.70	-0.01	-1.16	63.00	1.38	0.17	4.38	0.00	0.39	-1.12	-0.02		1.00
26113		-0.01	3.20	678.00	0.90	-1.85	-2.13	-0.60	-0.73	-0.77	-0.17		

3.4.1 Nitrate

Nitrate was detected in all the samples during both studies. Concentrations have increased or decreased but are not statistically different between studies. The highest concentrations were found in the same wells in both studies (stations 23136 and 23148). None exceeded the maximum contaminant level, however the samples collected at 23136 and 23148 during both studies were elevated (>7 mg/L), indicating anthropogenic sources are contributing to contamination.

3.4.2 Bacteria

Bacteria was not detected in any of the wells sampled in 1999. Six of those same wells tested positive for total coliform in 2016.

3.4.3 Atrazine

Atrazine products were detected in two wells in the 1999 study. Atrazine and desethylatrazine were detected at a combined total concentration of 0.11 µg/L in Station 23136. In 2016, 23136 detections of total atrazine decreased, totaling 57.45 ng/L in late winter and 40.68 ng/L in the fall. In 1999, simazine was detected at 0.011 µg/L in one well, station 23129. Station 23129 had no detections of simazine or other atrazines in 2016.

[5] Dark red cells indicate that the analyte was not detected in 1999 but was detected in 2016. Many reporting limits (RL) for 1999 analytical methods were higher than in 2016, possibly resulting in these non-detects, if concentrations were below those limits. For lead (1999 RL of <3 ug/L) and atrazine (1999 RL of <0.01 ug/L), this table shows that all 2016 detections were below the 1999 RL therefore, we cannot conclude if the 1999 concentrations were equal to or less than the 2016 concentrations. For all the other analytes where there are dark red cells, there were no 2016 detections below 1999 RL (1999 RL for : aluminum < 10 ug/L, lead < 3 ug/L, manganese <0.2 ug/L, nitrate <0.2 mg/L, atrazine <0.01 ug/L, bacteria <2 MPN/100mL).

Three other wells had detections of atrazine in 2016 that were not detected in 1999. Station 23135 had 5.81 ng/L and 5.37 ng/L detected of desethylatrazine in the winter and fall respectively. Station 22722 had 6.94 ng/L of deisopropylatrazine in the winter and was not resampled in the fall. Station 23148 had 15.5 ng/L of desethylatrazine in the winter and was not resampled in the fall.

3.4.4 Metals

There was a statistically significant difference between the average detections of iron in the 16 wells sampled ($F_{1,25} = 12.28$, $p < .0001$). Several wells in particular showed hundreds to thousands percent increases in iron between 1999 and 2016 (Stations 23130, 23131, 23140, 23148, and 26113). The other metals sampled showed both increases and decreases over time, however these changes either did not show any statistically significant difference between detections in 1999 and 2016, or the sample size of available detections was too small for statistical analysis.

4. Summary

The 2016 Walla Walla 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 100 wells within the study area are available. This represents the largest quality-controlled groundwater investigation in the area since 1999 (ODEQ). 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 primarily in the shallow alluvial aquifer. 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 37 wells with total coliform detections, there were four 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 current use and legacy pesticides were detected in 38 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 widespread bacteria contamination as well as a problem with elevated nitrate concentrations. Atrazine is a potential problem for contamination and should be monitored along with the herbicide dacthal. Hydrogeologic analyses and investigations into the sources of contamination were outside the scope of this study.

5. *To help establish long-term trending data and describe changes over time.*
   Changes in the detections of contamination from 1999-2016 are not significant enough to detect clear increasing or decreasing trends, except for iron which has increased significantly.

5. Recommendations

Aquifer contamination is a long-lasting problem and reversing the impacts of contamination in groundwater is neither straightforward nor easy. Steps should be taken to reduce any further negative impacts from human activity and continue to test and monitor for contamination so that it does not go undetected for very long. 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, bacteria, and pesticides, particularly atrazine and its degradates, is recommended to prevent vulnerable wells and aquifers from being subjected to unmonitored contamination. While concentrations of nitrate, bacteria, and lead exceeded their respective maximum contaminant levels in some wells, levels of all contaminants may change over time. A network of wells should be established and monitored to detect any changes over time.

Results from this study can be used to focus public health outreach in areas where contamination exits. There is no state regulatory oversight of water quality criteria when using water from private wells, and regulations only require wells to be tested at the point of sale. OHA recommends that private well owners to get their wells tested annually for nitrate and bacteria and to test it at least once for arsenic. Despite this recommendation, many well owners are unaware of their water quality. 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. Oregon's Statewide Groundwater Quality Monitoring Program intends to stay connected with future groundwater monitoring efforts in the Walla Walla basin and to look for opportunities to establish long-term monitoring stations around the state. To stay up to date and learn more about what Oregon is doing to monitor groundwater aquifer quality, visit DEQ's Groundwater Protection webpage.

There are many resources available to help domestic well owners in Oregon. As part of the recommendations of this Walla Walla 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 DWSP is currently without funds, but the website above and contact information below are still active. (domestic.wells@state.or.us , 971-673-0440)

- 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 (https://www.oregon.gov/OWRD/WRDPublications1/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 https://www.oregon.gov/deq/FilterDocs/dwpBasicTips.pdf
  - Groundwater Basics for Drinking Water Protection https://www.oregon.gov/deq/wq/programs/Pages/GWP-Basics.aspx

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Appendix A – Complete Site List

Well ID	Walla Walla Basin Groundwater Study Site ID	Latitude	Longitude	Well Log Availability	Well Log	Depth of Completed Well (ft bgs)	Aquifer Geology	Winter or Fall 2016 Sampling
22722	**UMA298**	45.96009	-118.44202	Yes	UMAT6377	162	gravel	Winter
22725	**UMA288**	45.97312	-118.39732	Yes	UMAT50630	50	gravel, sand and some clay	Winter
23128	**UMA287**	45.97125	-118.40048	Yes	UMAT4650	80	medium gravel, fine sand and clay	Winter
23129	**UMA299**	45.96683	-118.40316	Yes	UMAT4640	91	cemented gravel	Winter
23130	**UMA286**	45.96387	-118.39408	Yes	UMAT4635	101	gravel and sand	Winter
23131	**UMA309**	45.95975	-118.38607	Yes	UMAT5126	65	gravel and boulders with some cementation	Winter
23134	**UMA283**	45.97628	-118.38277	Yes	UMAT4536	90	sand, gravel and clay, some cementation	Winter
23135	**UMA300**	45.99985	-118.39323	Yes	UMAT4225	60	clay with fine to medium gravel	Winter and Fall
23136	**UMA296**	45.99985	-118.39323	Yes	UMAT4330	43	medium gravel	Winter and Fall
23138	**UMA303**	45.98555	-118.44060	Yes	UMAT4228	132	clay and gravel	Winter
23140	**UMA307**	45.98555	-118.44060	Yes	UMAT4412	79	gravel and clay	Winter

Well ID	Walla Walla Basin Groundwater Study Site ID	Latitude	Longitude	Well Log Availability	Well Log	Depth of Completed Well (ft bgs)	Aquifer Geology	Winter or Fall 2016 Sampling
23141	**UMA295**	45.99576	-118.40547	Yes	UMAT4466	95	medium to fine gravel, sand and clay	Winter
23148	**UMA290**	45.97879	-118.41219	Yes	UMAT6209	162	gravel	Winter
23149	**UMA289**	45.98005	-118.40266	Yes	UMAT4397	83	boulders, gravel and sand	Winter
26113	**UMA301**	45.99324	-118.38324	Yes	UMAT4197	63	medium boulders and small gravel	Winter
38224	**WW-001**	45.99118	-118.44571	Yes	UMAT5977	97	gravel, clay with some cementation	Winter
38229	**WW-004**	45.98776	-118.39225	Yes	UMAT57290	140	gravel, sand and clay	Winter
38230	**WW-005**	45.95142	-118.37696	Yes	UMAT57434	82	silty gravel	Winter
38231	**WW-006**	45.95109	-118.39151	Yes	UMAT54050	201	small to medium cobbles and clay	Winter
38234	**WW-009**	45.99125	-118.44482	Yes	UMAT58331	40	silty sand and gravel	Winter
38236	**WW-011**	45.98290	-118.48260	Yes	UMAT4305	200	gravel	Winter
38237	**WW-012**	45.97290	-118.48512	Yes	UMAT56447	40	silty fine sand and gravel	Winter and Fall
38238	**WW-013**	45.97290	-118.48512	Yes	UMAT4917	116	loose gravel some cementation with depth	Winter
38242	**WW-017**	45.95479	-118.44480	Yes	UMAT56495	200	gray clay	Winter and Fall
38243	**WW-018**	45.78311	-118.10175	Yes	UMAT50563	179	basalt	Winter and Fall

Well ID	Walla Walla Basin Groundwater Study Site ID	Latitude	Longitude	Well Log Availability	Well Log	Depth of Completed Well (ft bgs)	Aquifer Geology	Winter or Fall 2016 Sampling
38244	**WW-019**	45.78311	-118.10175	Yes	UMAT56268	250	basalt	Winter and Fall
38245	**WW-020**	45.85868	-118.22241	Yes	UMAT56107	140	gravel	Winter
38251	**WW-026**	45.85868	-118.22241	Yes	UMAT4698	45	dirt and gravel	Winter and Fall
38252	**WW-027**	45.83779	-118.36626	Yes	UMAT3976	315	brown and black basalt	Winter and Fall
38253	**WW-028**	45.99641	-118.41379	Yes	UMAT4216	95	boulders and gravel with some cementation	Winter
38254	**WW-029**	45.95873	-118.41371	Yes	UMAT53462	193	small to medium cobbles, sand and clay	Winter
38255	**WW-030**	45.95873	-118.41371	Yes	UMAT4018	125	brown and black basalt and brown and red cinder	Winter and Fall
38258	**WW-033**	45.86120	-118.35889	Yes	UMAT6177	452	basalt and cinder	Winter and Fall
38259	**WW-034**	45.86120	-118.35889	Yes	UMAT54869	104	fractured black basalt	Winter and Fall
38260	**WW-035**	45.90104	-118.37041	Yes	UMAT4668	70	medium to small gravel	Fall
38261	**WW-036**	45.90104	-118.37041	Yes	UMAT50356	165	gravel	Winter
38336	**WW-037**	45.89683	-118.31307	Yes	UMAT56931	804	basalt	Winter and Fall
38337	**WW-038**	45.89683	-118.31307	Yes	UMAT57235	905	basalt	Winter and Fall
38340	**WW-041**	45.96523	-118.39263	Yes	UMAT53530	195	basalt black fractured	Winter and Fall
38344	**WW-045**	45.97685	-118.37990	Yes	UMAT56077	120	medium to small gravel	Winter

Well ID	Walla Walla Basin Groundwater Study Site ID	Latitude	Longitude	Well Log Availability	Well Log	Depth of Completed Well (ft bgs)	Aquifer Geology	Winter or Fall 2016 Sampling
38345	**WW-046**	45.97570	-118.28940	Yes	UMAT3068	130	basalt black with talc	Fall
38349	**WW-050**	45.97570	-118.28940	Yes	UMAT55521	200	black basalt with green clay	Fall
38350	**WW-051**	45.94726	-118.33474	Yes	UMAT3890	60	grey clay, medium gravel and medium boulders	Fall
38351	**WW-052**	45.94726	-118.33474	Yes	UMAT3988	51	large and small boulders and gray clay	Fall
38352	**WW-053**	45.94726	-118.33474	Yes	UMAT4035	113	basalt gray	Fall
38353	**WW-054**	45.80558	-118.42033	Yes	UMAT56122	455	black basalt	Fall
38354	**WW-055**	45.97302	-118.38110	Yes	UMAT4561	81	black sand	Fall
38355	**WW-056**	45.95972	-118.53454	Yes	UMAT5028	383	gray basalt	Fall
38356	**WW-057**	45.98393	-118.46008	Yes	UMAT6196	125	gravel	Fall
38358	**WW-059**	45.92867	-118.37954	Yes	UMAT5408	305	basalt gray fractured	Fall
38359	**WW-060**	45.98129	-118.42924	Yes	UMAT4364	62	gravel medium fine	Fall
38361	**WW-062**	45.97878	-118.38592	Yes	UMAT50460	170	brown clay gravel	Fall
38363	**WW-064**	45.98587	-118.45912	Yes	UMAT6258	130	gravel	Fall
38367	**WW-068**	45.99615	-118.38247	Yes	UMAT5785	185	sand and gravel with cementation at depth	Fall

Well ID	Walla Walla Basin Groundwater Study Site ID	Latitude	Longitude	Well Log Availability	Well Log	Depth of Completed Well (ft bgs)	Aquifer Geology	Winter or Fall 2016 Sampling
38368	**WW-069**	45.97709	-118.43986	Yes	UMAT5404	125	cemented gravel	Fall
38374	**WW-075**	45.91048	-118.36804	Yes	UMAT55168	163	brown and black basalt with brown scoria at depth	Fall
38375	**WW-076**	45.98346	-118.41266	Yes	UMAT53830	220	small to medium cobbles	Fall
38377	**WW-078**	45.99732	-118.40828	Yes	UMAT56537	107	gravel fine-medium	Fall
38379	**WW-080**	45.97579	-118.39811	Yes	UMAT56653	128	gravel small to medium	Fall
38382	**WW-083**	45.93893	-118.44833	Yes	UMAT56382	1056	black fractured basalt	Fall
23142	**UMA308**	45.96454	-118.37640	No	-	-	-	Winter
38227	**WW-002**	45.99660	-118.40313	No	-	-	-	Winter
38228	**WW-003**	45.98943	-118.39992	No	-	-	-	Winter
38232	**WW-007**	45.95269	-118.40404	No	-	-	-	Winter
38233	**WW-008**	45.95127	-118.39315	No	-	-	-	Winter
38235	**WW-010**	45.96888	-118.43469	No	-	-	-	Winter and Fall
38239	**WW-014**	45.96888	-118.43469	No	-	-	-	Winter and Fall
38240	**WW-015**	45.95088	-118.42933	No	-	-	-	Winter
38241	**WW-016**	45.95088	-118.42933	No	-	-	-	Winter and Fall
38246	**WW-021**	45.95037	-118.44153	No	-	-	-	Winter and Fall

Well ID	Walla Walla Basin Groundwater Study Site ID	Latitude	Longitude	Well Log Availability	Well Log	Depth of Completed Well (ft bgs)	Aquifer Geology	Winter or Fall 2016 Sampling
38247	**WW-022**	45.78802	-118.26581	No	-	-	-	Winter
38248	**WW-023**	45.78802	-118.26581	No	-	-	-	Winter
38249	**WW-024**	45.96856	-118.48544	No	-	-	-	Winter
38250	**WW-025**	45.96856	-118.48544	No	-	-	-	Winter and Fall
38256	**WW-031**	45.96262	-118.43600	No	-	-	-	Winter
38257	**WW-032**	45.94645	-118.42546	No	-	-	-	Winter and Fall
38338	**WW-039**	45.95796	-118.40669	No	-	-	-	Winter
38339	**WW-040**	45.98956	-118.38257	No	-	-	-	Winter
38341	**WW-042**	46.00010	-118.40894	No	-	-	-	Winter
38342	**WW-043**	45.99018	-118.38276	No	-	-	-	Winter
38343	**WW-044**	45.94948	-118.37676	No	-	-	-	Winter
38346	**WW-047**	45.95285	-118.38278	No	-	-	-	Fall
38347	**WW-048**	45.95494	-118.37306	No	-	-	-	Fall
38348	**WW-049**	45.90690	-118.36197	No	-	-	-	Fall
38357	**WW-058**	45.98876	-118.37822	No	-	-	-	Fall
38360	**WW-061**	45.96680	-118.41270	No	-	-	-	Fall

Well ID	Walla Walla Basin Groundwater Study Site ID	Latitude	Longitude	Well Log Availability	Well Log	Depth of Completed Well (ft bgs)	Aquifer Geology	Winter or Fall 2016 Sampling
38362	**WW-063**	45.97305	-118.49168	No	-	-	-	Fall
38364	**WW-065**	45.95485	-118.41608	No	-	-	-	Fall
38365	**WW-066**	45.97681	-118.52141	No	-	-	-	Fall
38366	**WW-067**	45.97399	-118.52685	No	-	-	-	Fall
38369	**WW-070**	45.95263	-118.40200	No	-	-	-	Fall
38370	**WW-071**	45.99401	-118.40703	No	-	-	-	Fall
38371	**WW-072**	45.96153	-118.43929	No	-	-	-	Fall

Appendix B – Full Analyte List

List contains all compounds analyzed during the sampling period	
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	
Analyte group, *Analyte sub-group*, Analyte name	
Current Use Pesticides, cont'd	**Current Use Pesticides, cont'd**
Herbicides	*Insecticides*
Oxyfluorfen	Fenamiphos
Pebulate	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	Perchlorate
Acetamiprid	**Legacy Pesticides**
Azinphos-methyl (Guthion)	2,4,5-TP (Silvex)
Baygon (Propoxur)	Aldrin
Bifenthrin	Chlorobenzilate
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	
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)	Lead
alpha-BHC	Magnesium
beta-BHC	Manganese
delta-BHC	Potassium
gamma-BHC (Lindane)	Sodium
Chlordane	Uranium
alpha-Chlordane	Vanadium
cis-Chlordane	**Standard Parameters**
cis-Nonachlor	Alkalinity, Total as CaCO3
gamma-Chlordane+trans-Nonachlor	Chloride
Oxychlordane	Hardness as CaCO3, Total Recoverable
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

Appendix C – Example of Results Letter and Laboratory Report

Oregon
Kate Brown, Governor

Department of Environmental Quality
Laboratory and Environmental Assessment Division
3150 NW 229th, Suite 150
Hillsboro, OR 97124
Voice & TTY (503) 693-5700
FAX (503) 693-4999

July 2016

[redacted]

Station Description: 23135 Milton-Freewater Groundwater Quality Study Area well UMA300

Dear [redacted]

Thank you for volunteering to have your well tested in February 2016 as part of the Statewide Groundwater Monitoring Program in the Walla Walla River Basin. Your test results will help us develop a better understanding of the quality of Oregon's groundwater resources, including any potential health concerns in Umatilla County. With this letter, we have included a report of your well water analytical test results.

We would like to assist you with the following:

- Understanding how the report is presented
- Providing the Analytical Report for your records
- Understanding what your results mean for your health
- Explaining the terms and definitions used in the report

Should you or other members of the household have health concerns that you feel may be related to your domestic well, we encourage you to talk with your physician or contact the Oregon Health Authority's (OHA) Domestic Well Safety Program (DWSP) at **971-673-0977**.
For additional questions about:

- Your **report**, call DEQ at **503-693-5736**
- For information about **water treatment options**, consult the National Sanitation Foundation, the organization that certifies water treatment systems (http://www.nsf.org/services/by-industry/water-wastewater/residential-water-treatment).

Your well is one of many we tested in the Walla Walla River Basin area. A summary of the complete project will be available on our website. We will email study participants to let them know when this is posted.

A note about lead results

Your well water was tested for lead. However, in order to measure the quality of the water coming from the groundwater aquifer, rather than the water sitting in the pipes, our sampling procedures include a 5-10 minute flushing period before we collect a sample. If you are concerned about lead contamination from your plumbing you should retest your water using the "first flush" method.

1

Understanding your Report

The Analytical Report is organized so that the chemicals that were detected in your well water are **highlighted in bold** and at the top of the list. Many of these are basic parameters used to characterize the groundwater aquifer (under the headings *General Chemistry, General Field Parameters and Total Metals by Inductively Coupled Mass Spectrometry*). Bacteria (coliform, total and *E. coli*) and nitrate are also listed (*Microbiology and Nutrients*). The last few sections contain the results for the pesticides tested. These analytes are sorted by laboratory method. If there was a detection of any of these pesticides in your water it will be listed in bold at the top of the report, all other analytes are considered non-detect, designated by "<". Additionally, if there were any detections of chemicals known to have a potential health risk (such as nitrate, arsenic, or pesticides), we provided a brief description of the chemical, compared your result to the known risk levels, and made recommendations for follow-up testing or treatment at the end of the report. These recommendations are provided with cooperation from OHA. You may also reference the packet of materials we provided when we came to test your well to learn more about well maintenance and common contaminants.

There are also some online tools you may find helpful in understanding your results:
Drinking Water Interpretation Tool: http://www.psiee.psu.edu/water/dwit.asp
Well Water Interpretation Tool: http://ohiowatersheds.osu.edu/know-your-well-water/well-water-interpretation-tool

We are available to answer questions you may have about this analytical report or to provide additional resources on groundwater quality. Please feel free to contact us at:
groundwater.monitoring@deq.state.or.us or **503-693-5736.**

If we do not know the answer, we will direct you to health professionals at OHA or technical experts at your local health authority to assist you.

Thank you again for participating in this study!

Sincerely,

Kara Goodwin and Paige Evans

Statewide Groundwater Monitoring
Laboratory Environmental Assessment Program
Oregon Department of Environmental Quality
groundwater.monitoring@deq.state.or.us
503-693-5736

DEQ Laboratory and Environmental Assessment Program

Analytical Report

Station: 23135

Station Description: Milton-Freewater Groundwater Quality Study Area well UMA300

Sampled Date/Time: 2/22/2016 1:30:00PM

Laboratory ID: 1602090-03

Sample Type: Grab Sample::GS

Analysis Summary

Analyte Name	Result:	Units:	DQL:
Nutrients			
Nitrate/Nitrite as N	**1.49**	mg/L	A
Phosphate, Total as P	**0.05**	mg/L	A
General Chemistry			
Alkalinity, Total as CaCO3	**94**	mg/L	A
Chloride	**3.49**	mg/L	A
Sulfate	**9.21**	mg/L	A
Total Solids	**163**	mg/L	A
Total Metals by Inductively Coupled Plasma Mass Spectrometry			
Calcium, Total recoverable	**19.1**	mg/L	A
Hardness as CaCO3, Total recoverable	**76.5**	mg/L	A
Magnesium, Total recoverable	**6.98**	mg/L	A
Potassium, Total recoverable	**4.34**	mg/L	A
Sodium, Total recoverable	**13.1**	mg/L	A
Uranium, Total recoverable	**0.92**	µg/L	A
Vanadium, Total recoverable	**7.47**	µg/L	A
General Field Parameters			
Conductivity	**223**	µmhos/cm	A
Dissolved Oxygen	**5.7**	mg/L	A
pH	**7.1**	pH Units	A
Temperature	**11.9**	°C	A
Pesticides by Liquid Chromatography/Tandem Mass Spectrometry			
Desethylatrazine	**5.81**	ng/L	A
Phenoxy Herbicides by Electron Capture Detector			
DCPA acid metabolites	**1.6**	µg/L	A
Microbiology			
Coliform, Total	< 1	MPN/100 mL	A
E. Coli	< 1	MPN/100 mL	A
Total Metals by Inductively Coupled Plasma Mass Spectrometry			
Aluminum, Total recoverable	< 20.0	µg/L	A
Arsenic, Total recoverable	< 2.00	µg/L	A
Iron, Total recoverable	< 50.0	µg/L	A
Lead, Total recoverable	< 0.20	µg/L	A
Manganese, Total recoverable	< 2.00	µg/L	A
Low Level Analysis of Pesticides by Gas Chromatography/Mass Spectrometry			
2,6-Dichlorobenzamide	< 22.4	ng/L	A
4,4´-DDD	< 22.4	ng/L	A
4,4´-DDE	< 22.4	ng/L	A

DEQ Laboratory and Environmental Assessment Program

Analytical Report

Station: 23135
Station Description: Milton-Freewater Groundwater Quality Study Area well UMA300
Sampled Date/Time: 2/22/2016 1:30:00PM
Laboratory ID: 1602090-03
Sample Type: Grab Sample::GS

Analysis Summary

Analyte Name	Result:	Units:	DQL:
Low Level Analysis of Pesticides by Gas Chromatography/Mass Spectrometry			
4,4´-DDT	< 22.4	ng/L	A
Aldrin	< 22.4	ng/L	A
alpha-BHC	< 22.4	ng/L	A
beta-BHC	< 22.4	ng/L	A
Bifenthrin	< 22.4	ng/L	A
Bromacil	< 22.4	ng/L	A
Butachlor	< 22.4	ng/L	A
Butylate	< 22.4	ng/L	A
Chlorobenzilate	< 22.4	ng/L	A
Chloroneb	< 22.4	ng/L	A
Chlorothalonil	< 22.4	ng/L	A
Chlorpropham	< 22.4	ng/L	A
Chlorpyrifos	< 22.4	ng/L	A
cis-Chlordane	< 22.4	ng/L	A
Cyanazine	< 22.4	ng/L	A
Cycloate	< 22.4	ng/L	A
Dacthal (DCPA)	< 22.4	ng/L	A
delta-BHC	< 22.4	ng/L	A
Diazinon	< 22.4	ng/L	A
Dichlobenil	< 22.4	ng/L	A
Dichlorvos	< 22.4	ng/L	A
Dieldrin	< 22.4	ng/L	A
Dimethenamid	< 22.4	ng/L	A
Dimethoate	< 22.4	ng/L	A
Diphenamid	< 22.4	ng/L	A
Endosulfan I	< 22.4	ng/L	B
Endosulfan II	< 22.4	ng/L	A
Endosulfan sulfate	< 22.4	ng/L	A
Endrin	< 22.4	ng/L	A
Endrin aldehyde	< 22.4	ng/L	B
EPTC	< 22.4	ng/L	A
Ethoprop	< 22.4	ng/L	A
Etridiazole	< 22.4	ng/L	A
Fenamiphos	< 56.0	ng/L	A
Fenarimol	< 22.4	ng/L	A
Fenvalerate+Esfenvalerate	< 224	ng/L	A
Fluridone	< 22.4	ng/L	A

DEQ Laboratory and Environmental Assessment Program

Analytical Report

Station: 23135
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Sampled Date/Time: 2/22/2016 1:30:00PM
Laboratory ID: 1602090-03
Sample Type: Grab Sample::GS

Analysis Summary

Analyte Name	Result:	Units:	DQL:
Low Level Analysis of Pesticides by Gas Chromatography/Mass Spectrometry			
gamma-BHC (Lindane)	< 22.4	ng/L	A
Heptachlor	< 22.4	ng/L	A
Heptachlor epoxide	< 22.4	ng/L	A
Hexazinone	< 22.4	ng/L	A
Malathion	< 22.4	ng/L	A
Methoxychlor	< 22.4	ng/L	A
Methyl paraoxon	< 22.4	ng/L	A
Mevinphos	< 22.4	ng/L	A
MGK 264	< 22.4	ng/L	A
Mirex	< 22.4	ng/L	B
Molinate	< 22.4	ng/L	A
Napropamide	< 22.4	ng/L	A
Norflurazon	< 22.4	ng/L	A
Oxyfluorfen	< 22.4	ng/L	A
Parathion-ethyl	< 22.4	ng/L	A
Parathion-methyl	< 22.4	ng/L	A
Pebulate	< 22.4	ng/L	A
Pendimethalin	< 22.4	ng/L	A
Permethrin	< 44.8	ng/L	A
Pronamide	< 22.4	ng/L	A
Propachlor	< 22.4	ng/L	A
Pyriproxyfen	< 112	ng/L	A
Tebuthiuron	< 22.4	ng/L	A
Terbacil	< 22.4	ng/L	A
Terbufos	< 22.4	ng/L	A
Tetrachlorvinphos (Stirophos)	< 56.0	ng/L	A
trans-Chlordane	< 22.4	ng/L	A
trans-Nonachlor	< 22.4	ng/L	A
Triadimefon	< 22.4	ng/L	A
Tricyclazole	< 56.0	ng/L	A
Trifluralin	< 22.4	ng/L	A
Vernolate	< 22.4	ng/L	A
Pesticides by Liquid Chromatography/Tandem Mass Spectrometry			
Acetamiprid	< 4.48	ng/L	A
Acetochlor	< 11.2	ng/L	A
Alachlor	< 11.2	ng/L	A
Ametryn	< 4.48	ng/L	A

DEQ Laboratory and Environmental Assessment Program

Analytical Report

Station: 23135
Station Description: Milton-Freewater Groundwater Quality Study Area well UMA300
Sampled Date/Time: 2/22/2016 1:30:00PM
Laboratory ID: 1602090-03
Sample Type: Grab Sample::GS

Analysis Summary

Analyte Name	Result:	Units:	DQL:
Pesticides by Liquid Chromatography/Tandem Mass Spectrometry			
Aminocarb	< 4.48	ng/L	B
Atrazine	< 4.48	ng/L	A
Azinphos-methyl (Guthion)	< 22.4	ng/L	A
Baygon (Propoxur)	< 4.48	ng/L	A
Carbaryl	< 5.60	ng/L	A
Carbofuran	< 4.48	ng/L	A
DEET	< 33.6	ng/L	A
Deisopropylatrazine	< 4.48	ng/L	A
Diuron	< 4.48	ng/L	A
Fluometuron	< 4.48	ng/L	A
Imazapyr	< 44.8	ng/L	A
Imidacloprid	< 22.4	ng/L	A
Linuron	< 4.48	ng/L	A
Methiocarb	< 4.48	ng/L	A
Methomyl	< 4.48	ng/L	A
Metolachlor	< 11.2	ng/L	A
Metribuzin	< 4.48	ng/L	A
Metsulfuron Methyl	< 4.48	ng/L	A
Mexacarbate	< 4.48	ng/L	A
Neburon	< 5.60	ng/L	A
Oxamyl	< 4.48	ng/L	A
Prometon	< 4.48	ng/L	B
Prometryn	< 4.48	ng/L	A
Propazine	< 4.48	ng/L	A
Propiconazole	< 22.4	ng/L	A
Pyraclostrobin	< 4.48	ng/L	A
Siduron	< 4.48	ng/L	A
Simazine	< 4.48	ng/L	A
Simetryn	< 4.48	ng/L	B
Sulfometuron-methyl	< 4.48	ng/L	B
Terbutryn (Prebane)	< 4.48	ng/L	B
Terbutylazine	< 4.48	ng/L	A
Phenoxy Herbicides by Electron Capture Detector			
2,4,5-T	< 0.3	µg/L	A
2,4,5-TP (Silvex)	< 0.1	µg/L	A
2,4-D	< 0.1	µg/L	A
2,4-DB	< 0.6	µg/L	A

DEQ Laboratory and Environmental Assessment Program

Analytical Report

Station: 23135
Station Description: Milton-Freewater Groundwater Quality Study Area well UMA300
Sampled Date/Time: 2/22/2016 1:30:00PM
Laboratory ID: 1602090-03
Sample Type: Grab Sample::GS

Analysis Summary

Analyte Name	Result:	Units:	DQL:
Phenoxy Herbicides by Electron Capture Detector			
3,5-Dichlorobenzoic acid	< 0.3	µg/L	A
Acifluorfen	**Void**	µg/L	D
Dicamba	< 0.3	µg/L	A
Dichloroprop	< 0.3	µg/L	A
Dinoseb	**Void**	µg/L	D
MCPA	< 19.7	µg/L	A
MCPP	< 59.2	µg/L	A
Pentachlorophenol	< 0.1	µg/L	A
Picloram	< 0.6	µg/L	A
Triclopyr	< 0.3	µg/L	A
Pesticides by High Resolution Mass Spectrometry			
2,4´-DDD	< 0.0632	ng/L	A
2,4´-DDE	< 0.0632	ng/L	A
2,4´-DDT	< 0.0632	ng/L	A
4,4´-DDD	< 0.0632	ng/L	A
4,4´-DDE	< 0.0632	ng/L	A
4,4´-DDT	< 0.0632	ng/L	A
Aldrin	< 0.0632	ng/L	A
alpha-BHC	< 0.0632	ng/L	A
alpha-Chlordane	< 0.0632	ng/L	A
beta-BHC	< 0.0632	ng/L	A
cis-Nonachlor	< 0.0632	ng/L	A
delta-BHC	< 0.0632	ng/L	A
Dieldrin	< 0.0632	ng/L	A
Endosulfan I	< 0.158	ng/L	A
Endosulfan II	< 0.158	ng/L	A
Endosulfan sulfate	< 0.158	ng/L	A
Endrin ketone	< 1.26	ng/L	B
Endrin+cis-Nonachlor	< 0.126	ng/L	A
gamma-BHC (Lindane)	< 0.0632	ng/L	A
gamma-Chlordane+trans-Nonachlor	< 0.126	ng/L	A
Heptachlor	< 0.0632	ng/L	A
Heptachlor epoxide	< 0.0632	ng/L	A
Hexachlorobenzene	< 0.789	ng/L	A
Methoxychlor	< 0.253	ng/L	A
Mirex	< 0.0632	ng/L	A
Oxychlordane	< 0.0632	ng/L	A

DEQ Laboratory and Environmental Assessment Program

Analytical Report

Station: 23135
Station Description: Milton-Freewater Groundwater Quality Study Area well UMA300
Sampled Date/Time: 2/22/2016 1:30:00PM
Laboratory ID: 1602090-03
Sample Type: Grab Sample::GS

Analysis Summary

Analyte Name	Result:	Units:	DQL:
Pesticides by High Resolution Mass Spectrometry			
Trifluralin	< 0.526	ng/L	B
Perchlorate in Water by Liquid Chromatography/Tandem Mass Spectrometry			
Perchlorate	< 1.00	µg/L	A

DEQ Laboratory and Environmental Assessment Program

Analytical Report

Station: 23135

Station Description: Milton-Freewater Groundwater Quality Study Area well UMA300

Sampled Date/Time: 02/22/2016 01:30 PM

Laboratory ID: 1602090-03

Sample Type: Grab Sample::GS

Information about your detection

Nitrate/Nitrite as N

Nitrate is a naturally occurring oxide of nitrogen and is an essential component of all living things. It is the primary source of nitrogen for plants and it occurs naturally in soil and water. But if the levels of nitrate get too high it can pose a potential health risk. Sources of excess nitrate in water include fertilizers, septic systems, wastewater treatment effluent, animal wastes, industrial wastes, and food processing wastes. Nitrite is a chemical related to nitrate that quickly converts to nitrate in the presence of oxygen. The DEQ laboratory measures nitrate and nitrite together and reports the amount of nitrogen (nitrate/nitrite as N). Since the concentration of nitrate is often much higher than nitrite, we compare the combined nitrate/nitrite concentration to the nitrate MCL to evaluate risk. Nitrate levels of up to 2 mg/ L (milligrams per liter) in well water may be naturally-occurring or possibly indicates some low level of contamination. The EPA has set an MCL of 10 mg/L for nitrate (nitrate as N) for drinking water. Nitrate levels above 10 mg/L may present a serious health concern for infants and pregnant or nursing women. The concentration of nitrate in your well was **1.49 mg/L**.

Less than 2 mg/L -- no or very little impact from human activities and your results likely represent natural background levels.
2 to 4 mg/L-- a small impact from human activities may be present. However, this level of nitrate is not a health concern for most people.
4 to 7 mg/L-- obvious impact from human activities
7 to 9.9 mg/L-- obvious impact from human activities. Your water is approaching public health limits for nitrate (10 mg/L).

Recommendations for non-detect (ND) up to 10 mg/L:

1. Nitrate in this range does not pose a significant health risk for healthy individuals, but increased monitoring for nitrate is recommended.
2. Annual testing for nitrate is recommended. Seasonal monitoring once every six months in the middle of the wet and dry seasons is best for detecting seasonal highs and lows
3. When considering nitrate treatment options remember to account for individual tolerance to risk. For example, dietary exposure to foods that have nitrates, such as cured meats; pregnant women, infants, and children; pre-existing medical conditions; or persons who are 65 years of age or older may be at higher risk. We recommend that you share these test results with your physician if you have health concerns.

DEQ Laboratory and Environmental Assessment Program

Analytical Report

Station: 23135

Station Description: Milton-Freewater Groundwater Quality Study Area well UMA300

Sampled Date/Time: 02/22/2016 01:30 PM

Laboratory ID: 1602090-03

Sample Type: Grab Sample::GS

Information about your detection

Uranium, Total Recoverable

Uranium is a natural element that is found everywhere on earth, in rocks, air, water, animals, plants, and soils. Uranium has both civilian and military uses. The main civilian uses for uranium are in nuclear power plants, helicopters and airplanes. Very small amounts are used to make some ceramic ornament glazes, light bulbs, photographic chemicals and other household products. In the military, depleted uranium is used as shielding to protect some vehicles, and as a part of bullets, bombs, and missiles. Enriched uranium is used in civil nuclear power and in nuclear weapons. Uranium in water comes mainly from rocks and soil as water passes over them. Some accumulation of uranium occurs in plants, but not much can accumulate in fish or livestock. Uranium can have chemical and radiological effects on the body. Nearly all naturally-occurring uranium is non-radioactive. The radioactive isotope used in nuclear power/weapons is less than 1% of naturally-occurring uranium. To date, scientists have not been able to detect radiation effects from naturally-occurring uranium. The EPA has established a maximum contaminant level of 30 µg/L (parts per billion) for uranium in drinking water. Uranium was detected in your well water at a concentration of **0.92 µg/L** and is not expected to pose a significant health risk to you or your family.

DEQ Laboratory and Environmental Assessment Program

Analytical Report

Station: 23135

Station Description: Milton-Freewater Groundwater Quality Study Area well UMA300

Sampled Date/Time: 02/22/2016 01:30 PM

Laboratory ID: 1602090-03

Sample Type: Grab Sample::GS

Information about your detection

Vanadium, Total Recoverable

Vanadium and vanadium compounds can be found in the earth's crust and in rocks, some iron ores, and crude petroleum deposits. It is used in producing rust-resistant metal alloys, springs, high-speed tools, as a catalyst in ceramics, and in the production of superconductive magnets. Vanadium compounds have been used as dietary supplements. Vanadium mainly enters the environment from natural sources and from the burning of fuel oils. Nausea, mild diarrhea, and stomach cramps have been reported in people who have been exposed to some vanadium compounds. A number of effects have been found in animals ingesting vanadium compounds, including decreases in the number of red blood cells, increased blood pressure, and mild neurological effects. The amounts of vanadium given in these animal studies that resulted in harmful effects are much higher than those likely to occur in the environment. There is no drinking water standard for vanadium. The EPA has calculated a health-based regional screening level (RSL) for vanadium at 86 µg/L. Vanadium was detected in your well at a concentration of **7.47 µg/L** and is not expected to pose a significant health risk to you or your family.

DEQ Laboratory and Environmental Assessment Program

Analytical Report

Station: 23135

Station Description: Milton-Freewater Groundwater Quality Study Area well UMA300

Sampled Date/Time: 02/22/2016 01:30 PM

Laboratory ID: 1602090-03

Sample Type: Grab Sample::GS

Information about your detection

Atrazine, Simazine, Deisopropylatrazine and Desethylatrazine:

These are all triazine herbicides.
Atrazine is an herbicide used for control of annual grasses and broadleaf weeds on corn (field and sweet), sorghum, wheat, conifer forests, Christmas tree farms, sod farms, golf courses and lawns. Atrazine is also registered for use in Oregon on range grasses for the establishment of permanent grass cover on range and pasture land. Atrazine is known to disrupt normal hormone signaling in the body and can be harmful to health. The EPA has established a maximum contaminant level of 3 µg/L (equal to 3,000 ng/L) for atrazine in drinking water. **Atrazine was not detected in your well** and is not expected to pose a significant health risk to you or your family.

Simazine is a widely used herbicide in the United States for control of annual grasses and broadleaf weeds in crop and non-crop areas. Crops treated with simazine include, but are not limited to, fruit, nuts, apples, oranges, and corn. Non-crop sites include, but are not limited to, forests, turf (grown commercially for sod or on lawns and golf courses), roadways, industrial sites, lumberyards, rights-of-way, fences, buildings and outdoor structures, such as equipment or fuel storage areas. Simazine is also registered for use to control algae in ornamental ponds and aquariums. Simazine can be harmful to health. The EPA has established a maximum contaminant level of 4 µg/L (equal to 4,000 ng/L) for simazine in drinking water. **Simazine was not detected in your well** and is not expected to pose a significant health risk to you or your family.

Deisopropylatrazine and desethylatrazine are breakdown products of the triazine herbicides, such as atrazine and simazine. There is no health-based standard or screening level for deisospropylatrazine or desethylatrazine.

The total amount of these four chemicals detected in your well water is **5.81** ng/L, well below the health-based standard of the parent compounds (MCL = 3 µg/L or 3000 ng/L for atrazine, and MCL = 4 µg/L = 4000 ng/L for simazine) and is not expected to pose a significant health risk to you or your family.

DEQ Laboratory and Environmental Assessment Program

Analytical Report

Station: 23135

Station Description: Milton-Freewater Groundwater Quality Study Area well UMA300

Sampled Date/Time: 02/22/2016 01:30 PM

Laboratory ID: 1602090-03

Sample Type: Grab Sample::GS

Information about your detection

Dacthal and DCPA acid metabolites

DCPA acid metabolites are breakdown products of the preemergent herbicide dacthal (DCPA). These breakdown products are more water-soluble than the parent chemical and readily leach into groundwater. There have been very few studies on the toxicity of these breakdown products, however the available data indicate that they are no more toxic than the parent chemical. The USGS has calculated a Health-Based Screening Level for dacthal as 20 µg/L. Dacthal and/or its breakdown products were detected in your well water at a total concentration of **1.60** µg/L and are not expected to pose a significant health risk to you or your family.

DEQ Laboratory and Environmental Assessment Program

Analytical Report

Explanation of terms and phrases used in your Analytical Report

Data Quality Levels (DQL) listed on your Analytical Report:

A = Data of known Quality; meets Quality Control (QC) limits established in a DEQ approved plan.

B = Data of known but lesser quality; Data may not meet established QC but is within marginal acceptance criteria; or data value may be accurate, however controls used to measure Data Quality Objective elements failed (e.g. batch failed to meet blank QC limit); the data is generally usable for most situations or in supporting other, higher quality data.

C= Data of unacceptable quality; Generally due to QC failures but may be related to other known information about the sample. Data should not be used for quantitation purposes but may have qualitative use.

D= No data available; No sample collected or no reportable results. Samples are either voided or cancelled.

E= Data of unknown quality; Insufficient QA/QC or other information available to make determination. Data could be acceptable; however, no evidence is available to prove either way. Data is provided for Educational Use Only.

Terms

mg/L (milligrams per liter; parts per million; ppm)
Unit of concentration equivalent to one penny in $10,000; or one 8 oz. glass of water in a 65,000 gallon Olympic sized swimming pool

µg/L (micrograms per liter; parts per billion; ppb)
Unit of concentration equivalent to one second in 32 years. There are 1,000 µg/L in 1 mg/L.

ng/L (nanograms per liter; parts per trillion; ppt)
Unit of concentration equivalent to one drop of ink distributed in a 12 million-gallon reservoir. There are 1,000 ng/ L in 1 µg/L and 1,000,000 ng/L in 1 mg/L.

EPA
United States Environmental Protection Agency

MCL
Maximum Contaminant Level defined by EPA as the maximum permissible level of a contaminant in water, which is delivered to any user of a public water system. There are no regulations for water that comes from a private, domestic well. However, the MCL set for public water systems is a very reliable health based standard for domestic wells.
http://water.epa.gov/drink/contaminants

Human health benchmark for pesticides (HHBP), Regional Screening Level (RSL) and Health-based screening level (HBSL)
Non-Enforceable benchmark concentrations in water below which adverse health effects are not expected over a lifetime of exposure calculated by the EPA and the United States Geological Survey, respectively.
http://www.epa.gov/region9/superfund/prg/, http://water.usgs.gov/nawqa/HBSL

Appendix D – Example of a Well Drilling Report

UMAT 58331

STATE OF OREGON
MONITORING WELL REPORT
(as required by ORS 537.765 & OAR 690-240-0395)

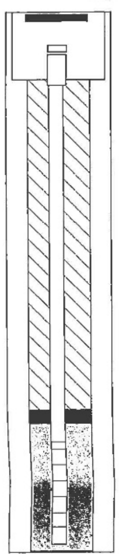
WELL I.D. LABEL# L 97778
START CARD # 1028981

(1) LAND OWNER Owner Well I.D.
First Name Last Name
Company Walla Walla Watershed
Address 810 S Main St
City Milton Freewater State OR Zip 97862

(2) TYPE OF WORK ☒ New ☐ Deepening ☐ Conversion ☐ Alteration (repair/recondition) ☐ Abandonment

(3) DRILL METHOD
☒ Rotary Air ☐ Rotary Mud ☐ Cable ☐ Hollow Stem Auger ☐ Cable Mud ☐ Reverse Rotary ☐ Other

(4) CONSTRUCTION Piezometer Well ☐
Depth of Completed Well 40 ft. Special Standard ☐



MONUMENT/VAULT Below Ground
From 0 To 1

BORE HOLE
Diameter 6 From To

CASING
Dia. 2 From ☐ 1 To 13
Gauge Wld Thrd
Material ◯ Steel ◉ Plastic ☐ ☒

LINER
Dia. From ☐ To
Gauge N/A Wld Thrd
Material ◯ Steel ◯ Plastic ☐ ☐

SEAL
From 1 To 13
Material Bentonite Chips
Amount 19 Pounds Grout weight

SCREEN
Casing/Liner Material PVC
Diameter From 15 To 40
Slot Size 20

FILTER
From 13 To 40 Material Sand Size of pack 10/20

(5) WELL TESTS
◯ Pump ◯ Bailer ◯ Air ◯ Flowing Artesian

Yield gal/min	Drawdown	Drill stem/Pump depth	Duration (hr)

Temperature °F Lab analysis ☒ Yes By Client
Supervising Geologist/Engineer Bob Rice
Water quality concerns? ☐ Yes (describe below) TDS amount

From	To	Description	Amount	Units

(6) LOCATION OF WELL (legal description)
County UMATILLA Twp 6 N N/S Range 35 E E/W WM
Sec 27 NE 1/4 of the NW 1/4 Tax Lot
Tax Map Number Lot
Lat ° ' " or DMS or DD
Long ° ' " or DMS or DD
◉ Street address of well ◯ Nearest address
[redacted]

(7) STATIC WATER LEVEL

	Date	SWL(psi)	+	SWL(ft)
Existing Well / Predeepening			☐	
Completed Well	12-22-2015		☐	

Flowing Artesian? ☐ Dry Hole? ☐
WATER BEARING ZONES Depth water was first found 22

SWL Date	From	To	Est Flow	SWL(psi)	+	SWL(ft)
12-22-2015	22	40	3	22	☐	
					☐	
					☐	
					☐	
					☐	

(8) WELL LOG Ground Elevation

Material	From	To
Sand	0	5
Sand & gravel	5	17
Silty Sand & gravel	17	40

RECEIVED
MAR 09 2020
OWRD

Date Started 12-22-2015 Completed 12-22-2015

(unbonded) Monitor Well Constructor Certification
I certify that the work I performed on the construction, deepening, alteration, or abandonment of this well is in compliance with Oregon monitoring well construction standards. Materials used and information reported above are true to the best of my knowledge and belief.
License Number 10516 Date 3-2-20
Password : (if filing electronically)
Signed

(bonded) Monitor Well Constructor Certification
I accept responsibility for the construction, deepening, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon monitoring well construction standards. This report is true to the best of my knowledge and belief.
License Number Date
Password : (if filing electronically)
Signed
Contact Info (optional)

ORIGINAL - WATER RESOURCES DEPARTMENT
THIS REPORT MUST BE SUBMITTED TO THE WATER RESOURCES DEPARTMENT WITHIN 30 DAYS OF COMPLETION OF WORK

Form Version: 0.95