DEPARTMENT OF ECOLOGY
State of Washington

Leaking Underground Storage Tank (LUST) Sites Near Sensitive Wellheads

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December 2009
Ecology Publication No. 09-09-048

Publication and Contact Information

This report is available on the Department of Ecology's website at
www.ecy.wa.gov/biblio/09090048.html

Washington State Department of Ecology - www.ecy.wa.gov

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Acknowledgements

- Ecology Toxics Cleanup Program Information Technology (IT) Section: Wayne Allenton and Jean Rakestraw, as well as Ian Mooser and Shannon Edwards for GIS support.

- Brett Hunter of Chevron Corporation for submitting electronic data to Ecology.

- Deanna Harding of Gettler-Ryan Inc. for assisting with the submittal of Chevron ground water monitoring data to Ecology.

- Joe Crossland (former Ecology employee, grants and contracts) and Mike Blum (UST/LUST coordinator), Ecology's Toxics Cleanup Program.

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Executive Summary

Study Objective

The objective of this study was to quantify the number of leaking underground storage tank (LUST) sites (for example, commercial gas stations) that are located near highly susceptible public water supply wells. Currently, approximately 5 million of Washington's 6 million residents obtain their drinking water from approximately 6,800 sources[1]. These sources include ground water, surface water (rivers, streams and lakes) and springs.

Why Was this Study Done?

There are three reasons why this study was done:

- First, there are currently a large number of active LUST sites. As of November 2005, Ecology's Toxics Cleanup Program (TCP) had a record of 1,915 active leaking underground storage tank (LUST) sites. In September 2006, Ecology received an Environmental Protection Agency (EPA) grant[2] to follow-up on the backlog of LUST sites. The information in this report was used to support this grant.

- Second, a number of these active LUST sites are in close proximity to highly susceptible public water supply wells.

- Third, and perhaps most importantly, under both state and federal law, public water supply well operators are not required to test for some common gasoline oxygenates; for example, methyl tert butyl ether (MTBE). In addition to MTBE, there are a number of other unregulated gasoline oxygenates that are not routinely tested for; for example, TAME[3], DIPE[4], TBA[5], and so on. Oxygenates like MTBE are highly soluble in water, and tend to migrate quite rapidly when released to the environment.

Methods

Geographic Information Systems (GIS)[6] methods and tools were used to evaluate the following:

- LUST sites within one mile of a *"high susceptibility"* well,
- LUST sites within one mile of *any* well,

[1] The Office of Drinking Water Fact Sheet, DOH PUB #331-287, March, 2005
[2] EPA grant ID# LS-960455-01-0 ($400,000), effective Sept-06 - Sept-09: "Review and Evaluation of LUST Sites". in Groundwater Monitoring Status".
[3] Methyl tert-amyl ether.
[4] Diisopropyl ether.
[5] T-butyl alcohol.
[6] ArcGIS, ArcView-ArcMap V. 9.1

- MTBE LUST sites near wells,
- Well depths and pumping rates,
- Populations served by wells,
- LUST sites that overlie sole source aquifers (SSAs), and
- LUST sites near stormwater drains.

Results

- Washington currently has 1,581 *"high susceptibility"* wells. The average depth of these wells is 133 feet and the average pumping rate is 859 gallons per minute (gpm). These wells also serve an average population of 1,557.

- 368 of 1,915 (19.2%) LUST sites are located within one mile of a *"high susceptibility"* well. 1,040 of 1,915 (54.3%) LUST sites are located within one mile of *any* well.

- 15 LUST sites with the gasoline oxygenate MTBE are located within one mile of a high susceptibility well.

- 221 of 1,915 (11.5%) LUST sites overlie Washington sole source aquifers (SSA).

- 30 of 1,915 (1.5%) LUST sites are within 1/16 mile (330 ft.) of a Puget Sound stormwater drain.

High Risk Areas

The results of this study were used to identify a "top ten" list of priority areas. These ten areas are Washington cities with highly susceptible well fields or wells that are within one mile of LUST "clusters" (areas with a high density of LUST sites). These ten cities are:

- Auburn
- Battle Ground
- Centralia
- Lakewood-South Tacoma
- Omak
- Renton
- Richland
- Spokane
- Tumwater
- Yakima

Ecology's Recommendations for High Risk Areas

If you own or operate a high susceptibility drinking water well that is near (that is < 1-mile) a LUST site, then you should consider periodic testing for MTBE and other gasoline oxygenates (for example, TBA, and so on). *Gasoline oxygenates such as MTBE are "unregulated" contaminants - you are not required to test for them. Furthermore, some of these gasoline oxygenates are not on the standard drinking water analytical scan (that is, EPA 524.2).*

Study Overview

Objectives

The objective of this study was to quantify the number of leaking underground storage tank (LUST) sites (for example, commercial gas stations) within one mile of "highly susceptible" public water supply wells. As of November 2005, Ecology's Toxics Cleanup Program (TCP) had a record of 1,915 active leaking underground storage tank (LUST) sites[7]. A number of these active LUST sites are located within close proximity to public water supply wells. Thus, these LUST sites are likely to pose more of a risk than others.

What's a "UST"?

A "UST" is an underground storage tank system. USTs are subject to federal regulations if 10 percent of the combined volume (including connected underground piping) is underground. The federal UST regulations[8] apply only to underground tanks and piping storing either petroleum or certain hazardous substances.

Here are some UST facts:

- As of October 2006, there were 10,869 operational underground storage tanks (USTs) in Washington (9). These UST's are located at 3,609 sites. Most of these UST sites are commercial gasoline stations.

- 2,893 of 10,869 USTs (26.6%) are located within one mile of a high susceptibility well (Figure 1, p. 12).

- The average operational UST site has three (3) licensed tanks[10]. Each tank has an average capacity of 10,000 gallons[11], or 30,000 gallons per site. This equates to 326 million gallons of fuel that is stored in underground storage tank systems across Washington.

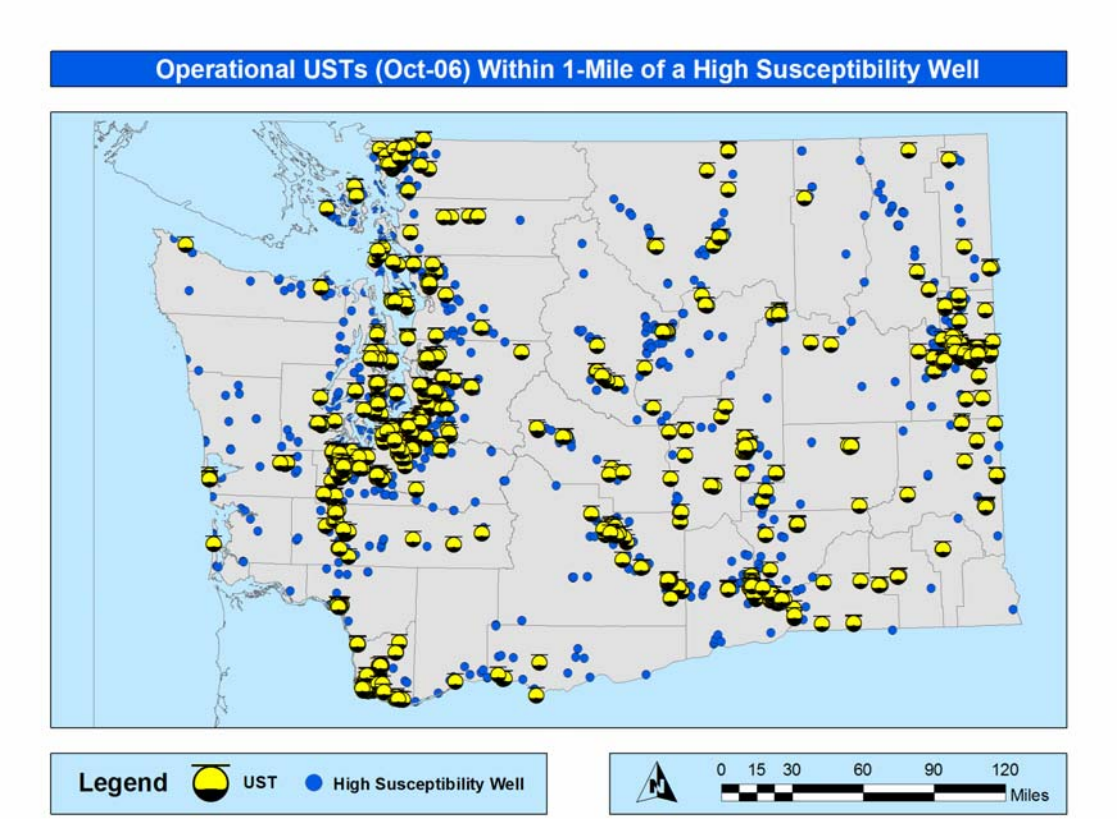
What's a "LUST"?

A "LUST" is a leaking underground storage tank. In most cases, LUSTs are associated with commercial gas stations or smaller bulk storage facilities. According to EPA, there have

[7] Source: Ecology Toxics Cleanup Program Integrated Site Information Systems (ISIS) data base; query by Jean Rakestraw, TCP.
[8] 40 CFR Part 260
[9] Source: Ecology Toxics Cleanup Program Oct-06 UST Data.
[10] Source: Oct-06 Ecolgoy UST data (10,869 USTs / 3,609 sites = 3 USTs per site).
[11] Source: sort of Oct-06 Ecology UST data.

been a total of 459,637 confirmed releases[12] from LUSTs here in the United States. There are now 648,436 active underground storage tanks (USTs), and ~ 1.6 million have been either decommissioned or taken out of service. Here in Washington, there have, to date, been 6,181 confirmed releases from LUSTs (12).

Figure 1: Operational USTs within 1-Mile of a High Susceptibility Well.



MTBE and Other Gasoline Oxygenates

MTBE (methyl tertiary-butyl ether) has historically been used in the United States as both a fuel oxygenate and an octane enhancer[13]. Adding oxygen to gasoline makes it burn more completely, which in turn reduces automotive emissions. Starting in 1990, MTBE was widely used in the United States as a fuel oxygenate, per the federal 1990 Clean Air Act (CAA) amendments.

[12] EPA Office of Underground Storage Tanks (OUST)
[13] Starting in 1979, MTBE was used to replace tetraethyl lead.

In addition to MTBE, other fuel oxygenates that may be present in gasoline include:

- tert-amyl methyl ether (TAME)
- diisopropyl ether (DIPE)
- ethyl tert-butyl ether (ETBE)
- tert-amyl alcohol (TAA)
- tert-butyl alcohol (TBA)
- ethanol

Ecology's 2000 MTBE Study

In 2000, Ecology published a study[14] on the occurrence of ground water MTBE at leaking underground storage tank sites (LUSTs). In this study, 70 LUST sites were selected for sampling (1 sample per site). Of the 70 total samples collected, 30 samples (43%) contained detectable levels of MTBE (Figure 3, p. 15; Table 63, p. 114). The range of MTBE values detected was 1-7,150 ug/L (mean = 441 ug/L, median = 13 ug/L). Since 2000, MTBE has continued to be detected in ground water. For example, MTBE was detected[15] at 43 LUST sites (2001-04, Figure 3).

USGS Studies on MTBE

In a recent study[16] by the United States Geological Survey (USGS), MTBE was the most frequently detected chemical in many aquifer supply wells. Specifically, MTBE was detected in ~ 3% of samples collected from 98 aquifer studies nationwide. MTBE was more frequently detected in areas with 1) high population density, 2) where it was used as an oxygenate, and 3) in areas with high rates of ground water recharge (that is New England and Mid-Atlantic states).

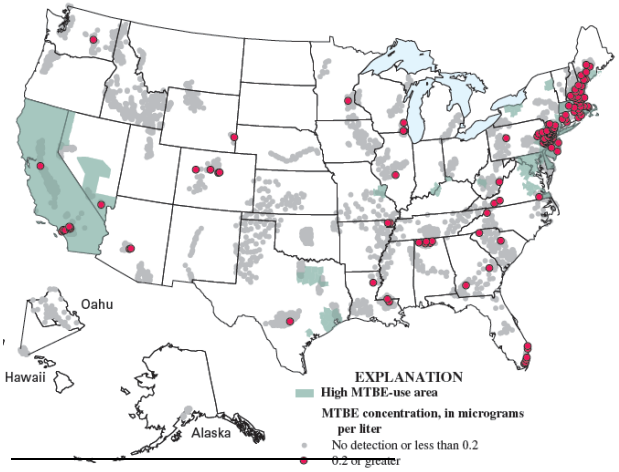


Figure 2: MTBE Detections (USGS, 2006).

Most detections of MTBE are in the Atlantic NE and New England (high density population). Red dots are MTBE @ 0.2 ug/L or greater.

[14] Occurrence of Methyl Tertiary-Butyl Ether (MTBE) in Groundwater at Leaking Underground Storage Tank Sites in Washington. October, 2000. Ecology Publication No. 00-09-054.
[15] Data submitted electronically to Charles San Juan, Ecology on behalf of Chevron (Brett Hunter) by Deana Harding, Gettler Ryan, Inc.
[16] Zogorski et al. (2006). Volatile Organic Compounds in the Nation's Ground Water and Drinking-Water Supply Wells – A Summary. USGS Circular 1292, USGS National Water Quality Assessment Program.

Figure 3: Ecology MTBE Study (2000) Results.

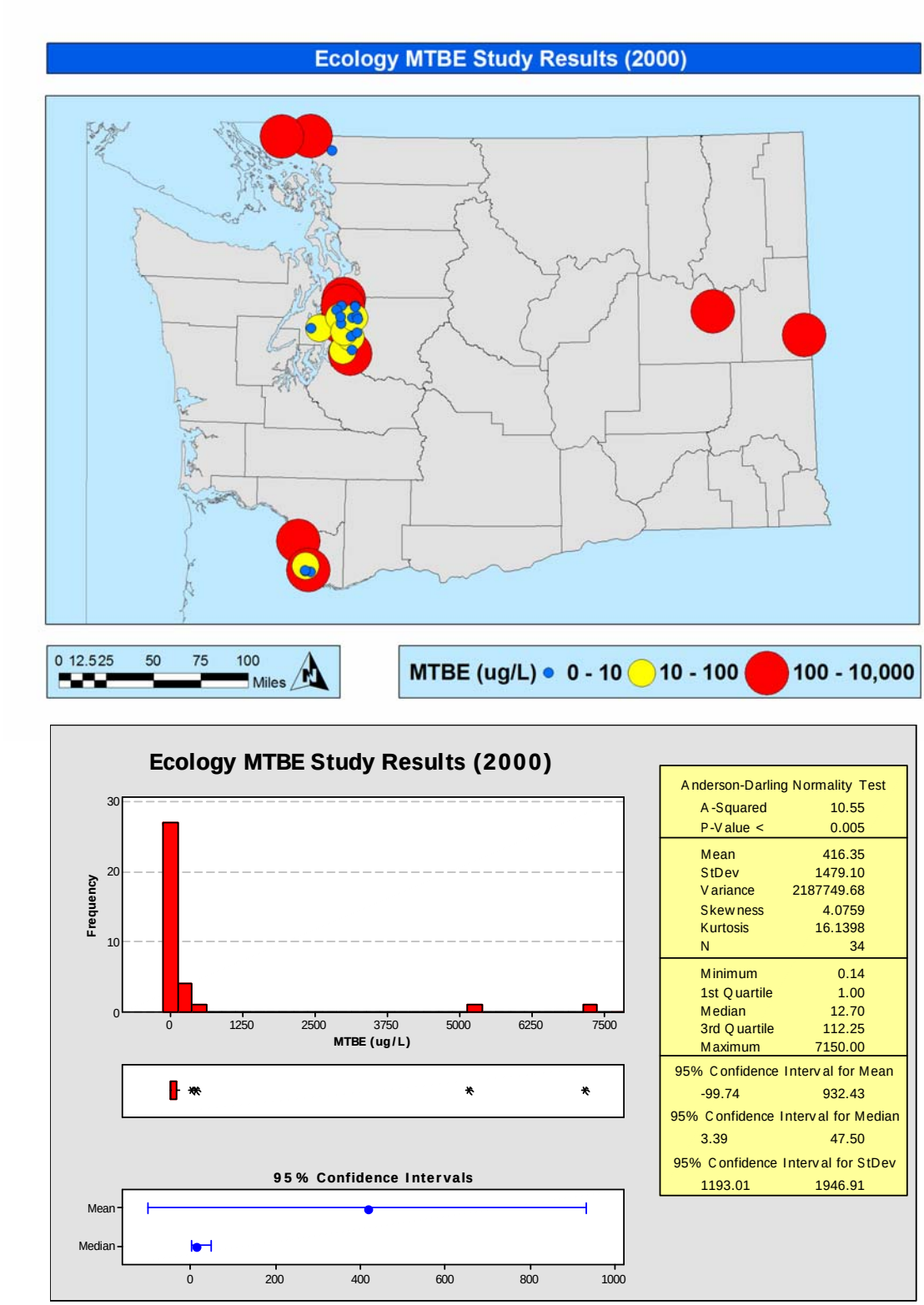
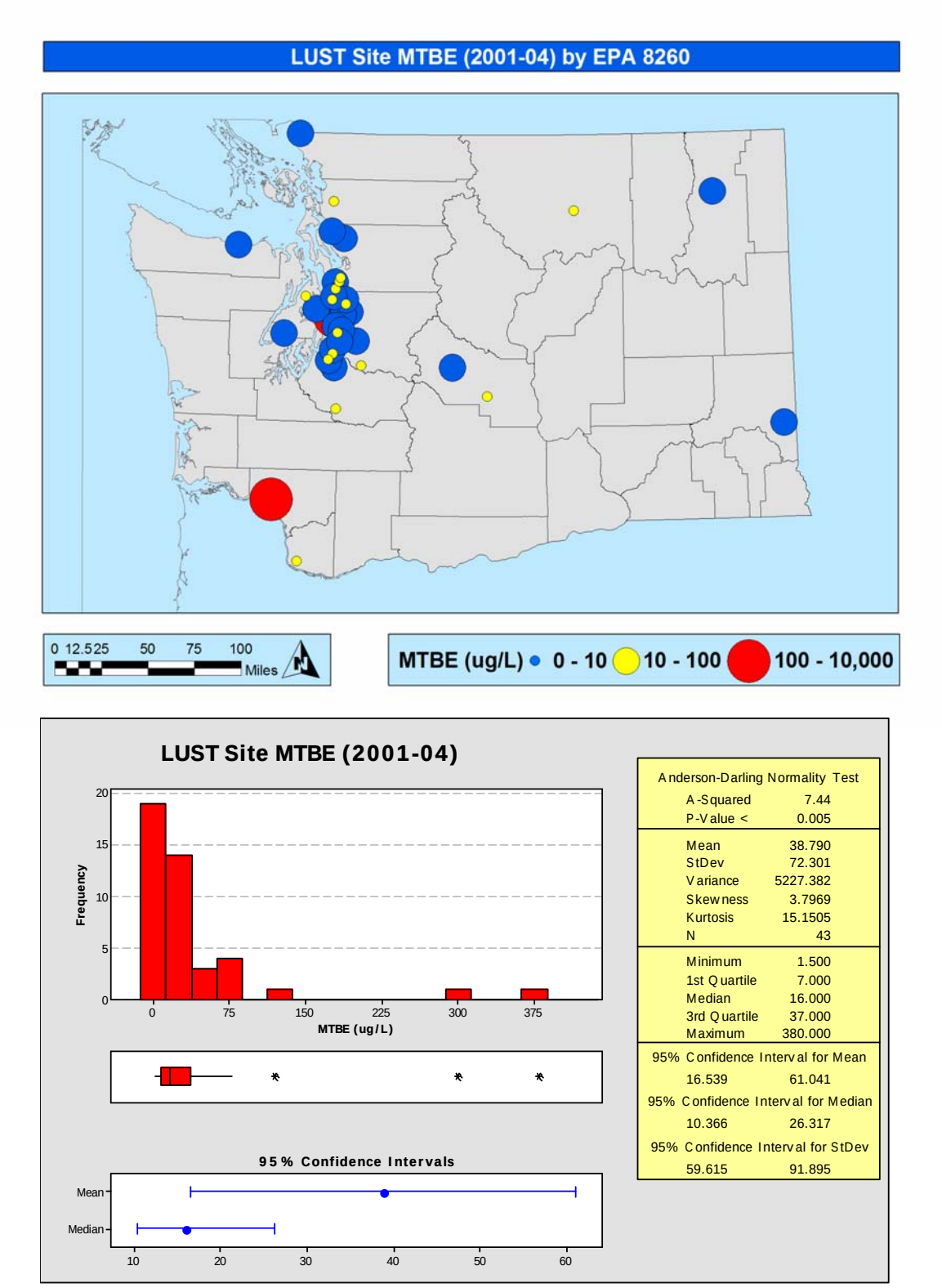


Figure 4: LUST Site MTBE (2001-04).

Note: this map is based on data submitted to Ecology by Chevron Corporation (Table 64, p. 115).

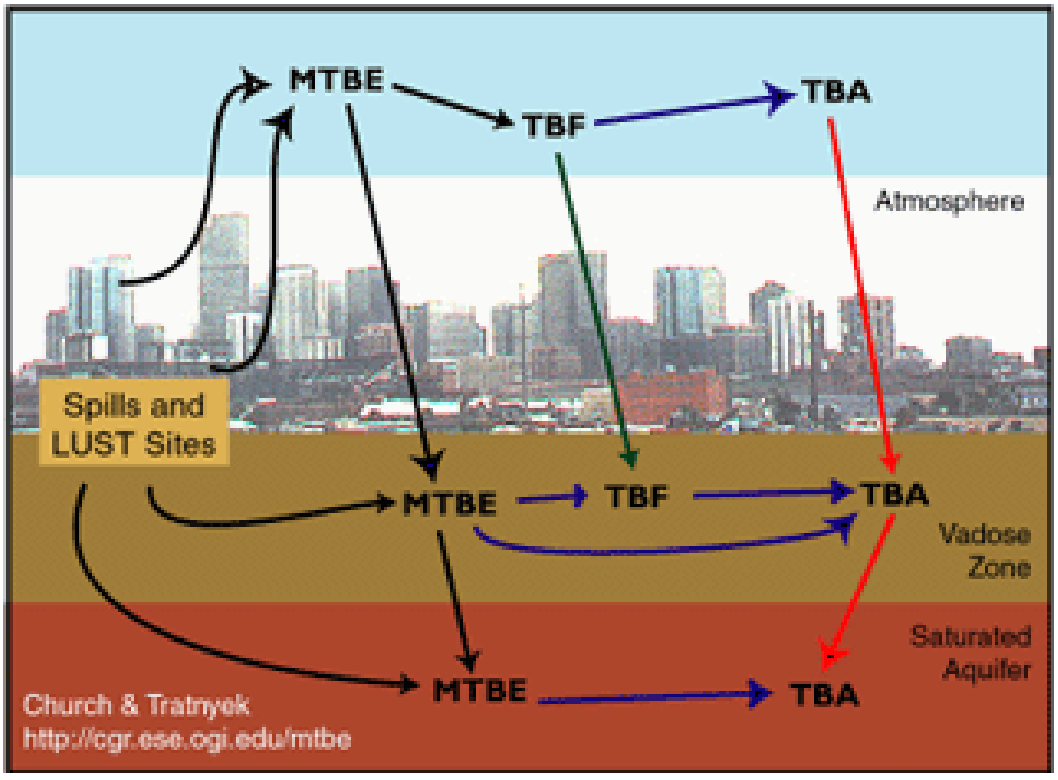


MTBE Fate and Transport

One of the most significant environmental issues with MTBE and other fuel oxygenates is that they tend to be highly soluble or even miscible in water. For example, MTBE has a water solubility[17] of ~ 50,000 mg/L, which is ~ 25X higher then benzene, which is one of the most soluble components of gasoline.

Thus, when automotive gasoline is released to the environment, chemical partitioning will occur amongst the soil, air and water. If gasoline containing MTBE (and other oxygenates) is mixed with water, then the MTBE will immediately partition to the aqueous phase. Also, the half-life of MTBE can be as short as three days in the atmosphere[18]. Once in the atmosphere, MTBE tends to partition to atmospheric water, including precipitation. Once this occurs, it may result in surface or ground water MTBE concentrations of ~ 3 ppb (18). Lastly, once MTBE mixes with ground water, it will migrate at nearly the same velocity as the ground water itself. Likewise, if there is any kind of vertical gradient, then MTBE will migrate more deeply[19] into aquifer systems.

Figure 5: MTBE Fate and Transport.



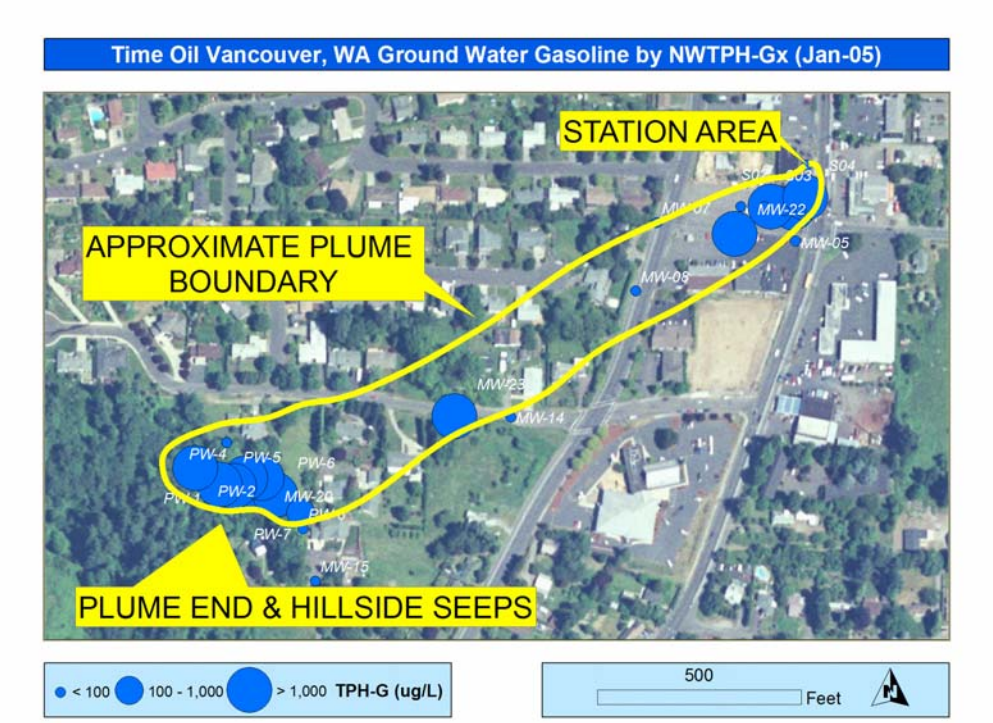
[17] Table 66, p. 117.
[18] Squillace et al. (1998). Environmental Behavior and Fate of Methyl tert-Butyl Ether (MTBE). USGS NAWQA Fact Sheet FS-203-96.
[19] "Diving Plume in Kansas", UTTU, Vol. 13, No. 4, July/August 1999, p. 14. University of Wisconsin-Madison, Department of Engineering Professional Development, Underground Tank Technology Update (UTTU).

How Long are Gasoline-MTBE Plumes?

Ground water contaminated with gasoline and MTBE can travel quite far. A 1996 study[20] of an MTBE-gasoline plume in East Patchoque New York study found that the plume has migrated ~ 6,000 ft. Here in Washington at the Vancouver Time Oil[21] site, a ground water dissolved-phase plume was discovered seeping out of a hillside ~ 2,000 ft. southwest of the site (Figure 6).

In August 1995, MTBE was discovered in the Santa Monica, California Charnock Well Field. A subsequent investigation by EPA[22] and the Regional Water Board initially identified 30 potential MTBE sources within a 1.25 mile radius of the city's Charnock Well Field. Many of these potential sources were LUST sites within one mile of the well field. The discovery of MTBE in the city well field resulted in the shutdown of several wells and cleanup costs of ~ $200 million.

Figure 6: Ground Water Dissolved-Phase Gasoline Plume (Jan-05), Time Oil Site, Vancouver, WA.



Map based on data submitted to Ecology. E-mail communication (2006). Charles San Juan, Ecology, to Brian Johnson, Database Specialist, AMEC Earth & Environmental, Inc., Portland, OR.

[20] Weaver, J.W. and Wilson, J.T. (1996). Analysis of the Gasoline Spill at East Patchoque, New York. ASCE Subsurface NAPL Conference, Washington, D.C.
[21] Handy Andy #8, 3314 NE 44th St., Vancouver, WA.
[22] EPA Charnock Well Field Cleanup

At the Port Hueneme[23], California Naval Air Station, a ~1,000 ft. long ground water BTEX plume has been identified. Within this same plume, there is also a 4,000 ft. long MTBE plume.

Recent Developments on MTBE Use in the United States

In 2005, the U.S. Congress passed the Energy Policy Act that eliminated the oxygen requirement in gasoline by mid-2006. Removal of the oxygen requirement is expected to decrease future use of MTBE in gasoline use.

MTBE State of Washington Use, Testing Requirements and Standards

Effective December 31, 2003, MTBE may not be intentionally added to any gasoline, motor fuel, or clean fuel produced for sale or use in the state of Washington[24]. Also, MTBE may not be knowingly mixed in gasoline above six-tenths of one percent by volume. Prior to 2001, if you had a petroleum release (for example, gasoline from a leaking fuel tank), then you were not required to test the soil or ground water for MTBE (or other oxygenates, ethers, and so on). You were not required to test for MTBE until August 2001, per Washington's revised MTCA[25] cleanup regulations. ***Consequently, prior to 2001, MTBE was not routinely tested for at Washington LUST sites. It is now required; however, there was a long period where it was not.*** Lastly, MTBE is currently on EPA's "unregulated contaminant monitoring" list. Thus, EPA has yet to set a national drinking water standard for MTBE. However, the State of Washington MTBE ground water cleanup standard is 20 ppb[26]. This standard[27] is based on a taste and odor threshold.

Leaded Gasoline Additives

In addition to MTBE, lead "scavengers" or anti-knock compounds were added to gasoline as octane enhancers. Two common lead additives are 1,2-dibromoethane (EDB) and 1,2-dichloroethane (DCA). Lead-based antiknock additive mixtures were used[28] in the United States from the 1920s through the late 1980s. There are at several reasons why lead additives may be an issue for LUST sites and high susceptibility wells:

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[23] Everett et al. (1998). Risk-Based Assessment of Appropriate Fuel Hydrocarbon Cleanup Strategies for the Naval Exchange Gasoline Station Naval Construction Battalion Center Port Hueneme, California. Lawrence Livermore National Laboratory report UCRL-AR-130891.

[24] Washington Senate EHB 1015, March 29, 2001. This legislation requires that MTBE may not be present in gasoline above six-tenths of 1 percent by volume.

[25] Model Toxics Control Act, Chapter 173-340 WAC, Table 830-1.

[26] Chapter 173-340 WAC, Table 720-1 (Method A Ground Water Cleanup Standards).

[27] EPA (1997). Drinking Water Advisory: Consumer Acceptability Advice and Health Effects Analysis on Methyl Tertiary-Butyl Ether (MTBE). EPA-822-F-97-009.

[28] Falta et al. Leaded-Gasoline Additives Still Contaminate Ground Water, ES&T, September 15, 2005.

- Leaded gasoline additives (EDB / DCA) were not routinely tested[29] for in the past (prior to 2001),

- They were widely used for a long period of time (~ 60 yrs here in the United States),

- Both EDB and DCA are highly soluble in water (4,300 and 8,500 mg/L respectively (28)),

- Both EDB and DCA are toxic; EPA has classified both as carcinogens,

- If high concentrations (ground water) of gasoline[30] are present, then the lab may have to dilute the sample, which raises the laboratory detection limits. This in turn may mean that even if EDB or DCA is analyzed for, the reported concentration may be above standards. For example, the federal drinking water standard for EDB is 0.05 ppb, and

- EDB concentrations may not decline over time. For example, in a recent study (28) of South Carolina LUST sites, it was found that in 40% of all monitor wells sampled, EDB concentrations actually increased over time, despite that it (EDB) is no longer used in gasoline.

EPA's Unregulated Contaminated Monitoring (UCM) Program

EPA's UCM[31] program is designed to collect data on contaminants that may be present in drinking water. The UCM program targets those contaminants for which there are no health-based standards. The UCM program is part of the federal Safe Drinking Water Act (SDWA). EPA is required to review the list of contaminants every five years. MTBE is currently on EPA's UCM "List 1". There are total of 12 contaminants on List 1; however, aside from MTBE, there are no other gasoline related substances. The List 1 contaminants are those for which analytical methods exist.

State of Washington Group A and B Water Systems

Under Washington Law[32], Group "A" public water systems are those that serve 15 or more residential connections or 25 people/day for 60 or more days/yr. Under Group A, there are

[29] You were not required to test for lead additives prior to the 2001 Ecology Model Toxics Control Act rule revisions (Chapter 173-340-WAC).
[30] EPA 8021, 8260 or Washington Method TPH-Gx.

[31] EPA uses the Unregulated Contaminant Monitoring (UCM) program to collect data for contaminants suspected to be present in drinking water, but that do not have health-based standards set under the Safe Drinking Water Act (SDWA). Every five years EPA reviews the list of contaminants, largely based on the Contaminant Candidate List.

[32] Chapter 246-290 WAC; Compliance Requirements for Group B Water System Fact Sheet, DOH PUB #331-282, Jan-06.

"community", "noncommunity", "nontranisent" and "transient" water systems. The two variables for all of these systems are: 1) number of people served, and 2) time or duration served. Each water system is grouped or defined by these two variables.

In addition to Group A water systems, there are Group B systems. Group B systems serve less than 15 residential connections and less than 25 people/day; or, 25 or more people/day during fewer than 60 days/yr.

How Many People Use Group A or B Water Systems?

According to the Washington Department of Health, (DOH) Drinking Water Division, approximately 5 million of Washington's 6 million residents obtain their drinking water from a Group A or B water system[33]. Another million residents are served by about 340,000 private sources such as wells, which are not subject to state or federal drinking water regulations.

Table 1: Number of Washington Group A and B Water Systems.

Group A Water Systems	Number
Community	2,265
Transient Non-Community	1,548
Non-Transient Non-Community	327
Total Group A	4,140
Group B Water Systems	13,040
Total Group A and B	17,180

Source: WDOH Drinking Water Division

(30-Mar-06).

Group A Water Systems and Monitoring Requirements

All Group A water systems must comply with the federal Safe Drinking Water Act (SDWA). The Safe Drinking Water Act (SDWA) was originally passed by Congress in 1974 to protect public health by regulating the nation's public drinking water supply. The law was amended in 1986 and 1996 and requires many actions to protect drinking water and its sources: rivers, lakes, reservoirs, springs, and ground water wells. All Group A water purveyors are required to monitor their water systems for the 53 organic substances specified in 40 CFR 141.24. Of these 53, there are only a few substances that are gasoline related; for example, benzene, toluene, ethyl benzene and xylene (total).

[33] The Office of Drinking Water Fact Sheet, DOH PUB #331-287, March, 2005

Group B Water Systems and Monitoring Requirements

The federal Safe Drinking Water Act (SDWA) does not apply to private wells that serve fewer than 25 individuals. Under Washington state law[34], Group B water systems that serve 2 to 14 connections are not subject to the federal Safe Drinking Water Act. Instead, they must meet state and local requirements for water quality and operations. Under Washington law, Group B systems must be sampled, every 12 months, for bacteria, nitrate and other contaminants, for example, treated systems, and so on. Group B systems are not required to test for volatile organic compounds (VOCs).

EPA Method 524.2

EPA Method 524.2[35] is the method that is routinely used to quantify volatile organic compounds (VOCs) in drinking water. MTBE is one of the target analytes[36] for EPA Method 524.2; however, MTBE is also an "unregulated contaminant", under both state and federal law. Specifically, there is no Maximum Contaminant Level (MCL) for MTBE. MTBE is currently listed on EPA's Contaminant Candidate List[37]. However, what that means is that MTBE may occur in drinking water, and future action may be taken to account for this. Consequently, when labs analyze water samples, they may or may not analyze and report MTBE levels. If requested, MTBE can be tentatively identified as a "TIC" or "tentatively identified compound"; however, additional analysis would be needed to confirm. In addition to MTBE, EPA 524.2 will not detect gasoline-related ethers or alcohols that may be present as an oxygenate or blending additive (Table 2).

Key Point – Laboratory "TICs" and MTBE

Most contract labs will not identify "TICs" unless specifically asked or told to do so. If you use EPA 524.2 to analyze for MTBE, then the lab may identify it as a "tentatively identified compound" or "TIC". However, if you do not ask the lab to identify all TICs, then chances are, they won't. Lastly, as previously discussed, aside from MTBE, there's a number of other ethers, alcohols and oxygenates that may be present in gasoline. Most of these are not on the EPA 524.2 target analyte list (that is TBA, TAME, DIPE, and so on). In summary, always check with the lab when analyzing for MTBE, as well as other ethers and alcohols.

Note: see also Appendix D – EPA Fact Sheet on Analytical Methods for Oxygenates, p. 121.

[34] WAC 246-291
[35] Purgeable Organic Compounds by Capillary Column GC/Mass Spectrometry.
[36] EPA Method 524.2, Rev. 4.1, 1995
[37] March 2, 1998, as required by the Safe Drinking Water Act.

Table 2: EPA Method 524.2 Gasoline Related Target Analytes.

524.2 Target Analytes	Not a Target Analyte	Might Be a Target
Benzene	**DIPE	**MTBE
***1,2-Dichloroethane (DCA)**	**ETBE	
***Ethylene Dibromide (EDB)**	**Ethanol	
Ethyl Benzene	**Methanol	
Naphthalene	**TAME	
Toluene	**TBA	
****TMB-isomers**	n-Hexane	
m,p,-Xylene	1-methylnaphthalene	
o-Xylene	2-methylnaphthalene	

* Leaded gasoline additives – 1,2-dibromoethane (EDB); 1,2-dichloroethane (DCA).
**Gasoline oxygenate – see Table 66, p. 119. Note: MTBE is on the 524.2 Rev. 4.1 target list; however, it's also an "unregulated" contaminant. Therefore, labs may not always quantify MTBE.
*** Trimehtylbenzene (TMB) isomers - 1,2,3-TMB, 1,2,4-TMB and 1,3,5-TMB.

Study Methods

Geographic Information System (GIS) tools were used to map and locate both LUST and public water supply well sites. A synopsis of the steps and methods used in this study is provided in this section.

Step 1: Identify Active LUST Sites

A list of "active" LUST sites was obtained from Ecology's Toxics Cleanup Program Integrated Site Information Systems (ISIS) data base. This data query resulted in a list of 1,915 sites (November, 2005). The term "active" means that the cleanup has yet to be completed. For example, some sites may have replaced leaking fuel tanks or removed contaminated soil. Others may be in long term ground water monitoring. Lastly, at some sites, no cleanup has been done.

Step 2: Identify High Susceptibility Wells

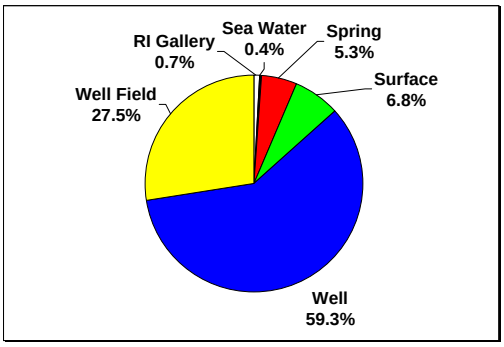
The public water supply well layer[38] was brought into ArcGIS[39]. This layer contains records and locations for 20,184 Washington public water supply wells[40]. Of these 20,184 water

[38] Steve Leibenguth, DOH, (360)236-3148.
[39] Geographic Information Systems, Version 9.1.
[40] Group A and B.

supply wells, 1,581 (8%) have been rated as "high susceptibility" wells. The "high susceptibility" well criteria was developed and defined by the Washington Department of Health (DOH), Drinking Water Division. In April, 1995, the DOH Drinking Water Division published guidelines on wellhead protection[41]. Within this wellhead protection guidance are guidelines on how to determine high susceptibility wells. Specifically, a susceptibility assessment form (or checklist), was used to identify high susceptibility wells.

The water sources for these 1,581 wells include ground water (from wells and well fields), springs, seawater and surface water (Figure 6).

Figure 7: High Susceptibility Source Types (Source: DOH Drinking Water)



Step 3: Input Data to GIS

ArcGIS (Version 9.2) was used to locate the 1,915 active LUST sites and 1,581 high susceptibility wells. The "select by location" function was used to identify LUST sites that are within one mile of a high susceptibility well.

Study Results

Q: How many LUST sites are located < or = 1-mile of a "high susceptibility" well? A: There are 368 LUST sites located within one mile of a high susceptibility well; 6 are located within 1/16 of a mile (Figure 7, Table 3).

[41] Well Head Protection Guidance Document, April, 1995. Washington Department of Health, Drinking Water Division (Publication #331-018).

Figure 8: LUST Sites Within 1-Mile of a High Susceptibility Well.

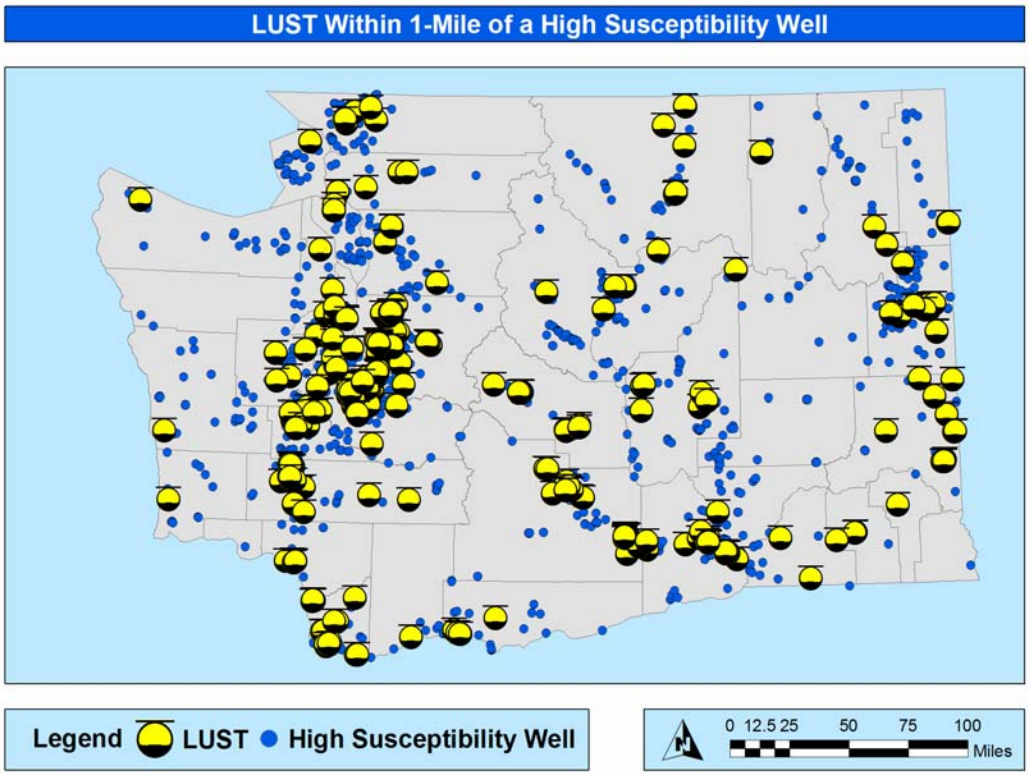
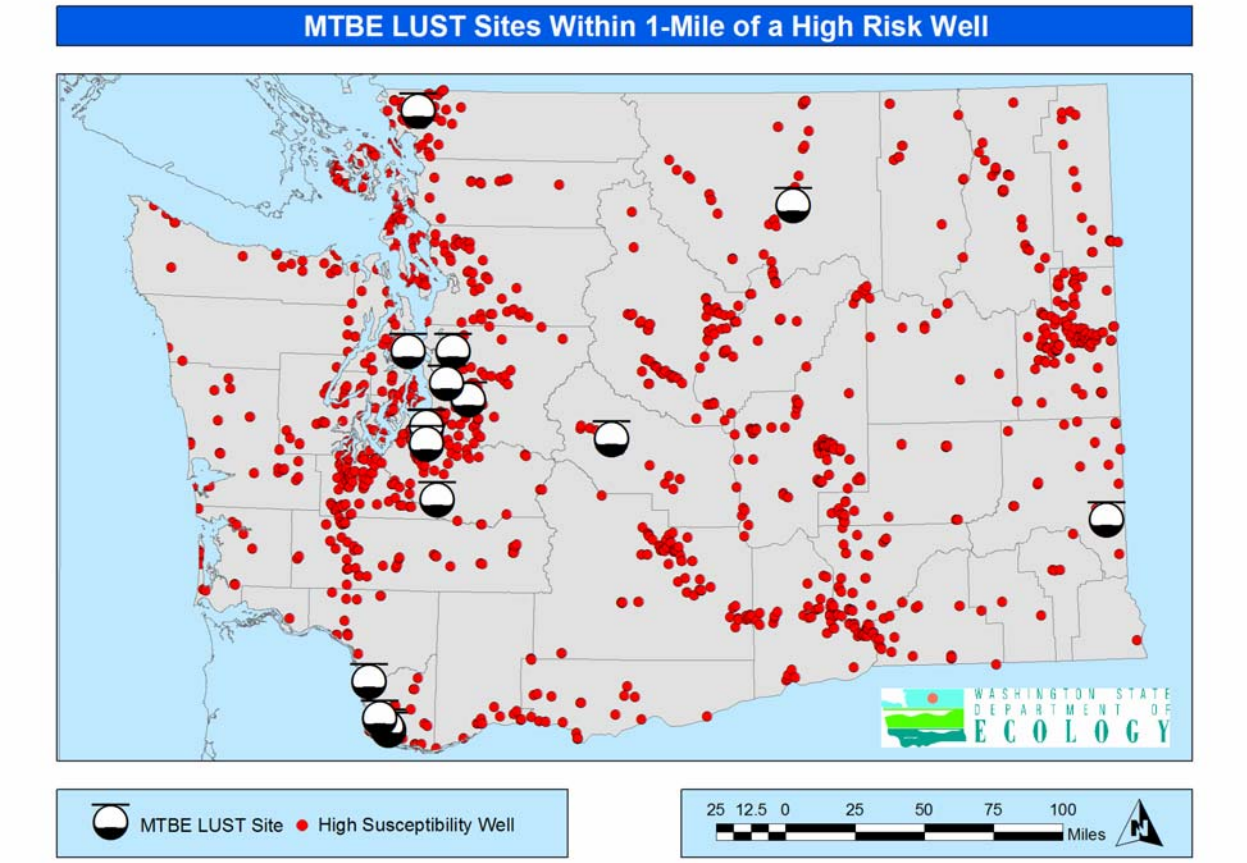


Table 3: Number of LUSTs Near *High Susceptibility* Wells.

Distance to *High Susceptibility* Well (Miles)	Number Of Active LUSTs
1	368
¾	265
½	160
¼	64
1/8	26
1/16	6

Q: How many MTBE LUST sites are located < or = 1-mile of a "high susceptibility" well? A: 15 MTBE LUST sites are within 1-mile of a high susceptibility well (Figure 9; see also Appendix B – MTBE LUST Site Information, p. 111) .

Figure 9: MTBE LUST Sites Within 1-Mile of a High Susceptibility Well.



Q: How may LUST sites are located < or = 1-mile of any well? A: There are 1,040 LUST sites located within one mile of *any*[42] well; 30 are located within 1/16 of a mile (Table 4; Figure 10).

Figure 10: LUST Sites Within 1-Mile of Any Well.

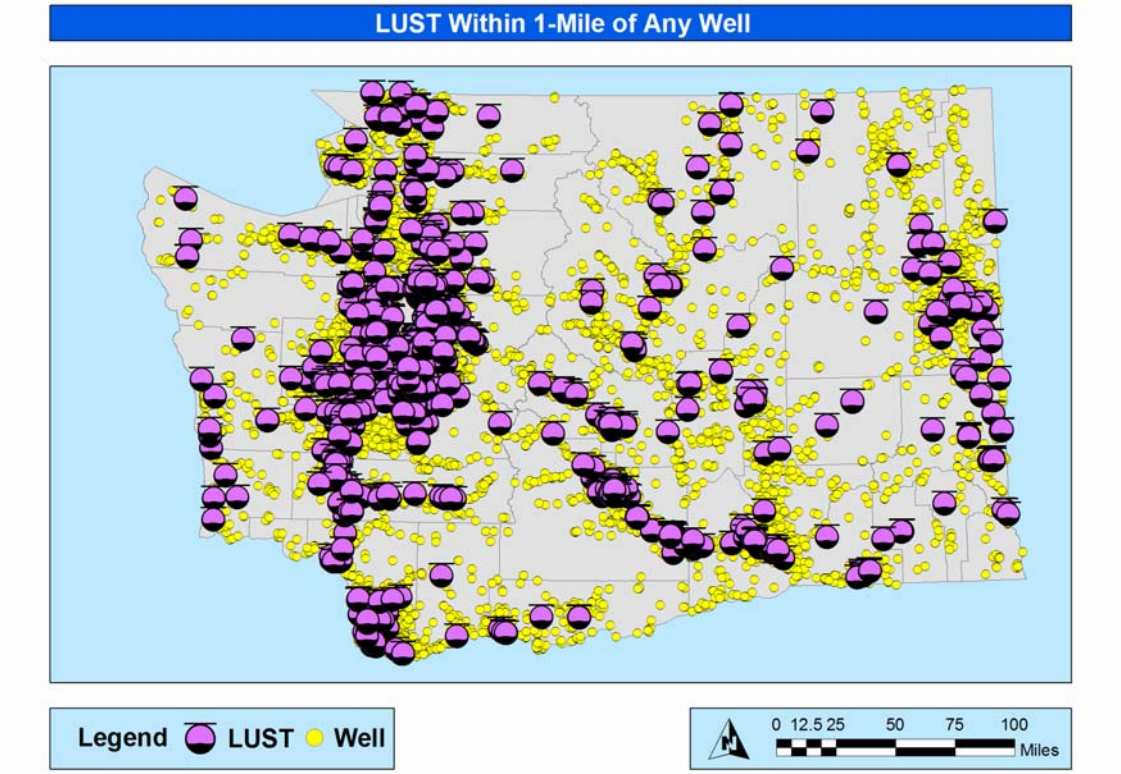


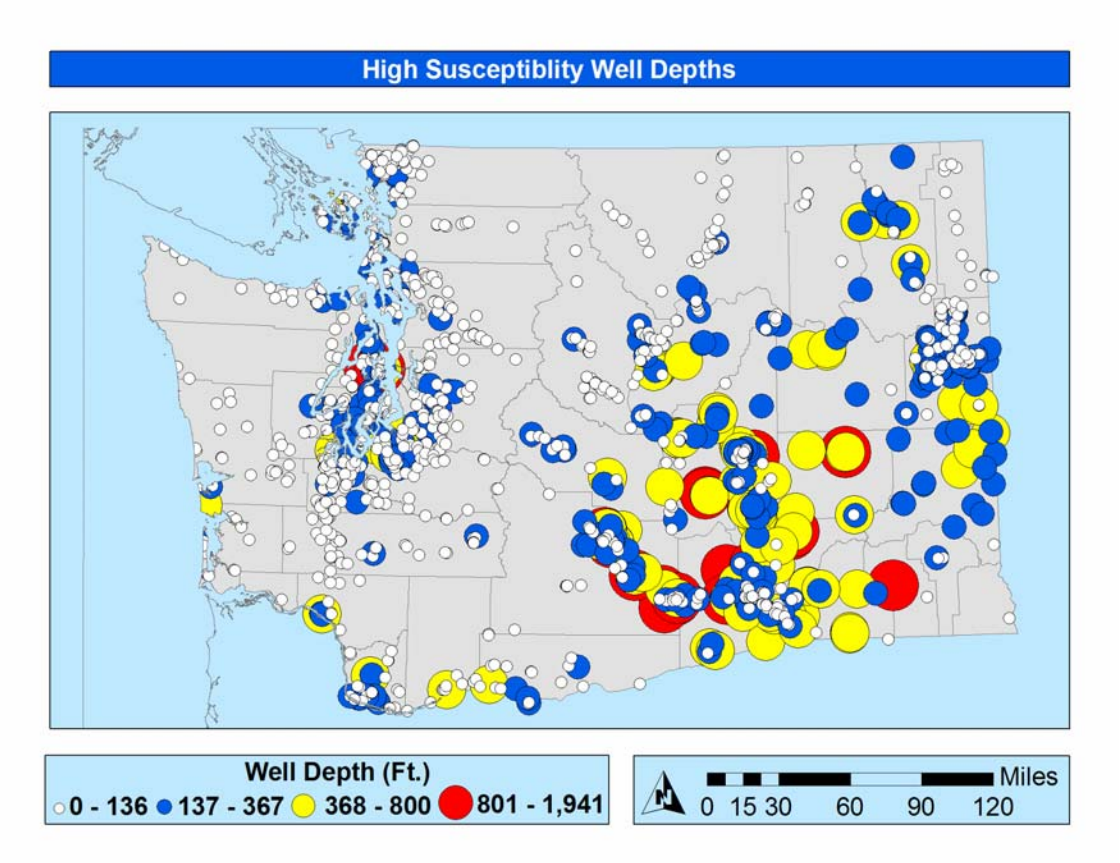
Table 4: Number of LUSTS Near *Any* Well.

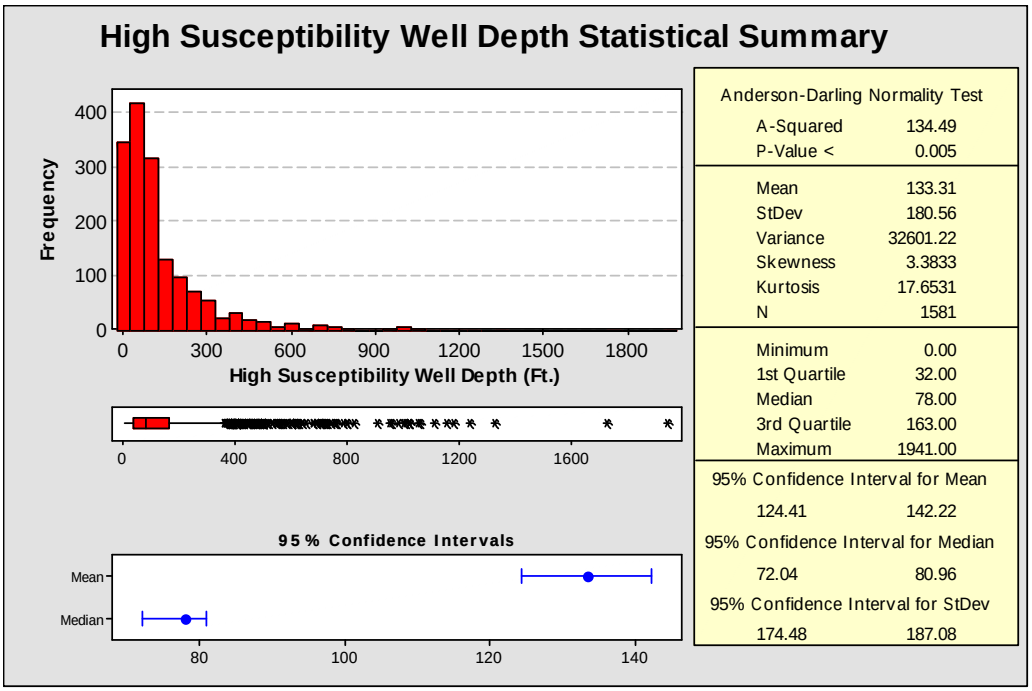
Distance to ***Any*** Well (Miles)	Number of Active LUSTs
1	1,040
¾	860
½	615
¼	275
1/8	120
1/16	30

[42] At the time of this publication, there were 20,184 well locations in Ecology's GIS layer for Department of Health (DOH) wells. This layer includes low, medium and high susceptibility wells, as well as all Group A and B wells.

Q***: What is the average high susceptibility well depth?*** A: The mean high susceptibility well depth was 133 ft. (Figure 11).

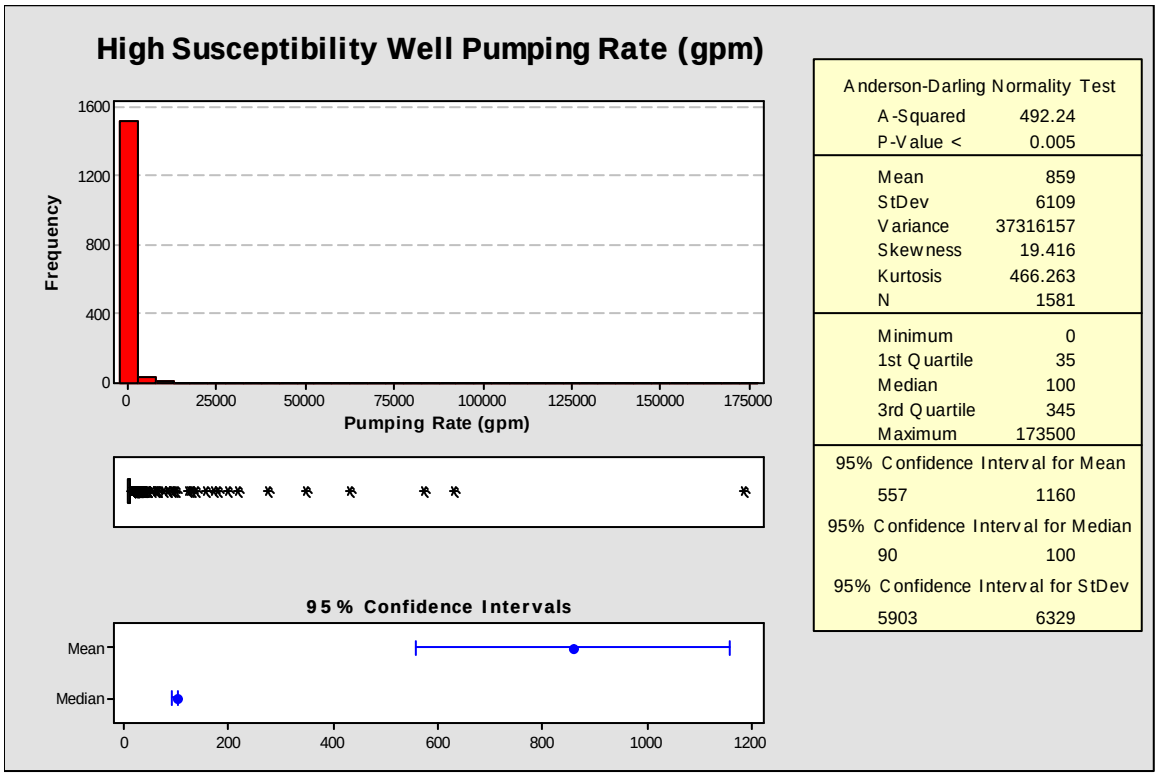
Figure 11: High Susceptibility Well Depths.





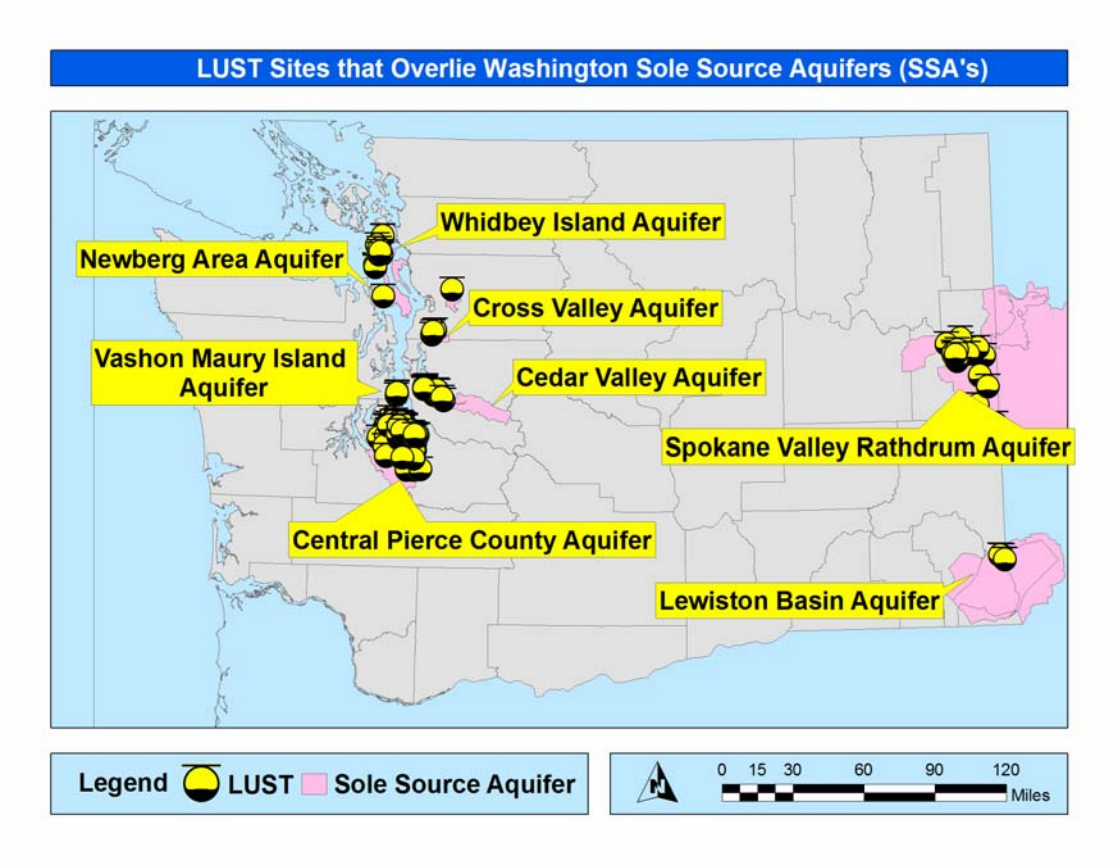
Q: What is the average high susceptibility well pumping rate? A: The mean high susceptibility well pumping rate was 859 gpm (Figure 12).

Figure 12: High Susceptibility Well Pumping Rates.



Q: How many LUST sites overlie Washington Sole Source Aquifer[43] (SSA) areas? A: 221 active LUST sites overlie designated Washington sole source aquifer areas (Figure 13).

Figure 13: LUST Sites that Overlie Washington Sole Source Aquifers (SSAs).



Q: What is the average population that is served by a high risk well? The average population that is served by high risk well was 1,557 (Table 5).

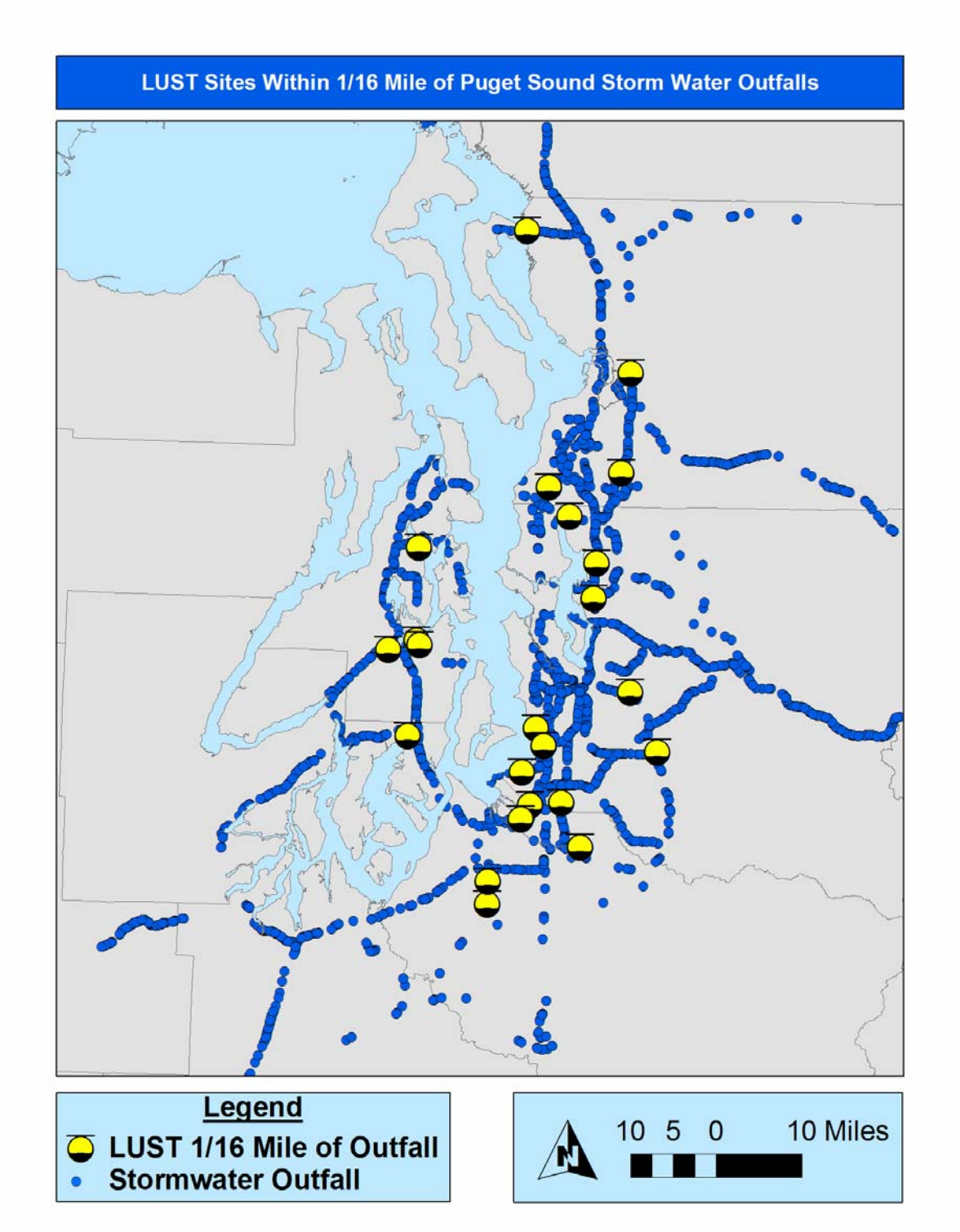
Table 5: High Susceptibility Well Population Statistics.

	Population
25th Percentile	141
Mean	1,557
Median	461
75th Percentile	2,216
Max	628,000

[43] The Sole Source Aquifer (SSA) Protection Program is authorized by Section 1424(e) of the Safe Drinking Water Act of 1974 (Public Law 93-523, 42 U.S.C. 300 et. Seq.).

Q: How many LUST sites are located near Puget Sound stormwater drains? A: 30 of 1,915 (1.5%) LUST sites are within 1/16 mile (330 ft.) of a Puget Sound stormwater drain (Figure 14).

Figure 14: LUST Within 1/16 Mile of a Puget Sound Storm Water Drain.



Discussion

Given the results of this study, the next question is this: what risks do LUST sites pose on water supply wells? Is there a way to forecast or predict current or future impacts? Here's what we know about MTBE: it tends to migrate quite rapidly off site. For example, ground water gasoline plumes (BTEX) tend to retard and biodegrade more quickly than MTBE plumes. Ether oxygenate plumes tend to be more mobile and extend further downgradient than gasoline plumes. **So here is a key point to consider: even if MTBE was not detected in the source area (that is a LUST site), it may be present off site or downgradient. Again, this is because gasoline BTEX plumes tend to retard and biodegrade more quickly than ether oxygenate plumes** (50). Consequently, if your well is located near a LUST site, then you should consider testing for MTBE (and other oxygenates). However, aside from testing, there's really no "sure" way to predict current or future impacts of LUST sites on wells.

Recommendations

Based on the results of this study, it is recommended that the following action be taken:

1. Prioritize LUST site cleanups, per the results of this study. Specifically, this study identified ten Washington cities (Auburn, Battle Ground, Centralia, Lakewood-South Tacoma, Omak, Renton, Richland, Spokane, Tumwater and Yakima) with LUST site "clusters" and highly susceptible well fields. LUST site cleanups for these 10 cities should be a priority.

2. Test water systems for MTBE and other gasoline oxygenates (for example, TBA, and so on).

3. Incorporate or use GIS in Ecology's Site Hazard Assessments[44] and Washington Ranking Method (WARM) model.

Priority Areas

Based on the results of this study, a "top ten" list of priority areas was identified. These ten areas are Washington cities with highly susceptible well fields or wells that are within one mile of LUST "clusters". A LUST "cluster" is just a group of sites that are relatively close to one another (that is less than one mile apart).

1. Auburn

The Auburn Water Division operates two high susceptibility wells (#2 & #6) that are within one mile of 11 LUST sites (Figure 17, p. 42; Table 9, p. 43). These two Group A

[44] WAC 173-340-320

community wells are 238-242 ft. deep with a reported pumping capacity of 3,000-3,500 gpm. They serve a population of 45,000.

2. Battle Ground

The Battle Ground Water Department operates two high susceptibility wells (#1 & #6) that are within a one-mile radius of 5 LUST sites (Figure 19, p. 46; Table 13, p. 47). These two wells are 148-400 ft. deep with a reported pumping capacity of 190-350 gpm. They serve a population of 12,958. The City of Battle Ground Well #1 is ~ 350 ft. southwest of the Battle Ground School District LUST site.

3. Centralia

The City of Centralia Utilities Department operates six high susceptibility wells that are within a one-mile radius of 10 LUST sites (Figure 20, p. 48; Table 15, p. 49). These six Group A community wells (Eshom, Borst #1 & #2, Riverside, K St. and Washington) are 65-93 ft. deep with a reported pumping capacity of 700-1,200 gpm (Table 16, p. 49). They serve a population of 14,000.

4. Lakewood-South Tacoma

The City of Tacoma Well #10C is ~ ½ mile east of the South Tacoma 76 LUST site (Figure 25, p. 58;Table 25, p. 59). Well #10C (Group A Community) is 83 ft. deep, with a reported pumping capacity of 1,400 gpm. This well serves a population of 301,800. Within this same area, there are a total of 12 LUST sites within a one-mile radius of eight high susceptibility wells, including Well #10C.

5. Omak

The City of Omak operates six high susceptibility wells that are within a one-mile radius of three LUST sites (Figure 29, p. 67; Table 33, p. 68). These six wells (Apple, Eastside, Kenwood, Okoma, OWP and Park) are 20-90 ft. deep, with a reported pumping capacity of 250-2,800 gpm. These are Group A community wells that serves a population of 4,705.

The Omak Gull (#611) station LUST site is ~ 600 ft. northeast of the City of Omak Okoma Well (90 ft. deep @ 500 gpm). The Omak Chevron LUST site is ~ 1,000 ft. northeast of the City of Omak Apple Well (20 ft. deep @ 480 gpm).

6. Renton

The City of Renton operates three highly susceptible wells (Group A Community) that are located ~ 130 ft. east of the Cedar River (Figure 34, p. 77). These three wells are 50-57 ft.

deep, with a reported pumping capacity @ 2,200 gpm. These three wells also serve a population of 54,500.

There are 20 active LUST sites within a one-mile radius of these wells (Table 43, p. 78). Approximately 15 of these 20 (75%) LUST sites are located within the calculated year 10-yr time of travel well head protection zone. On the east side of the Cedar River, the closet LUST site is the Renton Eagle Mart (ARCO #5207), which is ~ 2,300 ft. northwest.

7. Richland

The City of Richland operates eight high susceptibility wells that are within a one-mile radius of 14 LUST sites (Figure 36, p. 82; Table 47, p. 83). These eight Group A community wells are 56-386 ft. deep, with a reported pumping capacity of 224-2,803 gpm. They serve a population of 43,520.

8. Spokane

The City of Spokane Nevada St., Grace Ave., and Park Water wells are ~ 750 ft. east of the Water Yards LUST site (Figure 37, p. 85; Table 49, p. 86). These three Group A community wells are 122-126 ft. deep, with a reported pumping capacity of 19,000-62,500 gpm. They serve a population of 204,500.

9. Tumwater

The City of Tumwater operates three high susceptibility wells (Airport Wells #9, #10, #15) that are located approximately ~ 330 ft. east of the Equillon bulk fuel depot (Figure 40, p. 91). The three airport wells are 99-145 ft. deep, with a reported pumping capacity of 375-485 gpm (Table 56, p. 92). Within Tumwater, there are also three LUST sites within one mile of the City of Palermo Well Field wells. All of the City of Tumwater high susceptibility wells are Group A Community and they serve a population of 31,500.

10. Yakima

There are 16 LUST sites within 1 mile of 10 high susceptibility wells (Figure 42, p. 95; Table 60, p. 97).

Table 6: LUST Sites Near Washington Cities With High Susceptibility Well Fields.

Location	Population	Number of LUST	Number of High Susceptibility Wells	Well Depths (ft.)	Well Pumping Rate (gpm)
Arlington	12,647	2	3	0-40	850-150
Auburn	45,000	11	2	238-242	3,000-3,500
Bainbridge Island	5,750	2	2	380-1,053	100-288
Battle Ground	12,958	5	2	148-400	190-350
Centralia	14,000	10	6	65-93	700-1,200
Chehalis	7,100	7	1	0	2,300
Chelan	6,170	3	1	0	4,375
Cle Elum	1,820	5	2	0-21	300-1,000
Fife	26,155	7	1	687	250
Lakewood-South Tacoma	301,800	7	3	82-108	20-1,400
Moses Lake	19,661	4	6	0-712	80-1,900
North Bend	1,603	4	3	30-113	55-250
Oak Harbor	65	4	2	78-250	18-30
Omak	4,705	3	6	20-90	250-2,800
Oroville	2,260	4	4	32-80	500-950
Pacific	6,673	2	2	50	1,000-1,100
Pullman	20,970	6	1	160	1,200
Redmond	52,135	9	4	435-938	41-58
Renton	54,500	20	3	50-57	2,200
Republic	1,429	2	2	80-100	250-500
Richland	43,520	14	8	56-386	224-2,803
Spokane	204,500	7	10	60-130	60-62,500
Sunnyside	14,120	18	2	760-1,057	650-1,100
Tacoma (South)	301,800	6	5	79-167	2,000-8,000
Toledo	690	2	2	35-150	80-175
Tumwater	31,500	5	9	67-145	125-480
Vancouver	170,056	5	3	108-265	500-2,100
Yakima	3,805	16	9	35-1,725	20-1,500

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Information on Report Figures and Maps

Overview

The remainder of this report contains figures contain with of 28 Washington cities (Table 6, p. 35) that have high susceptibility wells near LUST sites. **There are other smaller Washington cities or areas with high susceptibility wells that are located near LUST sites. However, it wasn't practicable or possible to publish maps of each and every area.** Thus, the decision was made to only publish maps of major Washington cities or urban areas.

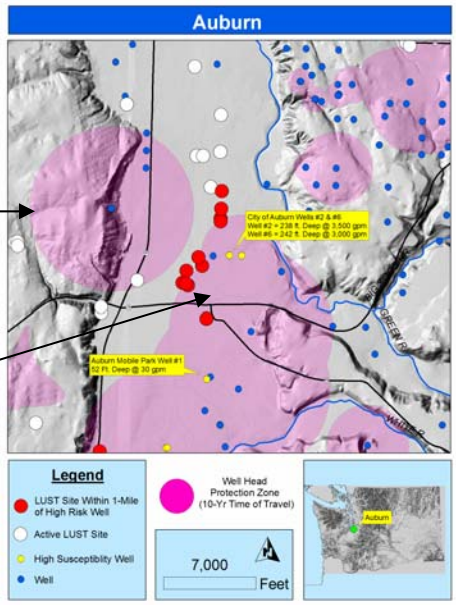
Maps

Each map has a LIDAR[45] (light detection and ranging) base layer that depicts surface topography. Major Washington rivers, roads and highways are also shown. The pink-shaded areas on each map are 10-year time of travel well head protection zones (WPZ). The 10-yr WPZ's were developed by the Washington Department of Health, Drinking Water Division (41). The yellow dots on each map mark the location of "high susceptibility" wells. These wells were deemed highly susceptible by their owners/operators, per the Washington Department of Health (DOH) wellhead protection guidance (41). The blue dots on each map mark the location of Group A or B water wells. Please note that the "highly susceptible" declaration for any well is voluntary. "Blue dot" wells may in fact be "highly susceptible". The white dots on each map mark the location of active LUST sites. The red dots mark the location of LUST sites that are within one mile of a highly susceptible well.

Tables

Each of the 28 maps if followed by two tables. The first table contains decimal latitude / longitude, name and address of all LUSTs sites that are within one mile of a high susceptibility well. The second table contains decimal latitude/longitude, name, depth, pumping rate and population served for all high susceptibility wells. All decimal latitude/longitude coordinates are based on the North American Vertical Datum of 1927 (NAD_27).

Example Map



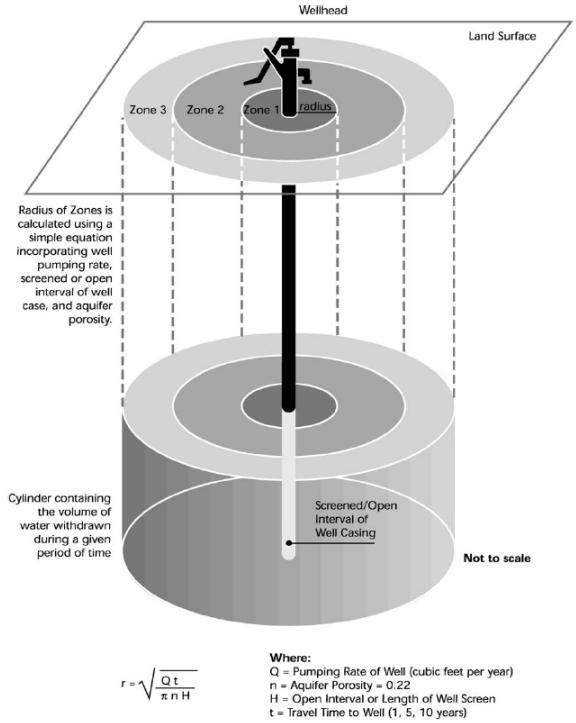
Wellhead Protection Zones

The pink shaded areas on each map denote "10-year time of travel" wellhead protection zones. ***If a LUST site is located within this zone, then it doesn't necessarily mean that the well is contaminated or will be contaminated.*** The ten year time of travel is just a theoretical calculation that is based on

[45] WA digital elevation model, 10 meter hillshade, Washington Stateplane, South Zone, HARN, feet.

the well pumping rate, well screen length and aquifer porosity.

Figure 15: Wellhead Time of Travel Calculation.

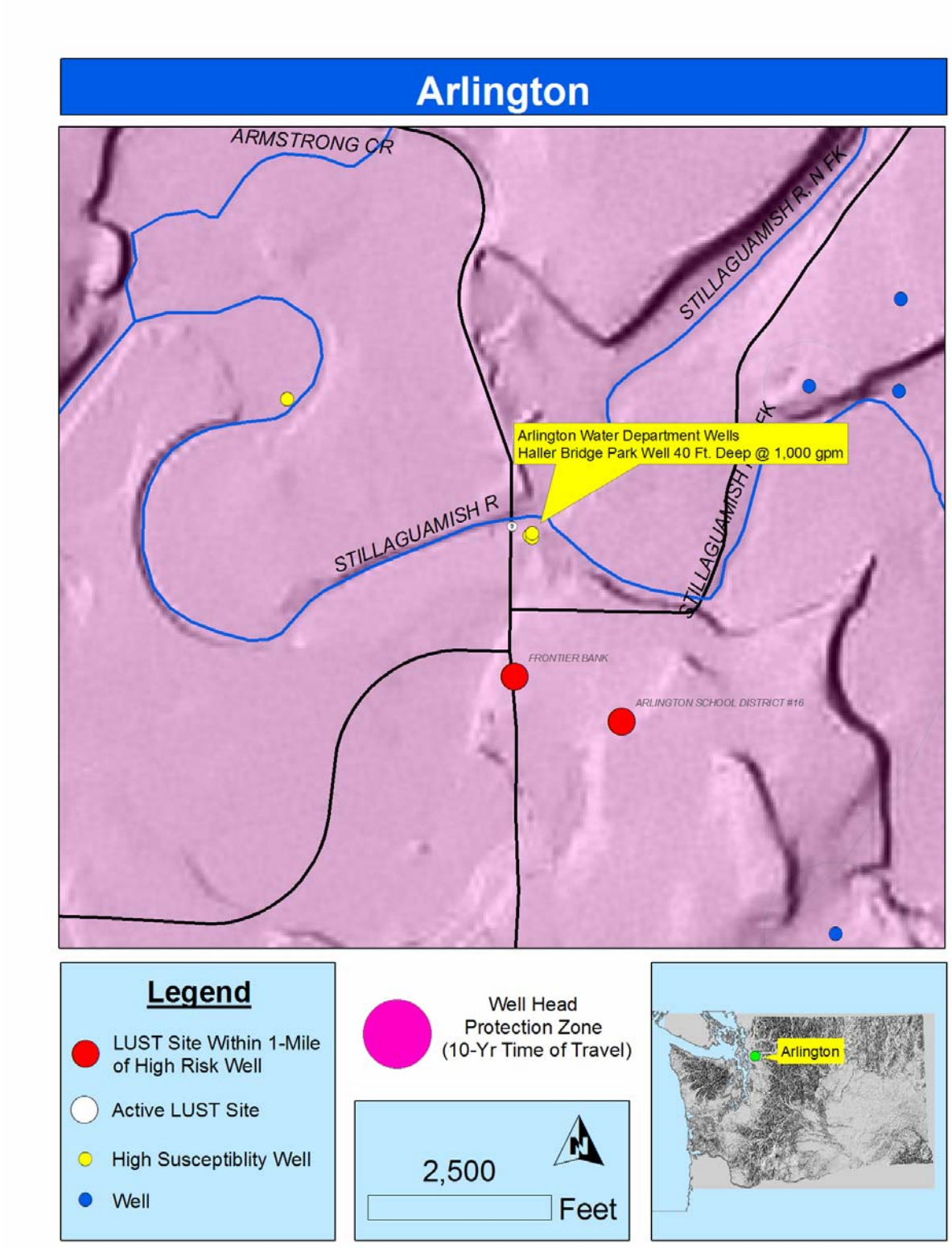


Source: Washington Dept. of Health Wellhead Protection Guidance (April, 1995). DOH Publication #331-018.

How is a Well Classified as "Highly Susceptible"?

This study used GIS methods and technology to evaluate LUST sites that are near "highly susceptible" wells. Well owners/operators may conduct a susceptibility assessment by using the form published in Appendix E of the Washington Department of Health (WDOH) Drinking Water Division Well Head Protection Guidance (Apr-95). Factors such as well depth, pumping rate, hydrogeologic environment, and so on, are used to make this classification.

Figure 16: Arlington.



Arlington

Two (2) LUST sites within 1-mile of the Arlington Water Department Haller Bridge Park Wells.

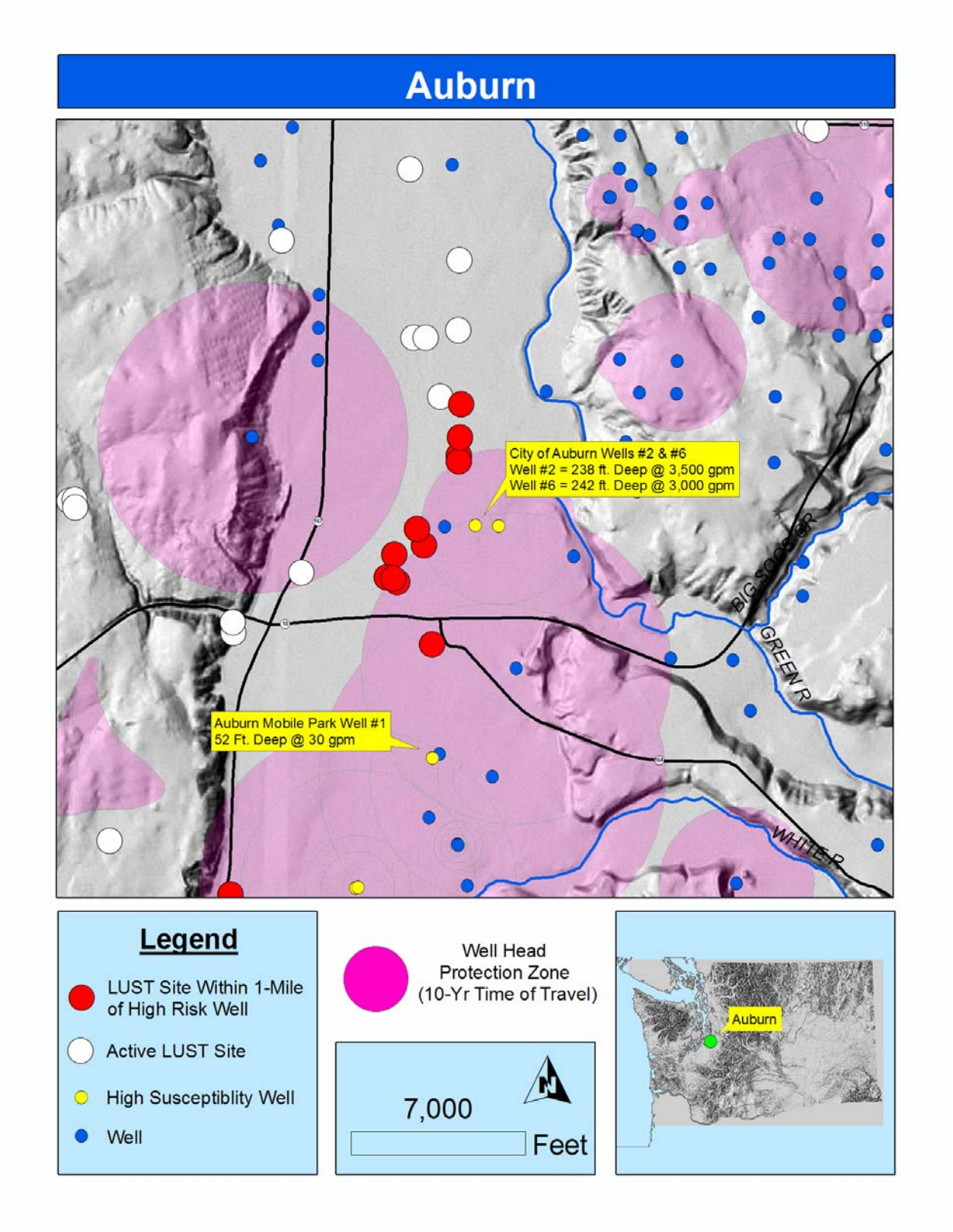
Table 7: Arlington LUST Sites.

X_Lon	Y_Lat	Lust Site	Address	Zip
-122.1278	48.1979	FRONTIER BANK	525 N OLYMPIC	982231246
-122.1218	48.1963	ARLINGTON SCHOOL DISTRICT #16	410 GIFFORD	982231277

Table 8: Arlington Water Department Wells.

X_Lon	Y_Lat	Well	Depth (ft.)	Gpm	Population
-122.1284	48.2030	GWI WELL HALLER BRIDGE PARK	40	1,000	12,647
-122.1283	48.2029	GWI WELL HALLER BRIDGE PARK	0	850	0
-122.1283	48.2031	HALLER BRIDGE PARK	40	1,050	12,647

Figure 17: Auburn.



Auburn

Eleven (11) LUST sites within 1-mile of the Auburn Water Division Wells #2 & #6.

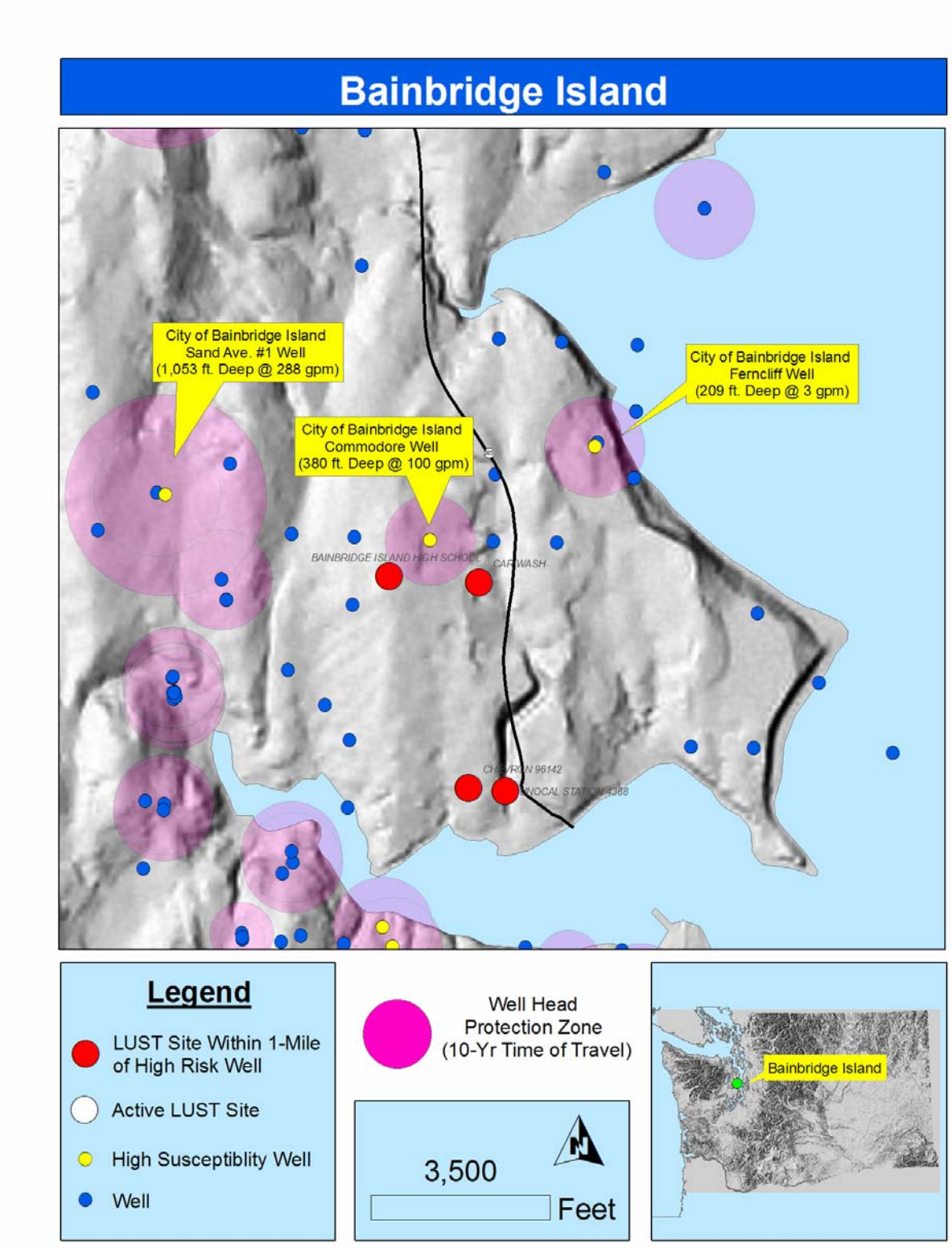
Table 9: Auburn LUST Sites.

X_Lon	Y_Lat	Lust Site	Address	Zip
-122.2214	47.3267	7-ELEVEN 2303-27219	2202 AUBURN WAY N	98002-2820
-122.2216	47.3211	ASPI DBA PDQ OIL CO #94998	1501 AUBURN WAY N	98002-3307
-122.2328	47.3076	AUBURN COLLISION CENTER	233 W MAIN ST	98001-4911
-122.2281	47.3130	AUBURN PRINT33 LS051 3RDSUB MP21.5	T21N R4EWM	98001
-122.2253	47.3004	CENEX HARVEST STATES COOPERATIVES	238 8TH SE	98002
-122.2317	47.3101	DON SMALL AND SONS OIL DISTRIBUTOR CO.	112 3RD NW	98002
-122.2215	47.3231	DOUGS AUTO ROW 76	1725 AUBURN WAY N	98002
-122.2269	47.3112	JACKPOT FOOD MART 309	415 AUBURN WAY NE	98002
-122.2216	47.3205	TEXACO STAR MART #63-232-1409	1439 AUBURN WAY N	98002
-122.2318	47.3075	V DUB CENTRAL	123 W MAIN	98001-4914
-122.2311	47.3071	WICKHAM & SONS AUTO & TRUCK REPAIR	23 A STREET SW	98002

Table 10: Auburn Water Division Wells.

X_Lon	Y_Lat	Well	Depth (ft.)	gpm	Population
-122.2162	47.3132	#2	242	3,000	45,000
-122.2200	47.3133	#6	238	3,500	45,000

Figure 18: Bainbridge Island.



Bainbridge Island

Two (2) LUST sites within 1-mile of the City of Bainbridge Island Sand Ave. # 1 and Commodore Wells.

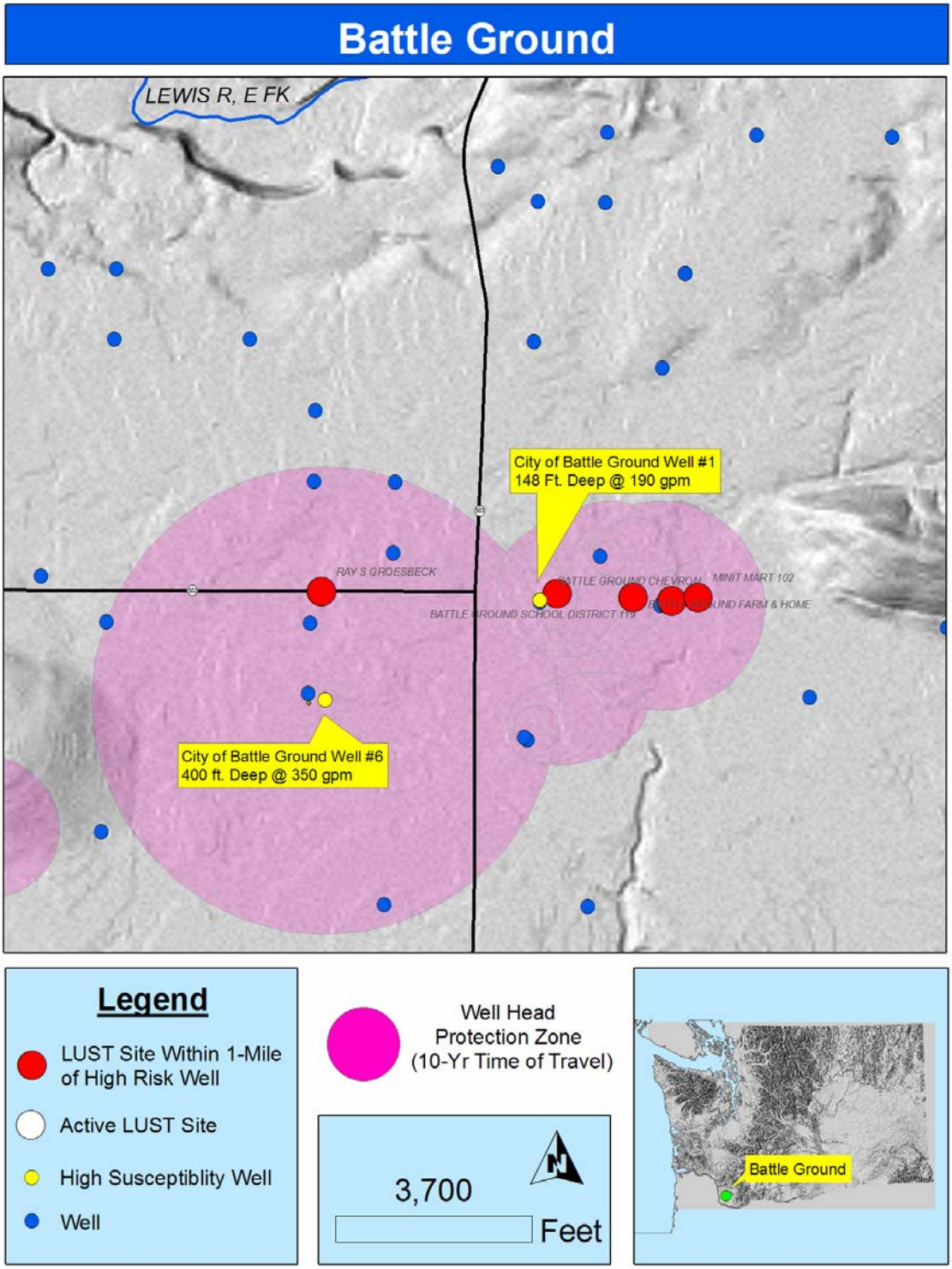
Table 11: Bainbridge Island LUST Sites.

X_long	Y_lat	Lust Site	Address	Zip
122.5239	47.6359	BAINBRIDGE ISLAND HIGH SCHOOL	9330 HIGH SCHOOL RD NE	98110-2619
-122.5168	47.6357	CAR WASH	1220 HILDEBRAND LN NE	98110

Table 12: Bainbridge Island Wells.

X_long	Y_lat	Well	Depth (ft.)	gpm	Population
122.5430	47.6398	SAND AVE. #1	1,053	288	5,750
-122.5220	47.6377	COMMODORE	380	100	5,750

Figure 19: Battle Ground.



Battle Ground

Five (5) LUST sites within 1-mile of the Battleground Water Department Wells #1 & #6.

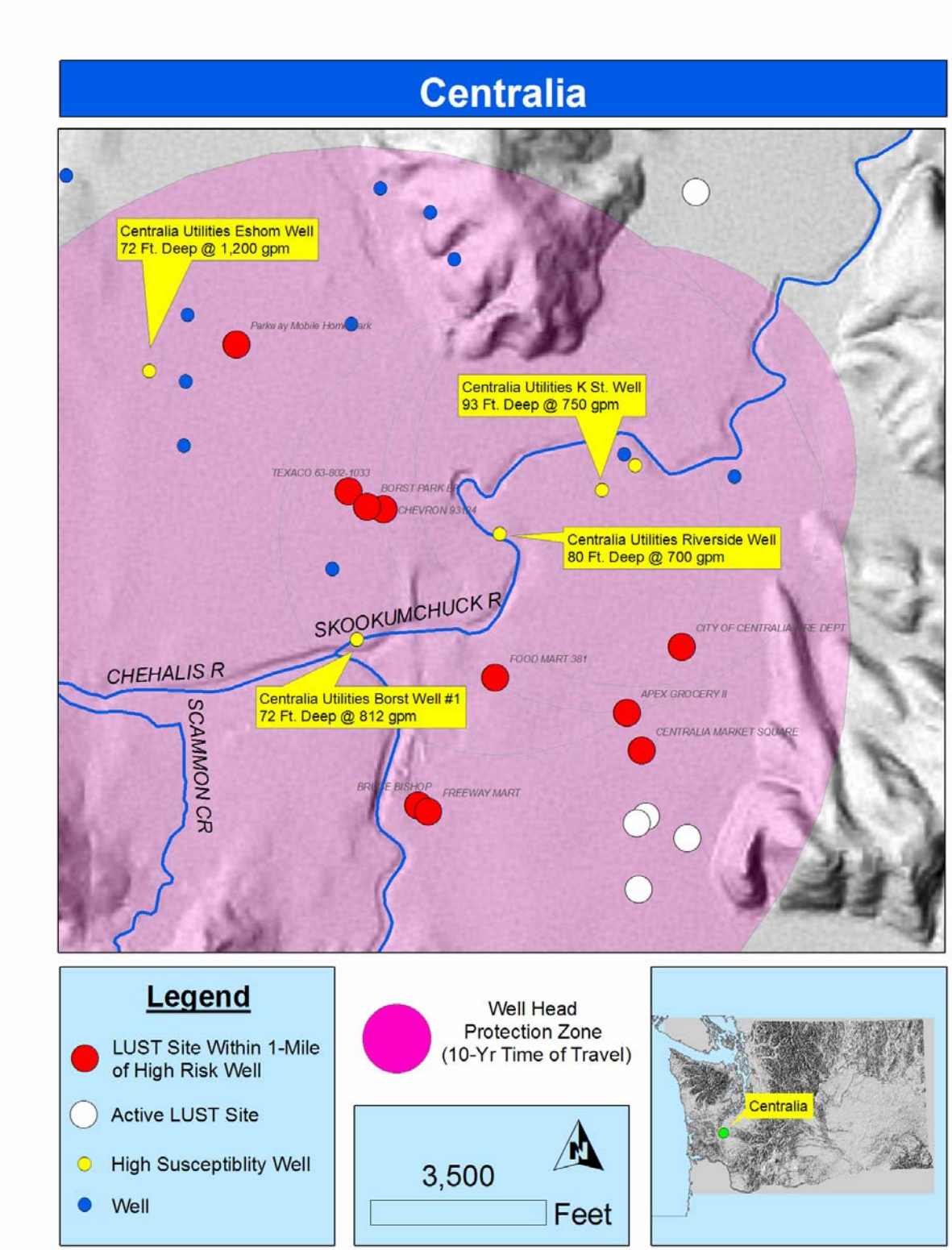
Table 13: Battle Ground LUST Sites.

X_long	Y_lat	Lust Site	Address	Zip
122.5321	45.7807	BATTLE GROUND CHEVRON	409 E MAIN	98604
-122.5350	45.7808	BATTLE GROUND FARM & HOME	210 E MAIN	98604-4516
-122.5406	45.7809	BATTLE GROUND SCHOOL DISTRICT 119	204 W MAIN ST	98604-9109
-122.5302	45.7809	MINIT MART 102	805 MAIN ST	98604
-122.5580	45.7807	RAY S GROESBECK	1912 W MAIN	98604

Table 14: Battle Ground Water Department Wells.

X_long	Y_lat	Well	Depth (ft.)	gpm	Population
-122.5431	45.7804	#1	148	190	12,958
-122.5587	45.7750	#6	400	350	12,958

Figure 20: Centralia.



Centralia

Ten (10) LUST sites within 1-mile of the Centralia Utilities Eshom, Borst #1 & #2, Riverside, K-St. and Washington Wells.

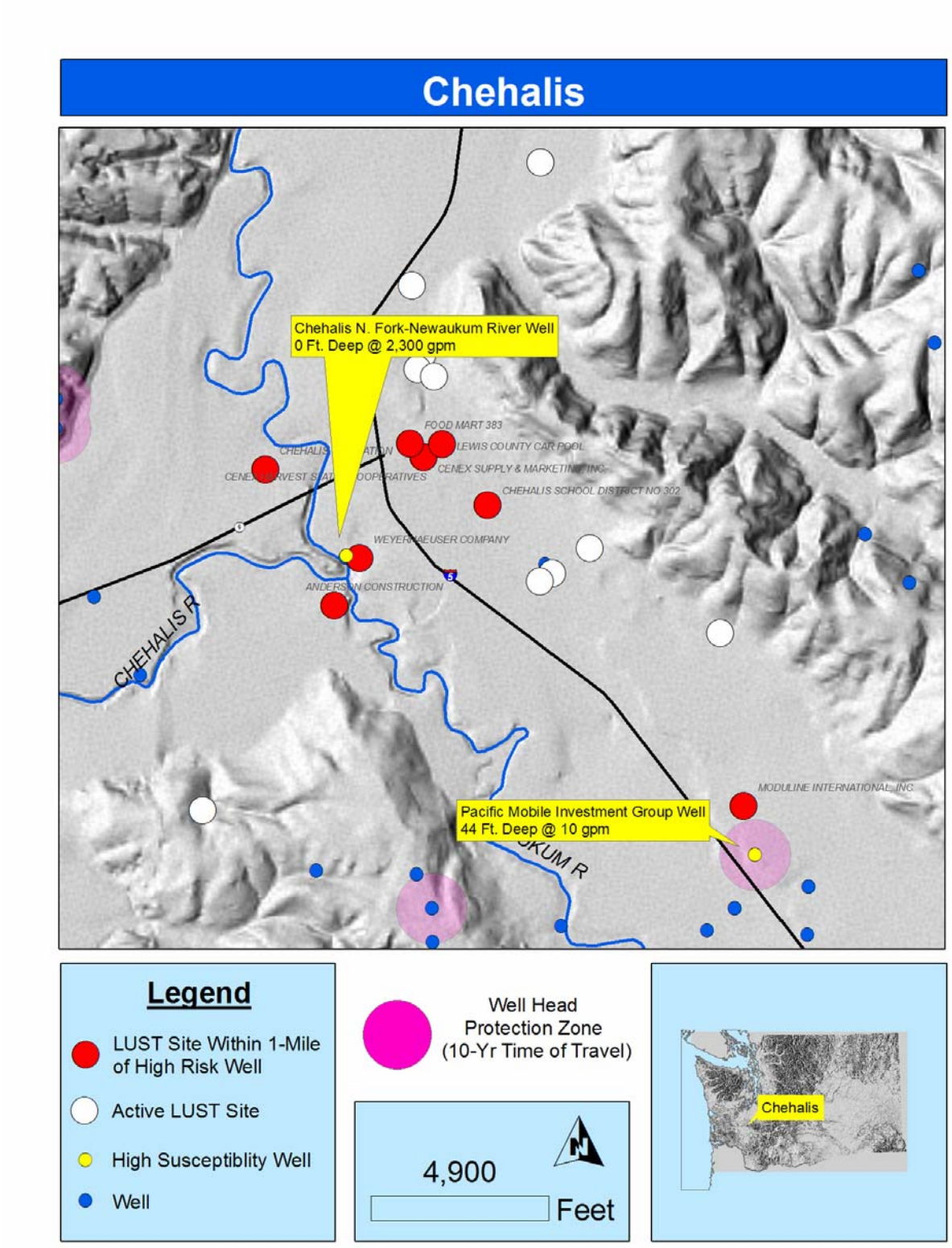
Table 15: Centralia LUST Sites.

X_long	Y_lat	Lust Site	Address	Zip
-122.9579	46.7169	APEX GROCERY II	402 W MAIN STREET	98531-4250
-122.9790	46.7277	BORST PARK BP	1010 BELMONT ST	98531-1832
-122.9742	46.7115	BRUCE BISHOP	1221 MELLEN & I-5	98571
-122.9566	46.7149	CENTRALIA MARKET SQUARE	SHOPPING CENTER	98531
-122.9537	46.7206	CITY OF CENTRALIA FIRE DEPT	512 N PEARL	98531-0609
-122.9734	46.7112	FREEWAY MART	1232 MELLEN ST	98531
-122.9898	46.7363	Parkway Mobile Home Park	1740 HARRISON AVE	98531
-122.9805	46.7285	TEXACO 63-802-1033	1111 HARRISON STREET	98531
-122.9684	46.7186	FOOD MART 381	102 HARRISON	98531-1322
-122.9777	46.7276	CHEVRON 93124	1050 HARRISON	98531

Table 16: Centralia Utilities Wells.

X_long	Y_lat	Well	Depth (ft.)	gpm	Population
122.9979	46.7345	ESHOM WW	72	1,200	14,000
-122.9808	46.7202	Borst Well #2 WW	65	1,200	14,000
-122.9807	46.7203	Borst Well #1 WW	72	812	14,000
-122.9697	46.7263	RIVERSIDE	80	700	14,000
-122.9617	46.7288	K STREET	93	750	14,000
-122.9591	46.7302	WASHINGTON	88	1,000	14,000

Figure 21: Chehalis.



Chehalis

Seven (7) LUST sites within 1-mile of the Chehalis Water Department Newaukum River Well.

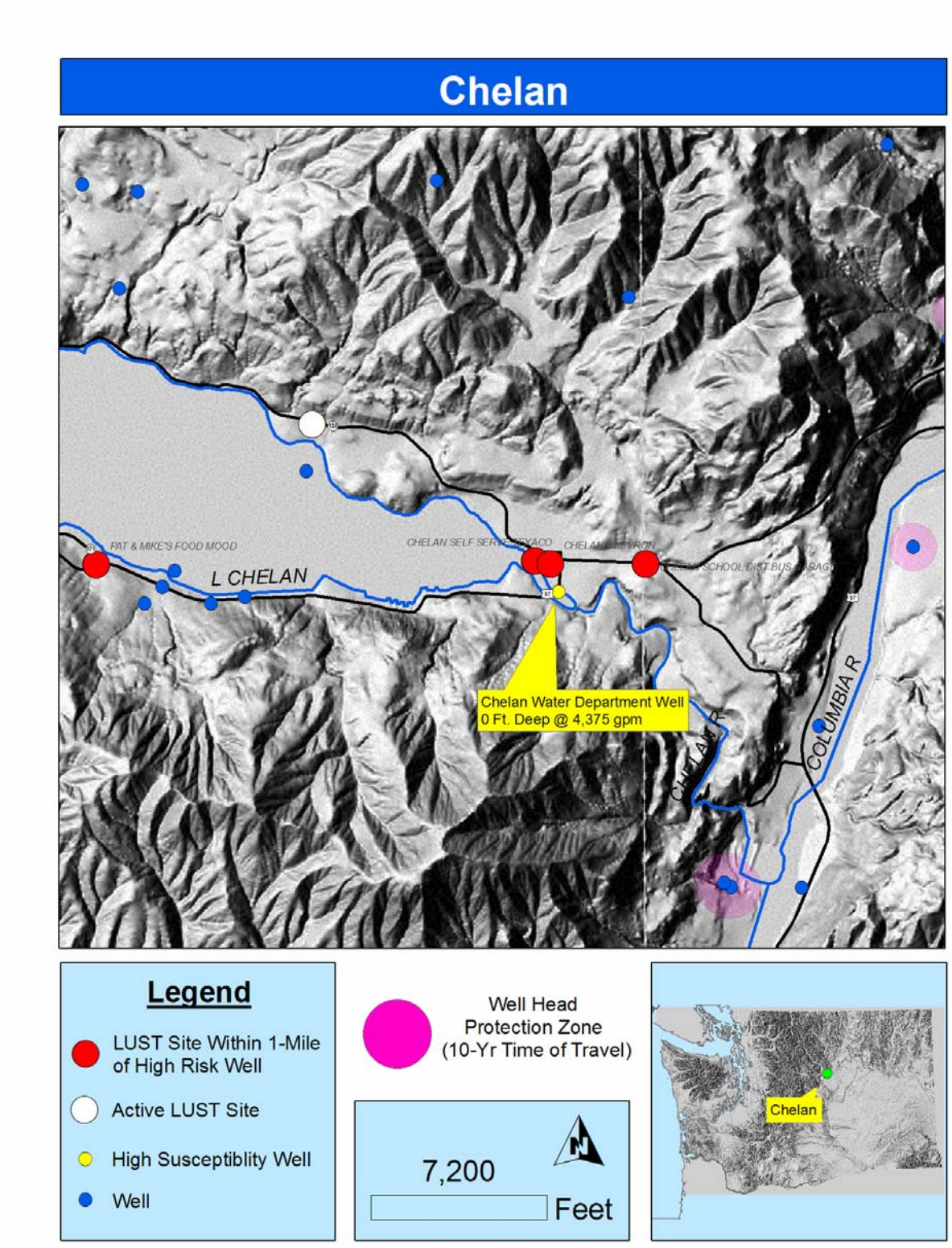
Table 17: Chehalis LUST Sites.

X_long	Y_lat	Lust Site	Address	Zip
-122.9817	46.6492	ANDERSON CONSTRUCTION	644 SHOREY RD	98532-9025
-122.9724	46.6606	CENEX SUPPLY & MARKETING, INC.	158 STATE ST	98532
-122.9897	46.6593	CHEHALIS SUBSTATION	1140 STATE HWY 603	98532-8918
-122.9652	46.6571	CHEHALIS SCHOOL DISTRICT NO 302	261 SW 3RD ST	98532-2523
-122.9739	46.6616	FOOD MART 383	614 W MAIN ST	98532-1511
-122.9704	46.6616	LEWIS COUNTY CAR POOL	476 W MAIN	98532-1920
-122.9791	46.6528	WEYERHAEUSER COMPANY	1100 SW SYLVENUS ST	98532-1113

Table 18: Chehalis Water Department Wells.

X_long	Y_lat	Well	Depth (ft.)	gpm	Population
-122.9818	46.6528	N.FORK-NEWAUKUM RIV.	0	2,300	7,100

Figure 22: Chelan.



Chelan

Three (3) LUST sites within 1-mile of the Chelan Water Department Lake Chelan Well.

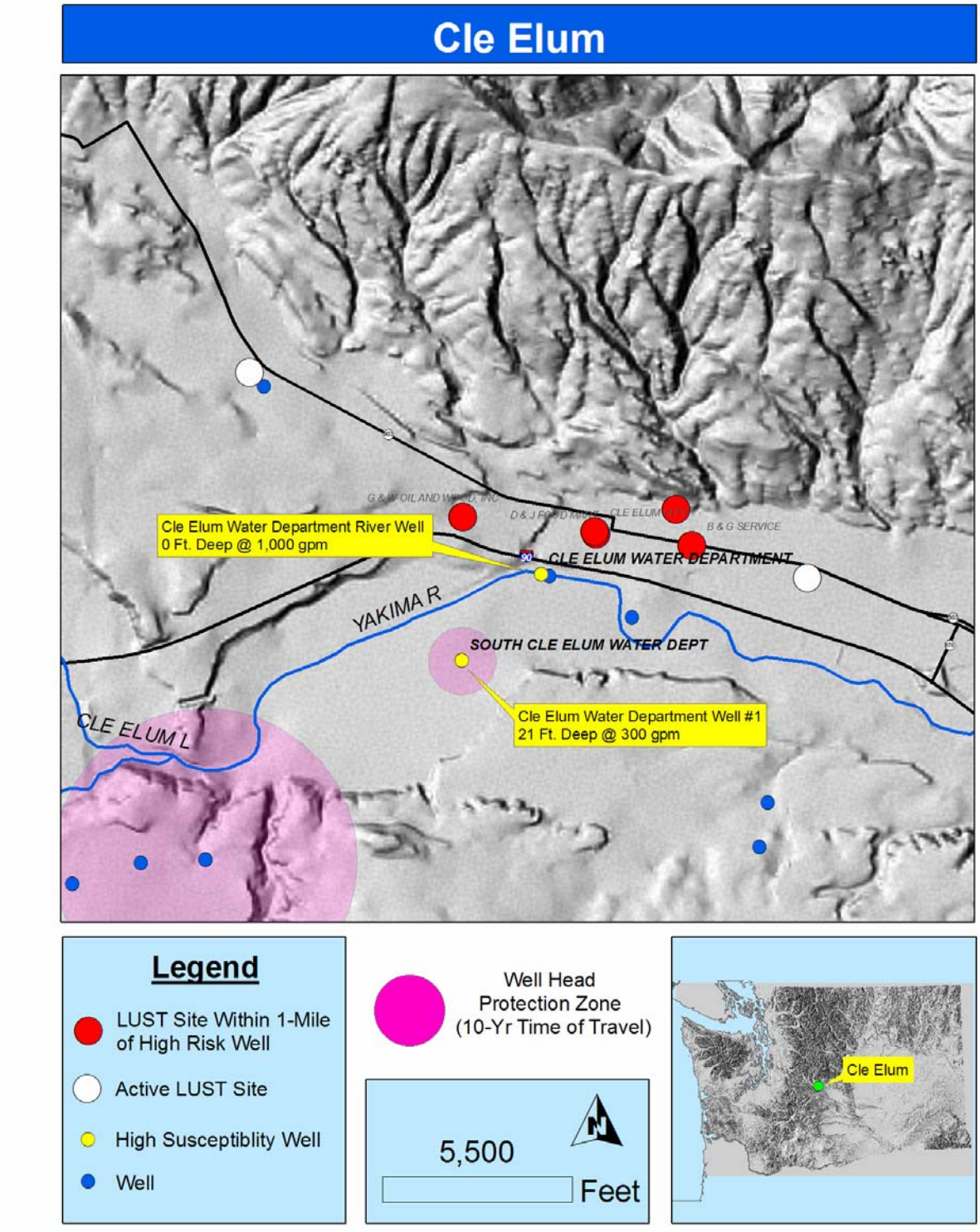
Table 19: Chelan LUST Sites.

X_Long	Y_Lat	Lust Site	Address	Zip
-120.0153	47.8396	CHELAN CHEVRON	232 E WOODIN AVE	98816
-119.9994	47.8395	CHELAN SCHOOL DIST BUS GARAGE	1055 WOODIN AVE	98816
-120.0178	47.8399	CHELAN SELF SERVE TEXACO	101 E WOODIN AVE	98816

Table 20: Chelan Water Department Wells.

X_long	Y_lat	Well	Depth (ft.)	gpm	Population
-120.0152	47.8363	Lake Chelan	0	4,375	6,170

Figure 23: Cle Elum.



Cle Elum

Five (5) LUST sites within 1-mile of the Cle Elum Water Department Cle Elum River Well and the South Cle Elum Water Department Well #1.

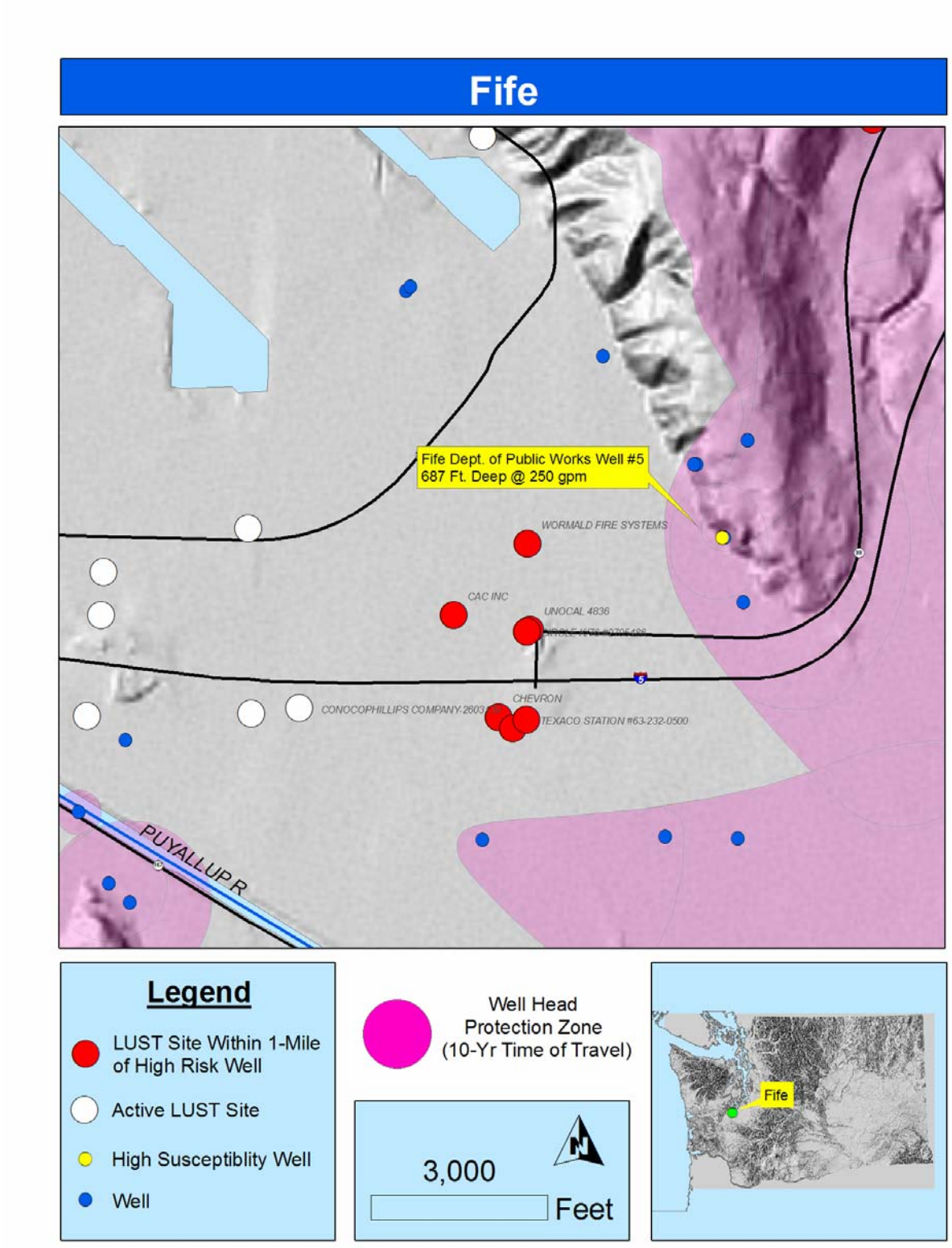
Table 21: Cle Elum LUST Sites.

X_long	Y_lat	Lust Site	Address	Zip
-120.9298	47.1940	B & G SERVICE	517 EAST FIRST STREET	98922-1256
-120.9411	47.1951	CLE ELUM CITY	202 FIRST ST W	98922
-120.9317	47.1969	CLE ELUM SHELL, INC.	207 W 1ST ST	98922
-120.9410	47.1949	D & J FOOD MART	201 W 1ST ST	98922
-120.9565	47.1962	G & W OIL AND WOOD, INC	CEMETARY RD	98922

Table 22: Cle Elum Water Department Wells.

X_long	Y_lat	Well	Depth (ft.)	gpm	Population
-120.9486	47.1915	Cle Elum River	0	1,000	1,820
-120.9577	47.1846	Well #1	21	300	566

Figure 24: Fife.



Fife

Seven (7) LUST sites within 1-mile of the Fife Department of Public Works Well #5.

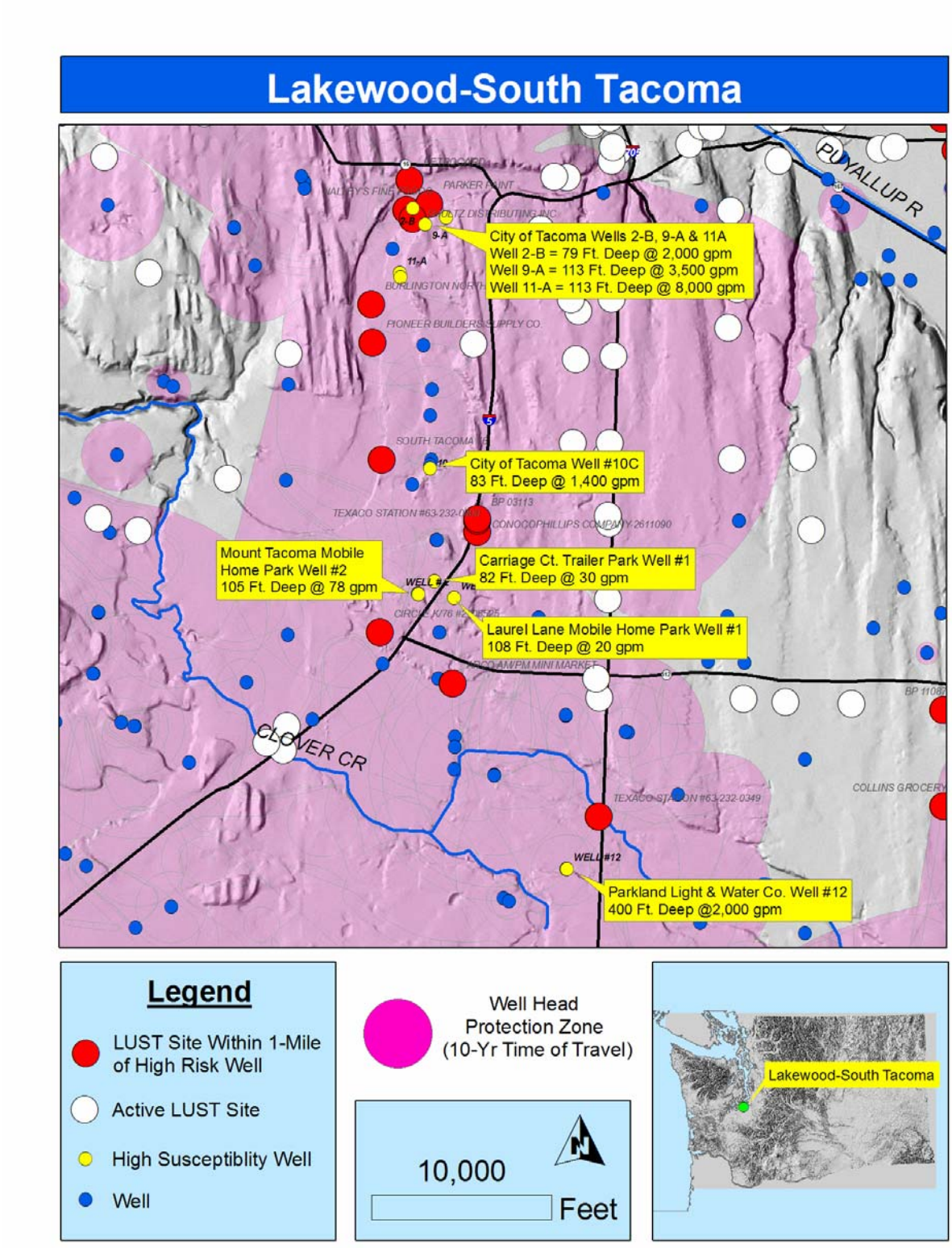
Table 23: Fife LUST Sites.

X_long	Y_lat	Lust Site	Address	Zip
-122.3615	47.2439	CAC INC	5018 PAC HWY E	98424
-122.3583	47.2392	CHEVRON	5319 20TH ST E	98424-1909
-122.3565	47.2432	CIRCLE K/76 #2705486	5405 PACIFIC HWY E	98424-2527
-122.3573	47.2387	CONOCO PHILLIPS COMPANY-2603139	2002 E 54TH	98424
-122.3564	47.2391	TEXACO STATION #63-232-0500	5501 20TH ST E	98424-2057
-122.3563	47.2433	UNOCAL 4836	2001 54TH AVE E	98422
122.3566	47.2473	WORMALD FIRE SYSTEMS	1106 54 AVE E	98424-2733

Table 24: Fife Department of Public Works Wells.

X_long	Y_lat	Well	Depth (ft.)	gpm	Population
-122.3445	47.2476	#5	687	250	26,155

Figure 25: Lakewood-South Tacoma.



Lakewood-South Tacoma

Twelve (12) LUST sites within 1-mile of the City of Tacoma Wells 2-B, 6-B, 9-A, 10-C 11-A, 12-A , Laurel Lane and Carriage Park Trailer Ct. Wells.

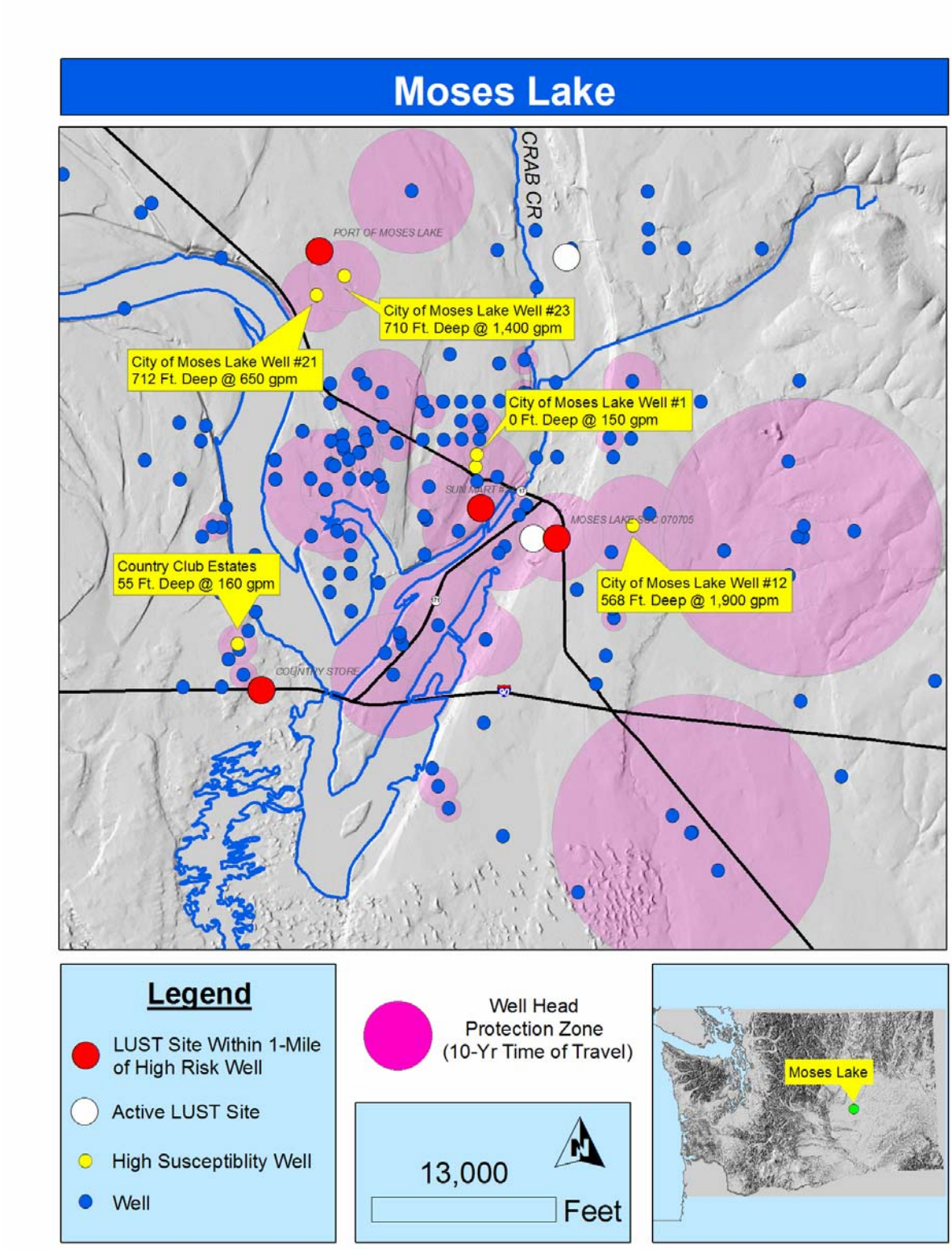
Table 25: Lakewood-South Tacoma LUST Sites.

X_long	Y_lat	Lust Site	Address	Zip
-122.4675	47.1564	ARCO AM/PM MINI MARKET	11109 STEELE ST	98444
-122.4629	47.1812	BP 03113	1830 SO 84TH	98444-3116
-122.4877	47.2136	BURLINGTON NORTHERN RAILROAD	4802 BURLINGTON WAY	98409-9999
-122.4840	47.1639	CIRCLE K/76 #2705525	10302 S TACOMA WAY	98499-4647
-122.4629	47.1815	CONOCO PHILLIPS COMPANY-2611090	8235 S HOSMER	98409
-122.4804	47.2281	NALLEY'S FINE FOODS	3303 SO. 35TH ST. PO BOX 11046	98411-0046
-122.4754	47.2291	PARKER PAINT	3003 SOUTH TACOMA WAY	98409-4711
-122.4799	47.2326	PETROCARD	3059 S LAWRENCE ST	98409
-122.4873	47.2078	PIONEER BUILDERS SUPPLY CO.	5401 S BURLINGTON WAY	98409-2701
-122.4790	47.2268	SHULTZ DISTRIBUTING INC.	3224 SOUTH TACOMA WAY	98409
-122.4845	47.1901	SOUTH TACOMA 76	7404 S TACOMA WAY	98409
-122.4628	47.1795	TEXACO STATION #63-232-0400	8433 SOUTH HOSMER	98444-1830

Table 26: Lakewood-South Tacoma Wells.

X_long	Y_lat	Well	Depth (ft.)	gpm	Population
-122.4734	47.1716	Carriage Court Trailer Park Well #1	82	30	80
-122.4750	47.1888	City of Tacoma 10-C	83	1,400	301,800
-122.4689	47.1692	Laurel Lane Mobile Home Park Well #1	108	20	75
-122.4803	47.2282	2-B	79	2,000	301,800
-122.4827	47.2177	6-B	112	4,200	301,800
-122.4828	47.2183	11-A	113	8,000	301,800
-122.4775	47.2258	9-A	113	3,500	301,800
-122.4728	47.2269	12-A	167	5,000	301,800

Figure 26: Moses Lake.



Moses Lake

Four (4) LUST sites within 1-mile of the City of Moses Lake Wells #1, #2, #12, #21, #23 and the Country Club Estates Well #1.

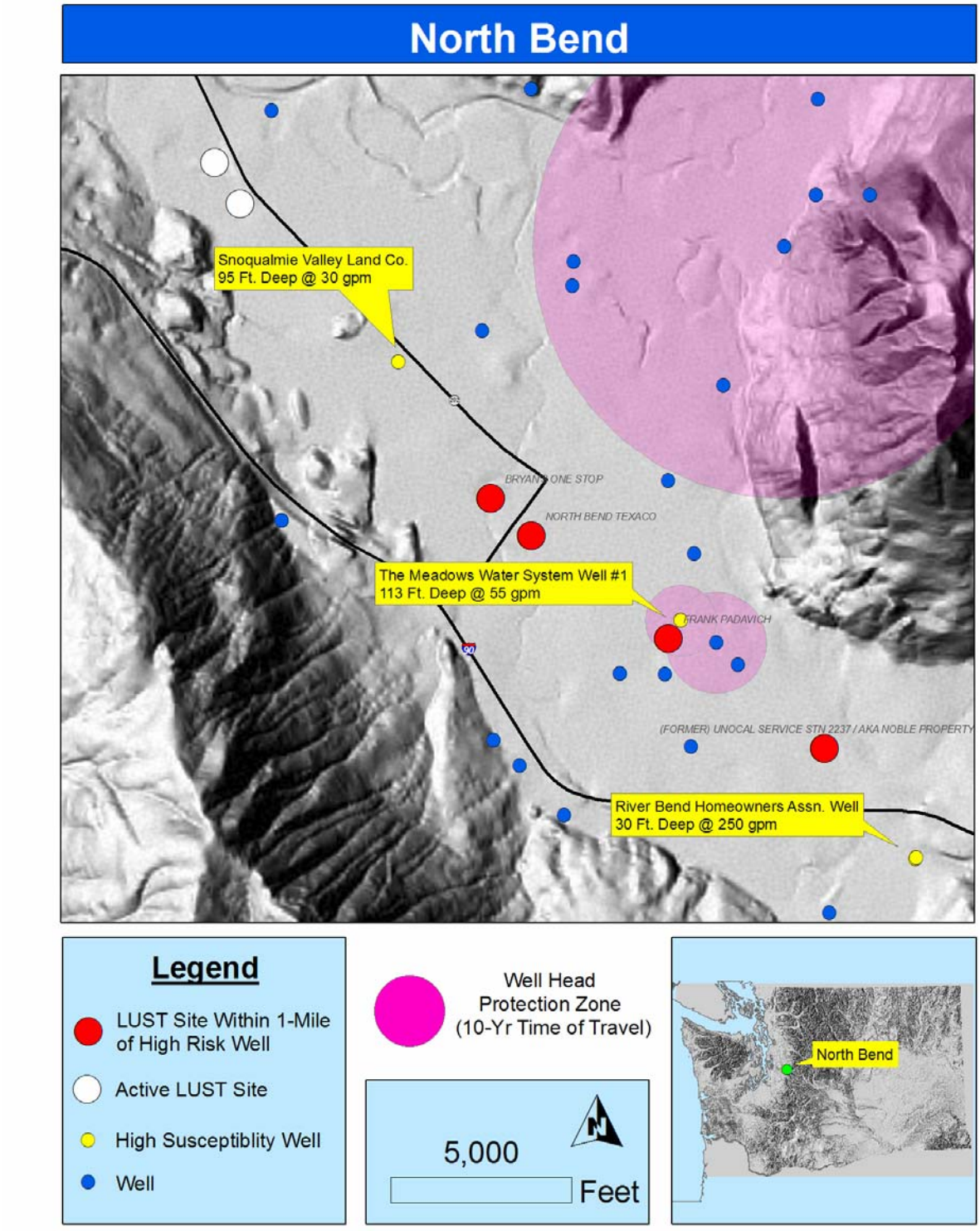
Table 27: Moses Lake LUST Sites.

X_long	Y_lat	Lust Site	Address	Zip
-119.3415	47.1037	COUNTRY STORE	4421 PRICHARD RD	98837
-119.2572	47.1321	MOSES LAKE SOC 070705	418 N CLOVER DR	98837
-119.3233	47.1884	PORT OF MOSES LAKE	7810 ANDREWS ST NE	98837
-119.2785	47.1382	SUN MART #24	640 N STRATFORD RD	98837

Table 28: Moses Lake Wells.

X_long	Y_lat	Well	Depth (ft.)	gpm	Population
-119.2806	47.1485	City of Moses Lake #1 AFA222	0	150	0
-119.2368	47.1343	City of Moses Lake #12 ABS451	568	1,900	19,661
-119.2811	47.1461	City of Moses Lake #2 AAJ108	0	80	0
-119.3255	47.1798	City of Moses Lake #21 ABR745	712	650	19,661
-119.3176	47.1835	City of Moses Lake #23 ABR746	710	1,400	19,661
-119.3493	47.1126	Country Club Estates #1 AFA234	55	160	114

Figure 27: North Bend.



North Bend

Four (4) LUST sites within 1-mile of the River Bend Home Owners Assn. and Meadows Water System Wells.

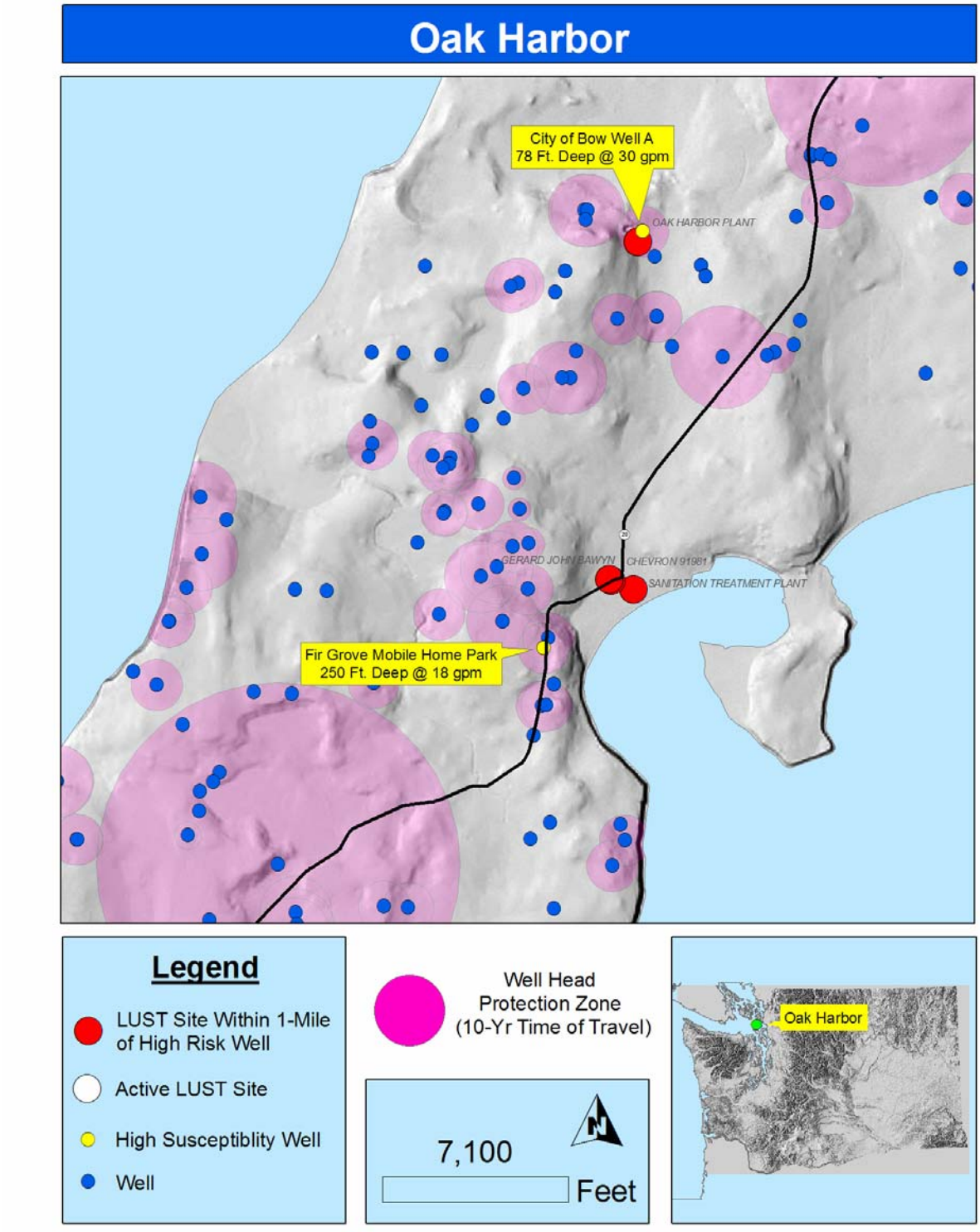
Table 29: North Bend LUST Sites.

X_Long	Y_lat	Lust Site	Address	Zip
-121.7518	47.4779	(FORMER) UNOCAL SERVICE STN 2237	330 & 354 E NORTH BEND WY	98045
-121.7895	47.4964	BRYAN'S ONE STOP	302 W NORTH BEND WAY	98045
-121.7694	47.4860	FRANK PADAVICH	1130 E NORTH BEND WAY	980459525
-121.7849	47.4936	NORTH BEND TEXACO	225 E NORTH BEND WAY	980450990

Table 30: North Bend Wells.

X_Long	Y_lat	Well	Depth (Ft.)	gpm	Population
-121.7428	47.4695	River Bend Home Owners Assn. Line Shaft	30	250	1,603
-121.7427	47.4696	River Bend Home Owners Assn. Submersible	52	250	1,603
-121.7693	47.4872	The Meadows Water System Well #1	113	55	127

Figure 28: Oak Harbor.



Oak Harbor

Four (4) LUST sites within 1-mile of the City of Bow Well A and Fir Grove Park Well # 1.

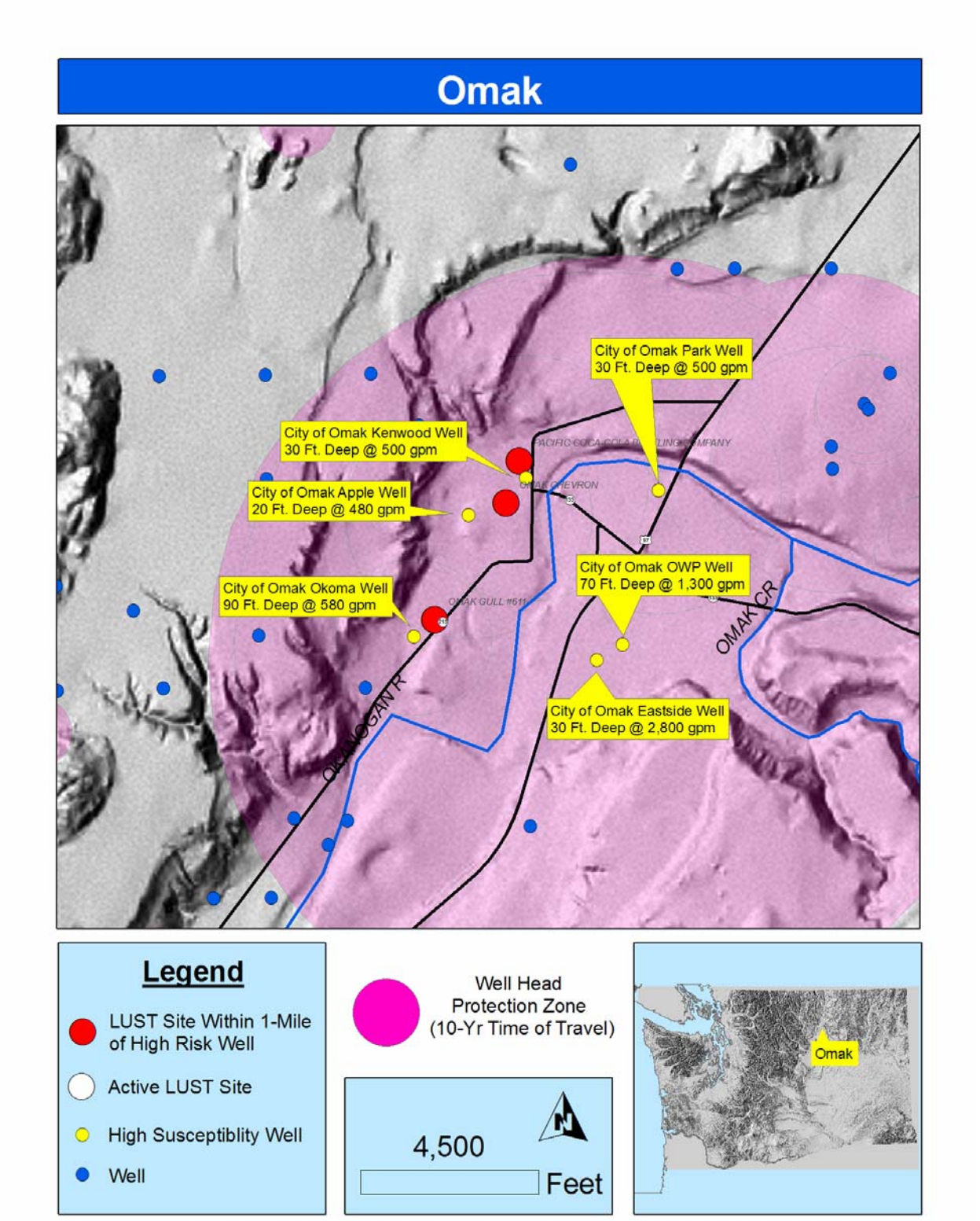
Table 31: Oak Harbor LUST Sites.

X_long	Y_lat	Lust Site	Address	Zip
-122.6581	48.2868	CHEVRON 91981	1359 W PIONEER WY	98277-3101
-122.6584	48.2869	GERARD JOHN BAWYN	1366 W PIONEER WAY	98277-3102
-122.6554	48.3223	OAK HARBOR PLANT	3199 NORTH OAK HARBOR ROAD	98277-3519
-122.6546	48.2859	SANITATION TREATMENT PLANT	1501 SE CITY BEACH ST PLANT	98277

Table 32: Oak Harbor Wells.

X_Long	Y_lat	Well	Depth (Ft.)	gpm	Population
-122.6560	48.3232	City of Bow WELL A	78	30	50
-122.6697	48.2794	Fir Grove Park Well #1	250	18	65

Figure 29: Omak.



Omak

Three (3) LUST sites within 1-mile of the City of Omak Apple, Eastside, Kenwood, Okoma, OWP and Park Wells.

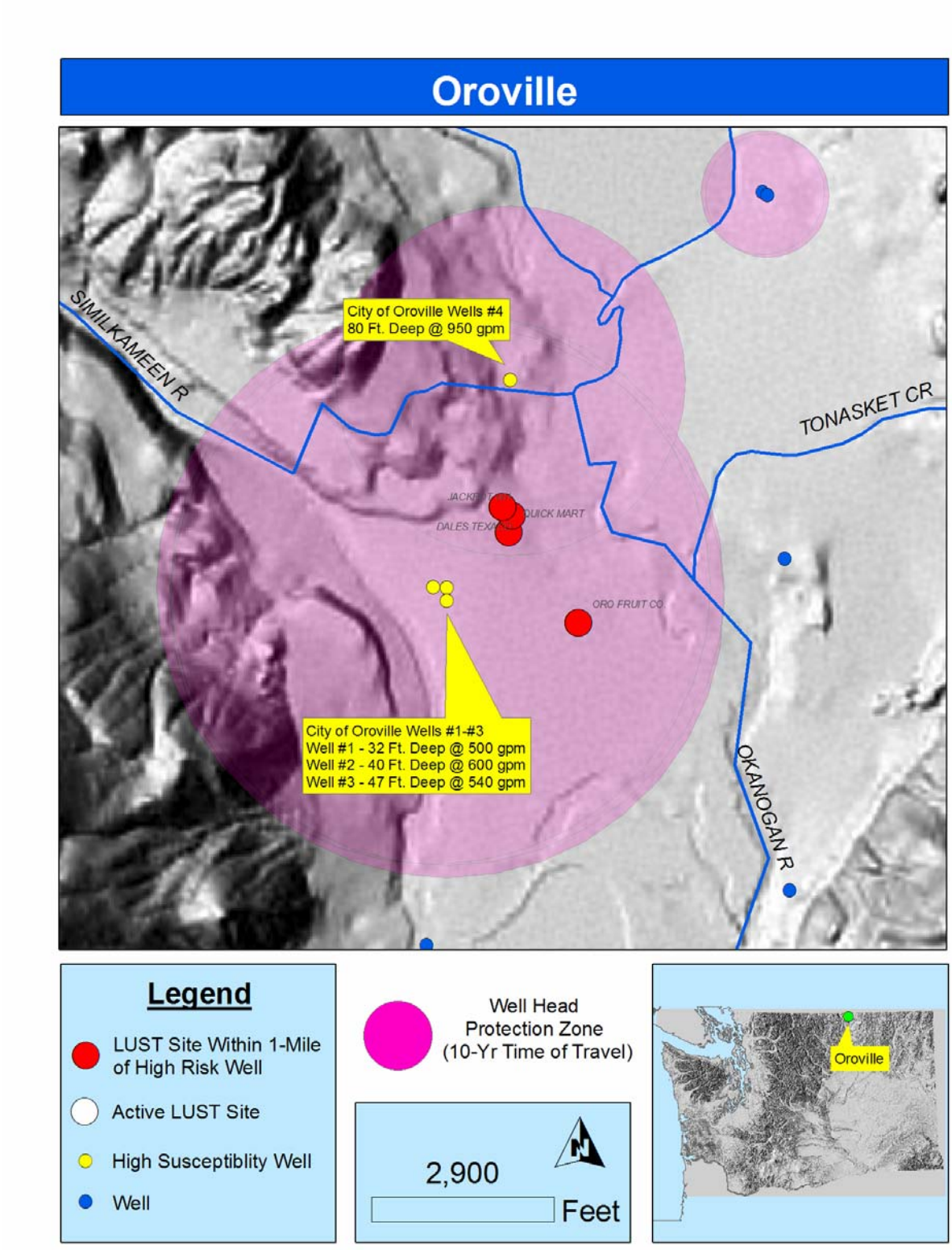
Table 33: Omak LUST Sites.

X_long	Y_lat	Lust Site	Address	Zip
-119.5299	48.4101	OMAK CHEVRON	30 S MAIN	98841
-119.5375	48.4021	OMAK GULL #611	607 OKOMA DR	98841
-119.5285	48.4130	PACIFIC COCA-COLA BOTTLING COMPANY	123 N MAIN STREET	98841

Table 34: Omak Wells.

X_Long	Y_Lat	Well	Depth (Ft.)	gpm	Population
-119.5350	48.4092	Apple Well	20	480	4,705
-119.5219	48.3990	Eastside Well - AGJ179	30	2,800	4,705
-119.5290	48.4117	Kenwood	30	500	4,705
-119.5409	48.4008	Okoma Well	90	500	4,705
-119.5192	48.4001	OWP Well	70	1,300	4,705
-119.5153	48.4107	Park Well - AGJ178	44	250	4,705

Figure 30: Oroville.



Oroville

Four (4) LUST sites within 1-mile of the City of Oroville Wells #1 - #4.

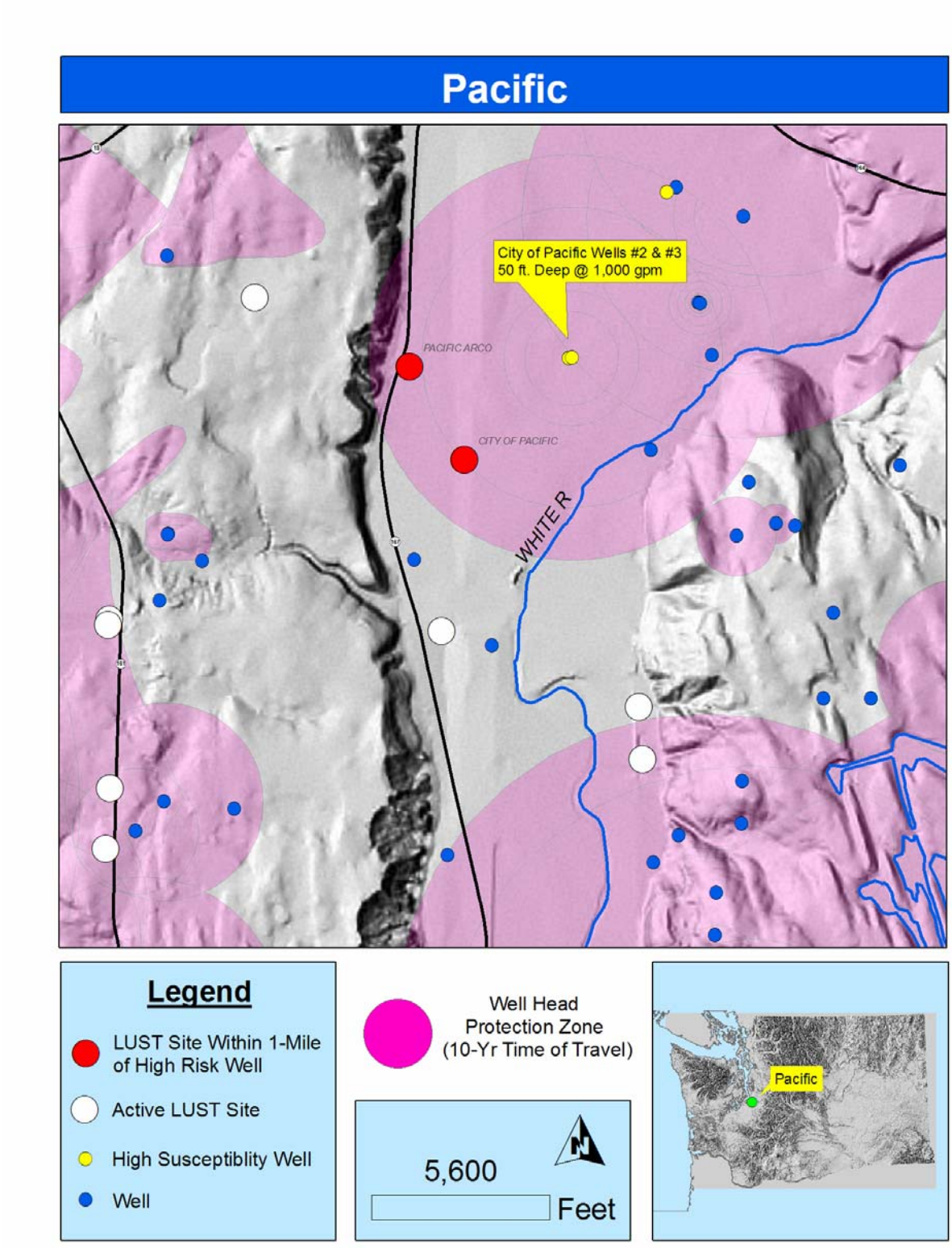
Table 35: Oroville LUST Sites.

X_long	Y_lat	Lust Site	Address	Zip
-119.4350	48.9394	QUICK MART	1501 MAIN ST	98844-9372
-119.4305	48.9354	ORO FRUIT CO.	224 APPLEWAY AVE	98844-0560
-119.4348	48.9401	JACKPOT 081	1518 MAIN ST	98844
-119.4354	48.9405	DALES TEXACO	1714 MAIN ST	98844

Table 36: Oroville Wells.

X_long	Y_lat	Well	depth (Ft.)	gpm	Population
-119.4403	48.9369	#1	32	500	2,260
-119.4403	48.9363	#2	40	600	2,260
-119.4412	48.9369	#3	47	540	2,260
-119.4360	48.9459	#4	80	950	2,260

Figure 31: Pacific.



Pacific

Two (2) LUST sites within 1-mile of the City of Pacific Wells #2 & #3.

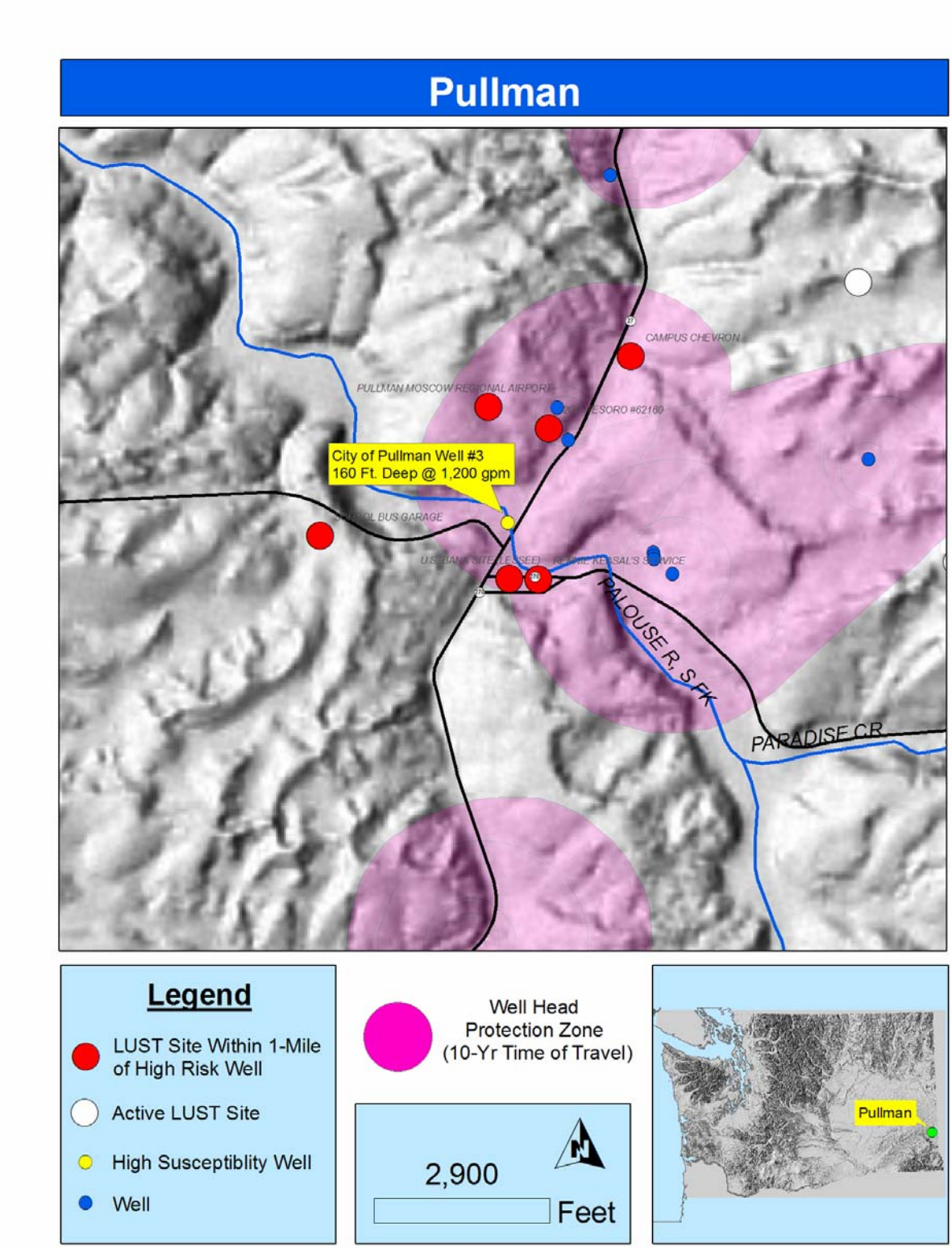
Table 37: Pacific LUST Sites.

X_long	Y_lat	Lust Site	Address	Zip
-122.2497	47.2646	CITY OF PACIFIC	100 3RD AVE SE	98047-1399
-122.2569	47.2725	PACIFIC ARCO	401 ELLINGSON RD	98047

Table 38: City of Pacific Wells.

X_Long	Y_lat	Well	depth (Ft.)	gpm	Population
-122.2377	47.2734	#2	50	1,000	6,673
-122.2381	47.2734	#3	50	1,100	6,673

Figure 32: Pullman.



Pullman

Six (6) LUST sites within 1-mile of the City of Pullman Well #3.

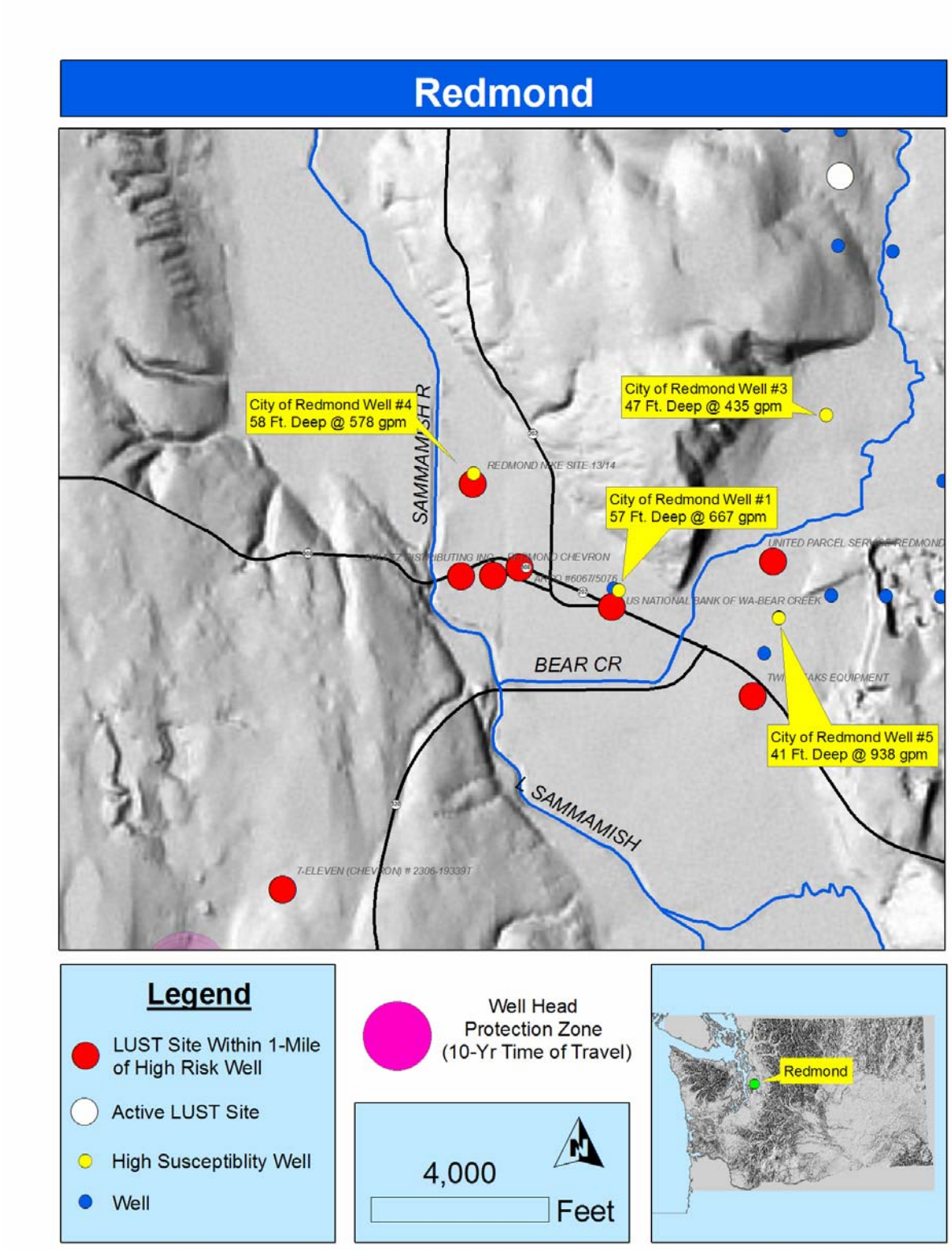
Table 39: Pullman LUST Sites.

X_long	Y_lat	Lust Site	Address	Zip
-117.1766	46.7363	2GO TESORO #62160	770 GRAND AVE N	99163
-117.1710	46.7394	CAMPUS CHEVRON	NE 400 STADIUM WAY	99163
-117.1805	46.7374	PULLMAN MOSCOW REGIONAL AIRPORT	ROUTE 3 BOX 850	991639801
-117.1777	46.7295	RENNIE KEASAL'S SERVICE	485 E MAIN	99163
-117.1919	46.7319	SCHOOL BUS GARAGE	NW 935 OLSEN STREET	99163
-117.1796	46.7296	U.S. BANK SITE (LESSEE)	339 E. MAIN	991632620

Table 40: City of Pullman Wells.

X_long	Y_lat	Well	Depth (ft.)	gpm	Population
-117.1806	46.7320	#3	160	1,200	20,970

Figure 33: Redmond.



Redmond

Nine (9) LUST sites within 1-mile of the City of Redmond Water System Wells #1 - #5.

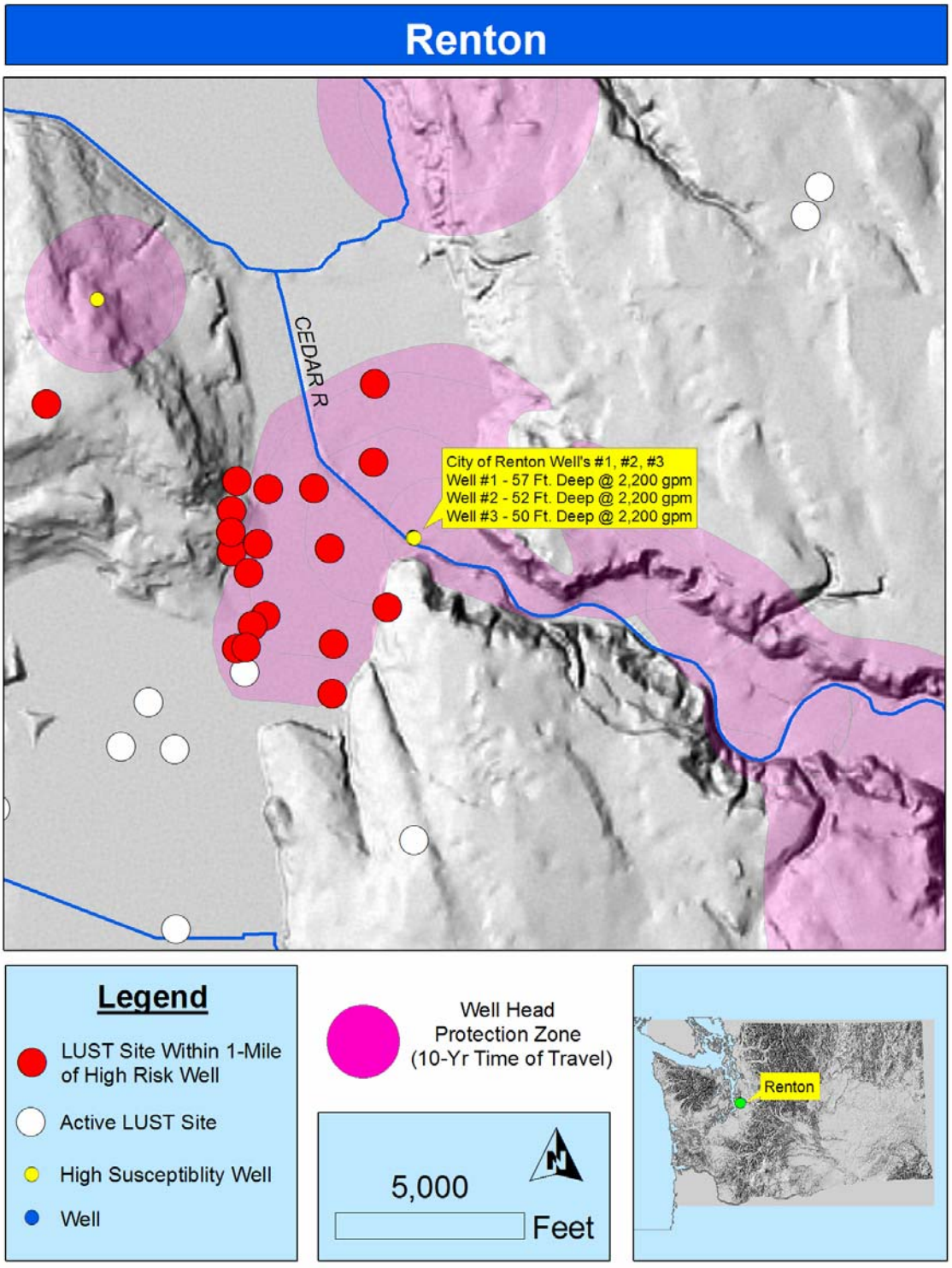
Table 41: Redmond LUST Sites.

X_long	Y_lat	Lust Site	Address	Zip
-122.1442	47.6546	7-ELEVEN (CHEVRON) # 2306-19339T	5040 148TH AVE NE	98052
-122.1232	47.6747	ARCO #6067/5076	8009 164TH AVE NE	98052
-122.1404	47.6477	HOBART CORPORATION	4600 150TH AVE N.E.	98052-5113
-122.1256	47.6742	REDMOND CHEVRON	16010 REDMOND WAY	98052-3827
-122.1276	47.6798	REDMOND NIKE SITE 13/14		98052
-122.1285	47.6741	SHULTZ DISTRIBUTING INC.	7822 180TH AVE NE	98052-4927
-122.1017	47.6671	TWIN PEAKS EQUIPMENT	17950 REDMOND WAY	98052
-122.1001	47.6754	UNITED PARCEL SERVICE-REDMOND	18001 NE UNION HILL RD	98052-3336
-122.1147	47.6724	US NATIONAL BANK OF WA-BEAR CREEK	17000 AVONDALE WAY NE	98052-4409

Table 42: City of Redmond Water System Wells.

X_long	Y_lat	Well	Depth (ft.)	gpm	Population
-122.1154	47.6733	#1	57	667	52,135
-122.0968	47.6843	#3	47	435	52,135
-122.1288	47.6803	#4	58	578	52,135
-122.1007	47.6718	#5	41	938	52,135

Figure 34: Renton.



Renton

Twenty (20) LUST sites within 1-mile of the City of Renton Wells #1 - #3.

Table 43: Renton LUST Sites.

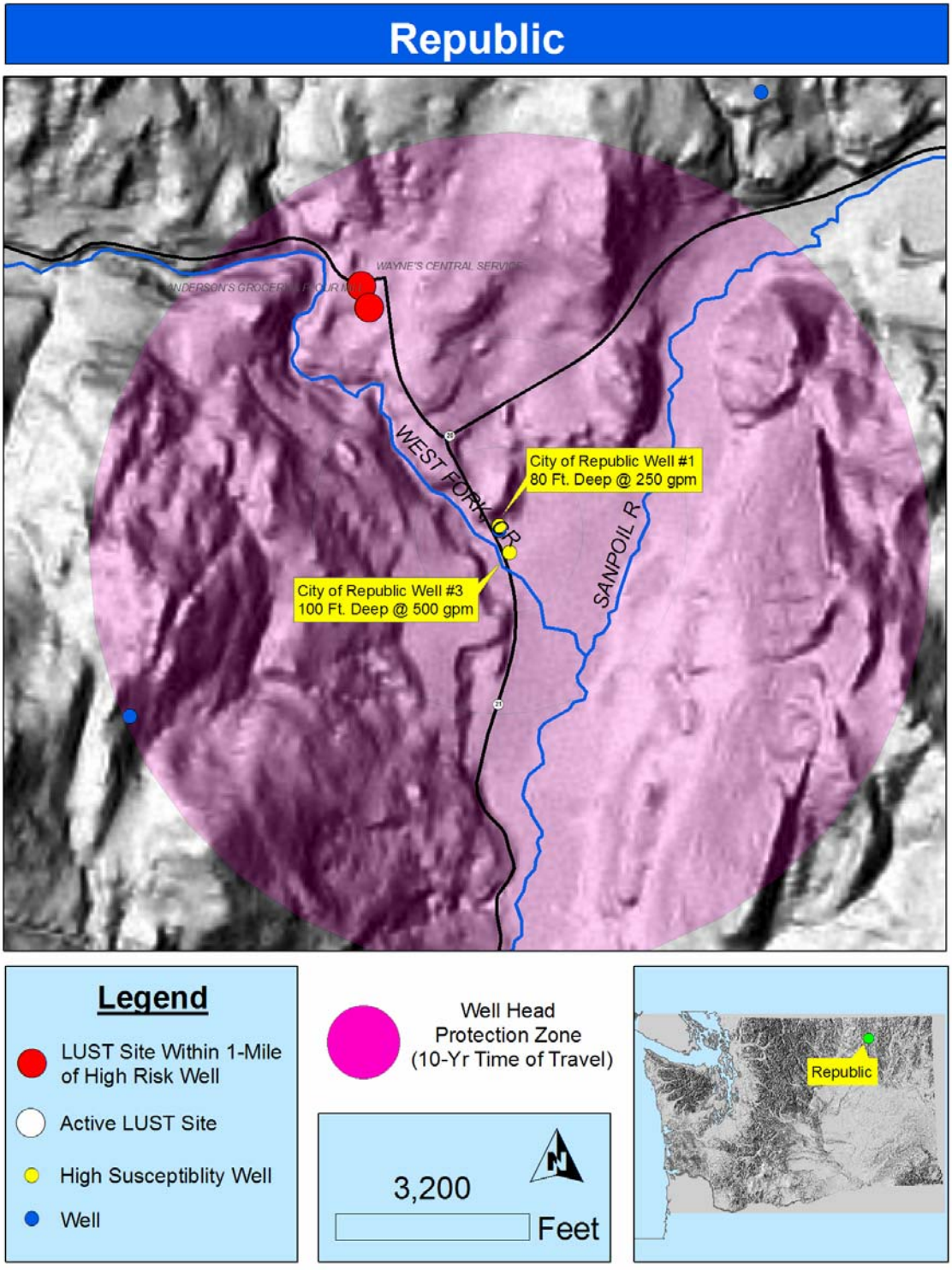
X_Lon	Y_Lat	Lust Site	Address	Zip
-122.2098	47.4849	77 Burnett Ave South	77 BURNETT AVE S	98055
-122.2186	47.4816	ARCO AM/PM MINI MARKET	175 RAINIER AVE S	98055
-122.2181	47.4853	CASTAWAYS RESTAURANT	1101 W PERIMETER RD	98055
-122.2157	47.4808	COOKS CHEVRON MART II	201 S 3RD ST	98055
-122.2074	47.4701	EXXON STATION – BERKWITH	3100 BENSON RD. SOUTH	98055-5100
-122.1981	47.4309	FRIENDLY FOOD MART	19044 108TH AVE SE	98055
-122.2074	47.4737	GULL 1201	509 SOUTH GRADY WAY	98055-3211
-122.2147	47.4756	PUGET SOUND CHRY-PLY INC.	585 RAINIER AVE S	98055-2412
-122.2161	47.4749	RENTON 1	621 RAINIER AVE S	98055-2410
-122.2080	47.4806	RENTON CO 070276	225 WILLIAMS AVE SO	98055-2106
-122.2035	47.4869	RENTON EAGLE MART	401 PARK AVE N	98055
-122.2036	47.4926	RENTON PLANT	800 PARK AVE N	98055
-122.2166	47.4787	SAFEWAY	103 S 3RD	98055
-122.2147	47.4848	SDS PARTNERS	307 AIRPORT WY S	98055-1333
-122.2017	47.4764	SEARS ROEBUCK & COMPANY	359 RENTON CENTER WAY S.W.	98055-2393
-122.2177	47.4732	SOUND FORD INC	750 RAINIER AVE S	98055-3203
-122.1001	47.4665	TARGET EQUIPMENT RENTALS	18017 SE RENTON-MAP. VAL. HWY	98059
-122.2186	47.4832	UNOCAL 5024	59 RAINIER AVE	98055-2005
-122.2167	47.4733	USA MINI MART #115	765 RAINIER AVE S	98055-0000
-122.2185	47.4802	WALKER'S RENTON SUBARU	250 RAINIER AVE S	98055-2001

Renton

Table 44: City of Renton Wells.

X_long	Y_lat	Well	Depth (ft.)	gpm	Population
-122.2003	47.4813	#1 (RW-1)	57	2,200	54,500
-122.2004	47.4813	#2 (RW-2)	52	2,200	54,500
-122.2004	47.4814	#3 (RW-3)	50	2,200	54,500

Figure 35: Republic.



Republic

Two (2) LUST sites within 1-mile of the City of Republic Wells #1 - #3.

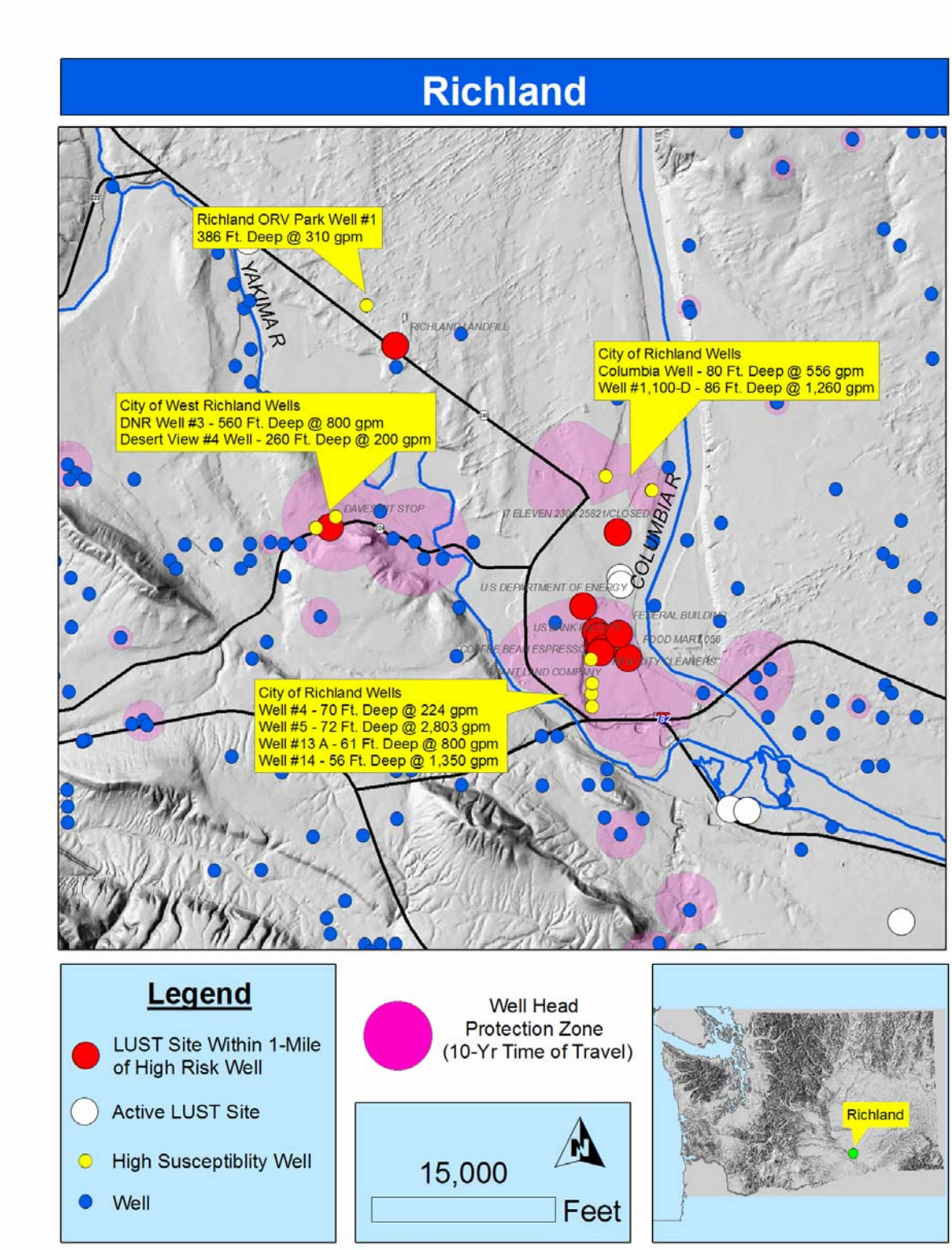
Table 45: Republic LUST Sites.

X_long	Y_lat	Lust Site	Address	Zip
-118.7384	48.6475	WAYNE'S CENTRAL SERVICE	615 S CLARK	99166
-118.7379	48.6465	ANDERSON'S GROCERY & FLOUR MILL	711 S CLARK AVE	99166-0386

Table 46: City of Republic Wells.

X_long	Y_lat	Well	Depth (ft.)	gpm	Population
-118.7305	48.6364	#1	80	250	1,429
-118.7298	48.6352	#3	100	500	1,429

Figure 36: Richland.



Richland

Fourteen (14) LUST sites within 1-mile of the City of eight (8) City of Richland Wells: Columbia, #1100-D, #1, #4, #5, #13A, #14, #1100-8.

Table 47: Richland LUST Sites.

X_long	Y_lat	Lust Site	Address	Zip
-119.2752	46.3006	7 ELEVEN 2304 25821/CLOSED	1824 G. WA.WY	99352
-119.2817	46.2774	COFFEE BEAN ESPRESSO	840 STEVENS	99352
-119.2815	46.2747	COLUMBIA OIL COMPANY	1345 LEE BLVD	99352
-119.2753	46.2779	FEDERAL BUILDING	825 JADWIN AVE	99352-3562
-119.2724	46.2725	FOOD MART 056	500 GEORGE WASHINGTON WAY	99352-4421
-119.2815	46.2747	FORMER CHEVRON STATION 9-8944	1323 LEE BLVD	99352
-119.2813	46.2739	GRANT LAND COMPANY	1333 GILLESPIE	99352-4101
-119.2805	46.2747	LEO'S LINE-UP + TIRES AUTO EXPRESS	1315 LEE BLVD	99352
-119.2821	46.2759	NEW CITY CLEANERS	747 STEVENS	99352-4108
-119.2820	46.2746	P & K AUTO SERVICE INC.	1415 GILLESPIE	99352-4102
-119.2828	46.2785	RICHLAND CITY EQ. MAINT. SHP.	965 GOETHALS DR	99352-3503
-119.3460	46.3432	RICHLAND LANDFILL	3302 GROSSCUP RD	99352
-119.2867	46.2843	U S DEPARTMENT OF ENERGY	825 JADWIN	99352-3562
-119.2821	46.2753	US BANK FACILITY	701 STEVENS DRIVE	99352

Richland

Table 48: City of Richland Wells.

X_long	Y_lat	Well	Depth (ft.)	gpm	Population
-119.2652	46.3098	Columbia Well	80	556	43,520
-119.2800	46.3131	Well #1100-D	86	1,260	43,520
-119.3563	46.3520	Well #1	386	310	142
-119.2856	46.2645	Well #4	70	224	43,520
-119.2856	46.2617	Well #5	72	2,803	43,520
-119.2857	46.2723	Well #13A	61	800	43,520
-119.2853	46.2669	Well #14	56	1,350	43,520
-119.2800	46.3131	Well #1100-8	120	250	43,520

Figure 37: Spokane.

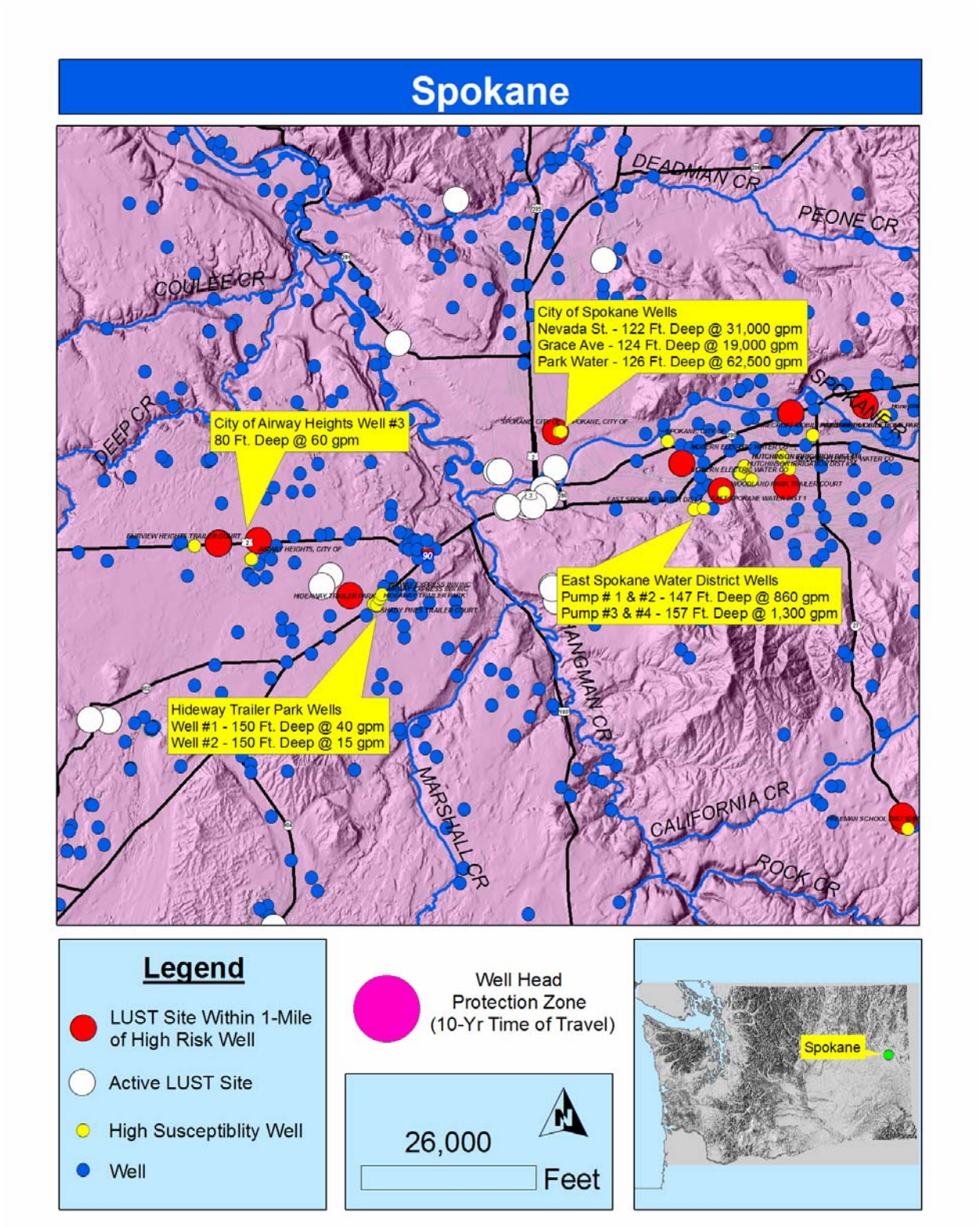


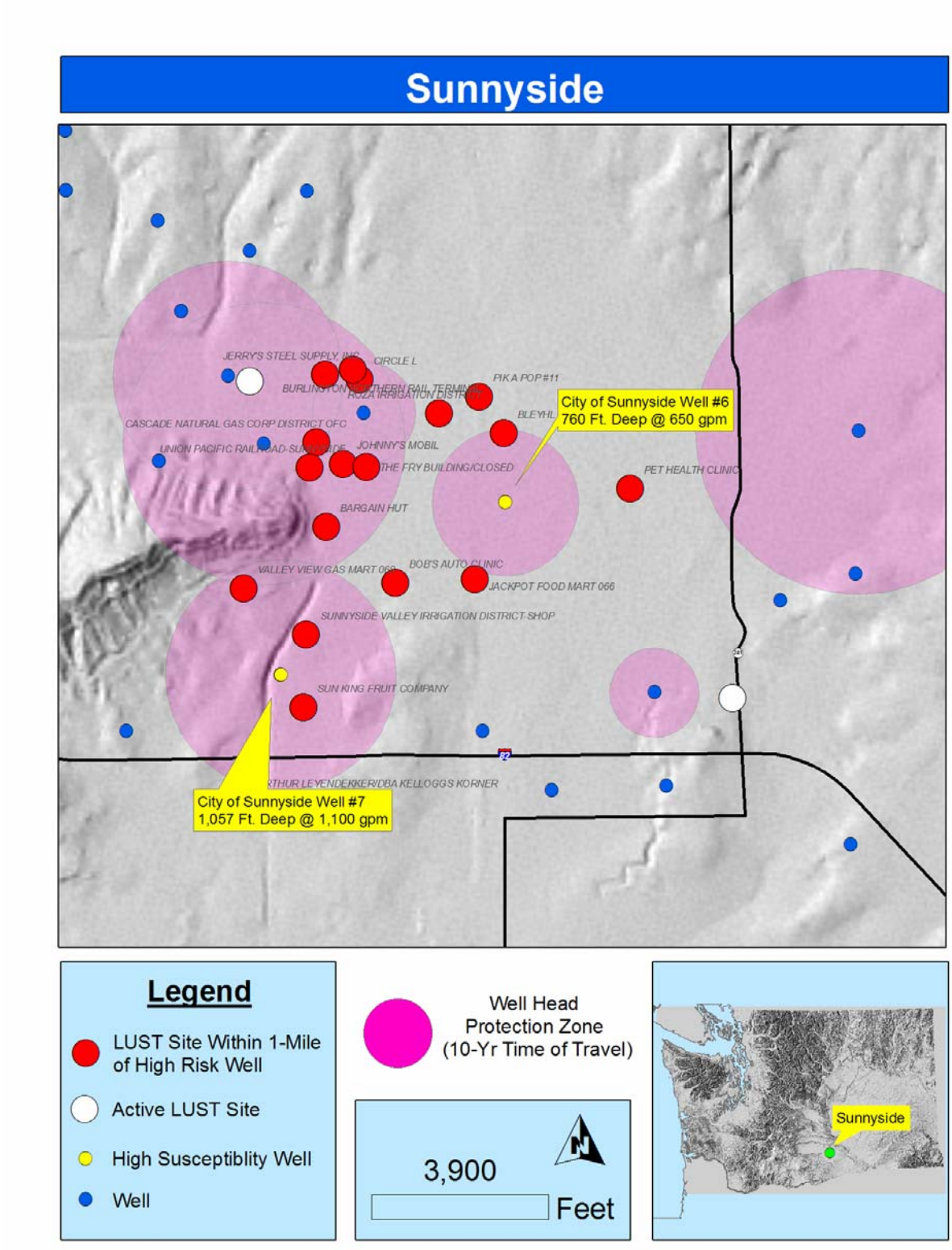
Table 49: Spokane LUST Sites.

X_Lon	Y_Lat	Lust Site	Address	Zip
-117.2580	47.6574	A TO Z RENTALS & SALES, INC.	10903 E SPRAGUE	99206-5214
-117.2538	47.6871	GOBER'S OIL INC.	11215 E TRENT	99206
-117.5774	47.6438	HAYFORD CONOCO	10724 W SUNSET HWY	99204
-117.2088	47.6890	KAISER ALUMINUM & CHEMICAL INC	15000 E EUCLID AVENUE PO BOX 151	99215-5108
-117.2973	47.6566	QWIK STOP #1635	8119 SPRAGUE AVE E	99212
-117.5232	47.6199	SPOKANE AIRWAYS INC	3727 S. DAVISON BLVD, BLDG 701	99219-9125
-117.3960	47.6834	WATER YARDS (WATER DEPARTMENT)	914 E NORTH FOOTHILLS DR	99207

Table 50: Spokane Wells.

X_Lon	Y_Lat	Water System Name	Well	Depth (ft.)	Gpm	Population
-117.2572	47.6644	MODERN ELECTRIC WATER CO	Well #2 - AHC941	118	3,035	10,788
-117.2800	47.6607	MODERN ELECTRIC WATER CO	Well #4 - AHC944	113	4,200	10,788
-117.2613	47.6693	MODERN ELECTRIC WATER CO	Well #8 - AHC942	128	1,760	10,788
-117.2421	47.6777	PINECROFT MOBILE HOME PARK	Well #1- AHC918	60	90	248
-117.2421	47.6777	PINECROFT MOBILE HOME PARK	Well #2 - AHC919	60	90	248
-117.2421	47.6777	PINECROFT MOBILE HOME PARK	Well #3 - AHC920	60	130	248
-117.5106	47.6161	SHADY PINES TRAILER COURT	Well #1	130	60	70
-117.3949	47.6833	SPOKANE, CITY OF	Nevada St - AHC725	122	31,000	204,500
-117.3938	47.6832	SPOKANE, CITY OF	Grace Ave - AHC724	124	19,000	204,500
-117.3298	47.6777	SPOKANE, CITY OF	Park Water - AHC722	126	62,500	204,500

Figure 38: Sunnyside.



Sunnyside

Eighteen (18) LUST sites within 1-mile of the City of the City of Sunnyside Well's #6 & #7.

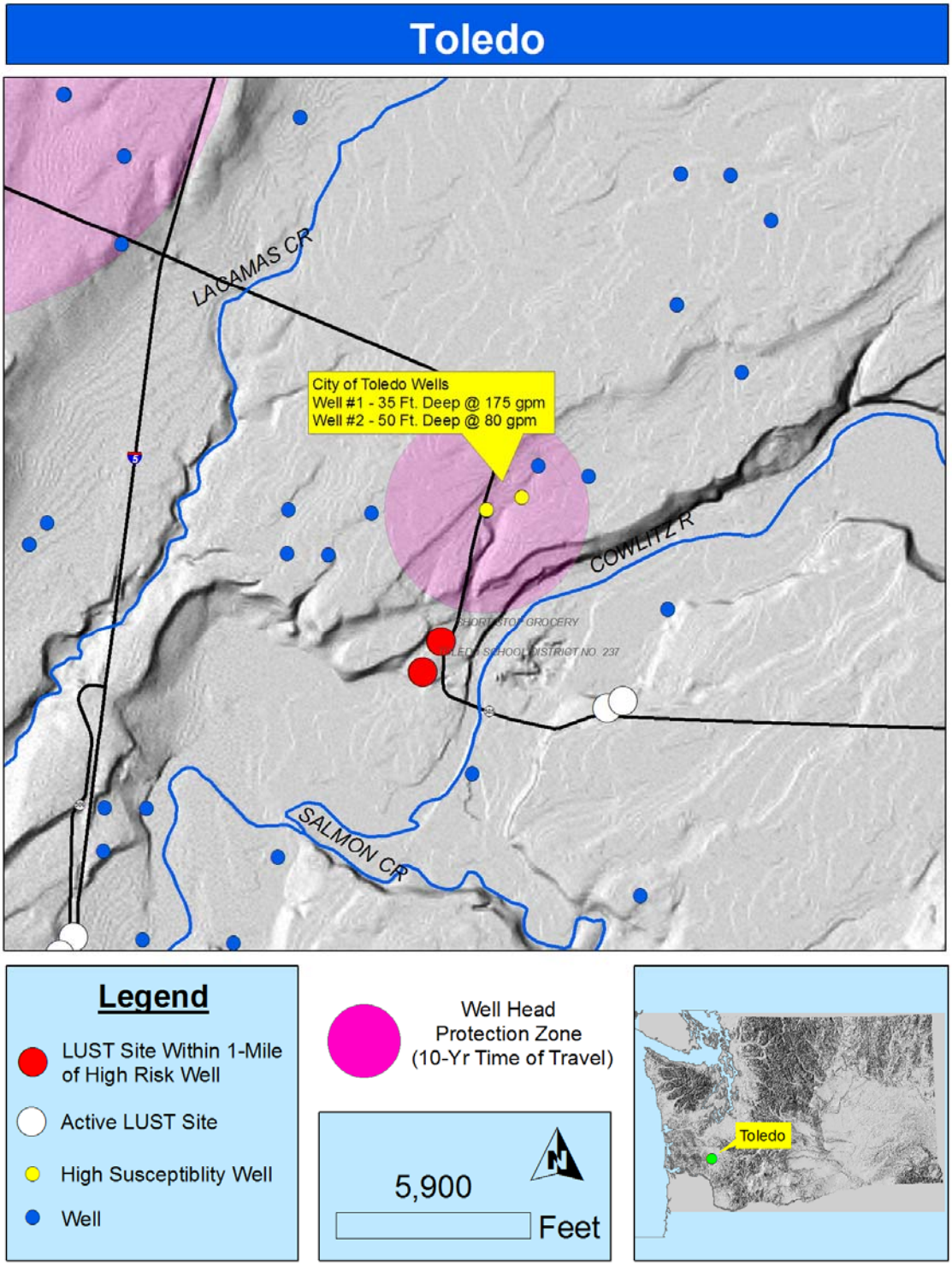
Table 51: Sunnyside Wells.

X_long	Y_lat	Lust Site	Address	Zip
-120.0206	46.3035	ARTHUR LEYENDEKKER/DBA KELLOGGS KOR	270 MIDVALE RD	98944-9702
-120.0133	46.3201	BARGAIN HUT	515 HARRISON	98944
-119.9978	46.3257	BLEYHL FARM SERVICE, INC.	EASTWAY SHOP CTR	98944
-120.0109	46.3296	BNSF RAIL TERMINAL	MP.54.5 12TH SUB. PTLD DIV.	98944
-120.0073	46.3167	BOB'S AUTO CLINIC	1006 LINCOLN	98944-2373
-120.0141	46.3252	CASCADE NATL. GAS CORP DIST. OFC	512 DECATUR AVE	98944-1414
-120.0103	46.3290	CIRCLE L	809 HWY 12	98944-1332
-120.0004	46.3169	JACKPOT FOOD MART 066	1121 S 16TH ST	98944-2433
-120.0133	46.3293	JERRY'S STEEL SUPPLY, INC.	232 N SIXTH ST.	98944-1311
-120.0118	46.3239	JOHNNY'S MOBIL	636 E EDISON	98944-2202
-119.9868	46.3223	PET HEALTH CLINIC	2210 A E EDISON RD	98944-9214
-119.9999	46.3279	PIK A POP #11	1524 YAKIMA VALLEY HWY	98944
-120.0034	46.3269	ROZA IRRIGATION DISTRICT	125 13TH ST	98944-0810
-120.0154	46.3092	SUN KING FRUIT COMPANY	325 E SOUTH HILL ROAD	98944-9409
-120.0151	46.3136	SUNNYSIDE VALLEY IRRIGATION DISTRICT-SHOP	1433 SO 4TH STREET	98944
-120.0098	46.3237	THE FRY BUILDING/CLOSED	111 N 6TH STREET	98944
-120.0147	46.3237	UNION PACIFIC RAILROAD-SUNNYSIDE	S 5TH AVE & EDISON	98944
-120.0205	46.3164	VALLEY VIEW GAS MART 068	107 W LINCOLN	98944-2016

Table 52: Sunnyside Wells.

X_long	Y_lat	Well	Depth (ft.)	gpm	Population
-120.0185	46.3111	Well #7	1057	1,100	14,120
-119.9989	46.3214	Well #6 - AFL811	760	650	14,120

Figure 39: Toledo.



Toledo

Two (2) LUST sites within 1-mile of the City of the City of Toledo Well's #1 & #2.

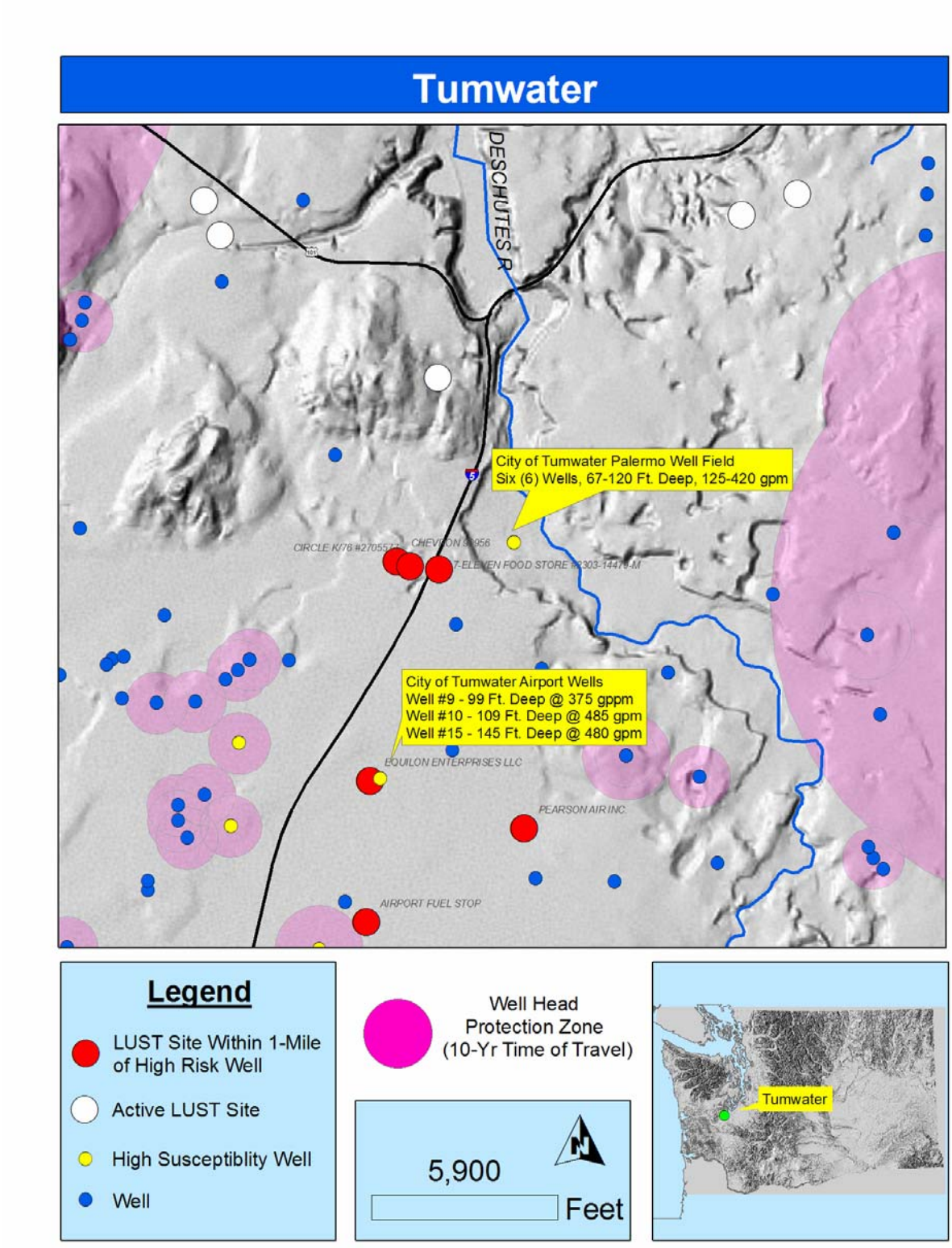
Table 53: Toldeo LUST Sites.

X_long	Y_lat	Lust Site	Address	Zip
-122.8490	46.4416	TOLEDO SCHOOL DISTRICT NO. 237	155 FIFTH/PO BOX 469	98591-0469
-122.8469	46.4442	SHORT STOP GROCERY	560 5TH ST N	98591-0000

Table 54: Toledo Municipal Wells.

X_long	Y_lat	Well	Depth (ft.)	gpm	Population
-122.8432	46.4551	#1	35	175	690
-122.8390	46.4563	#2	50	80	690

Figure 40: Tumwater.



Tumwater

Five (5) LUST sites within 1-mile of the nine (9) City of Tumwater Well's.

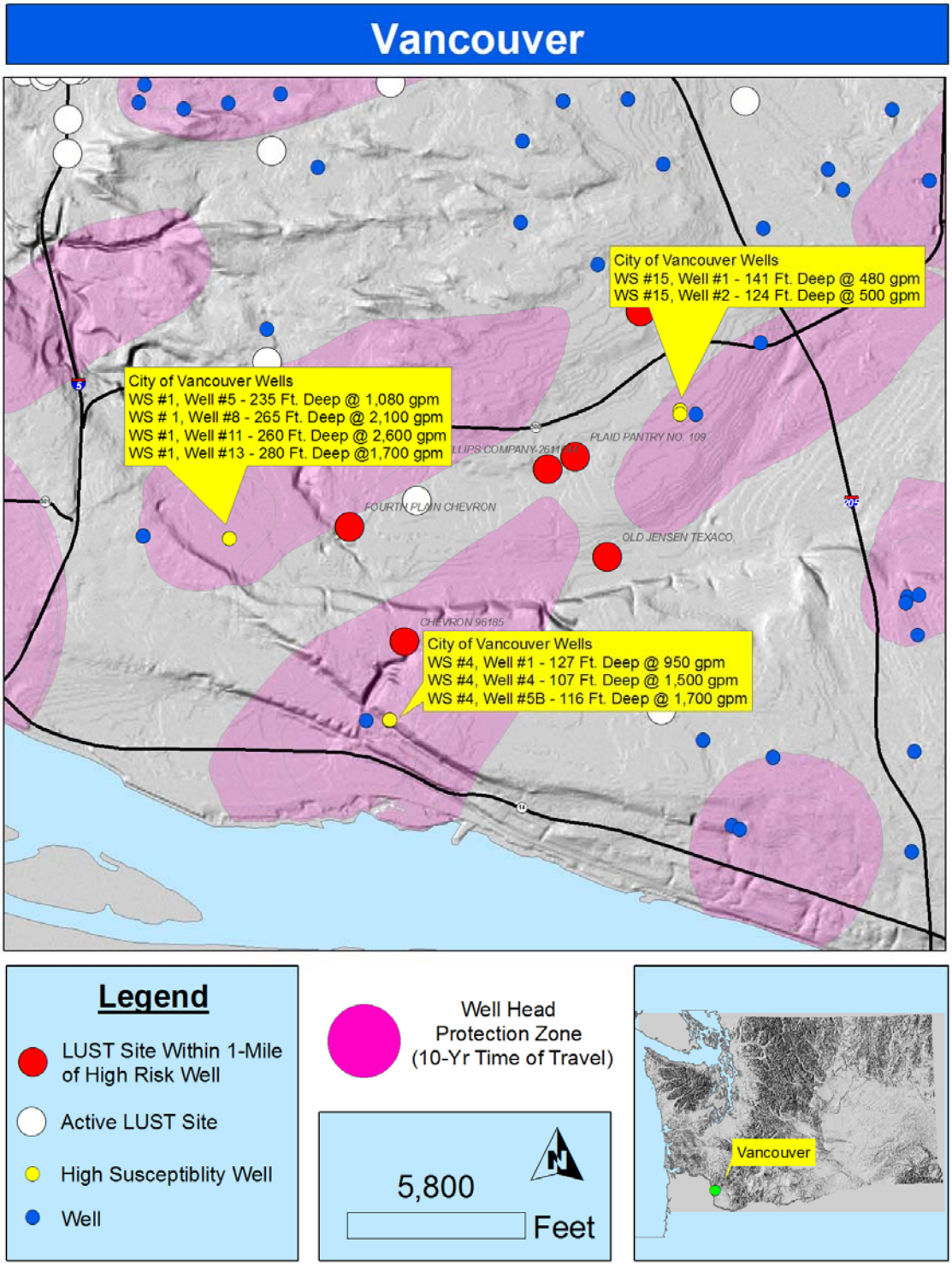
Table 55: Tumwater LUST Sites.

X_long	Y_lat	Lust Site	Address	Zip
-122.9101	46.9995	7-ELEVEN FOOD STORE #2303-14479-M	5310 CAPITOL BLVD S	98501
-122.9179	46.9688	AIRPORT FUEL STOP	8220 CENTER ST SW	98502
-122.9155	47.0001	CHEVRON 90956	670 TROSPER RD SW	98502
-122.9138	46.9997	CIRCLE K/76 #2705577	501 TROSPER RD SW	98512-6930
-122.9180	46.9810	EQUILON ENTERPRISES LLC	7370 LINDERSON WAY SW	98501

Table 56: City of Tumwater Wells.

X_long	Y_lat	Well	Depth (ft.)	gpm	Population
-122.9020	47.0019	#2, PALERMO WW	92	125	31,500
-122.9020	47.0019	#3, PALERMO WW	96	290	31,500
-122.9020	47.0019	#4, PALERMO WW	90	420	31,500
-122.9020	47.0019	#5, PALERMO WW	115	280	31,500
-122.9020	47.0019	#6, PALERMO WW	120	380	31,500
-122.9020	47.0019	#8 PALERMO WW	67	350	31,500
-122.9180	46.9811	#9, AIRPORT WW	99	375	31,500
-122.9180	46.9811	#10, AIRPORT WW	109	485	31,500
-122.9180	46.9811	#15, AIRPORT WW	145	480	31,500

Figure 41: Vancouver.



Vancouver

Five (5) LUST sites within 1-mile of the three (3) City of Vancouver Wells.

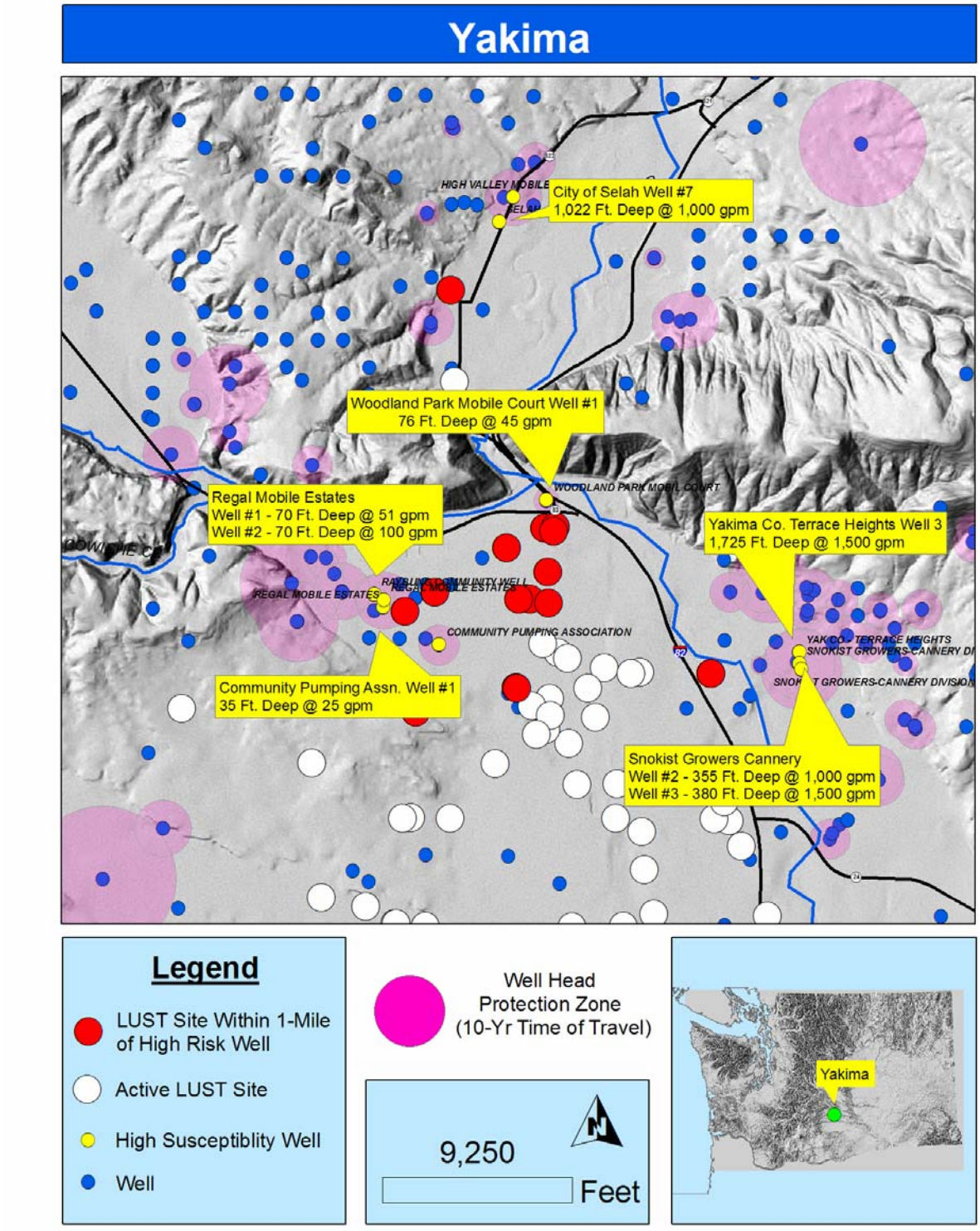
Table 57: Vancouver LUST Sites.

X_long	Y_lat	Lust Site	Address	Zip
-122.6181	45.6286	CHEVRON 96185	5005 E MILL PLAIN BLVD	98661-7014
-122.5891	45.6587	CHEVRON STATION #205412	9414 VANCOUVER MALL DR	98662
-122.6004	45.6444	CONOCO-PHILLIPS COMPANY-2611044	3105 NE ANDERSEN	98661
-122.6255	45.6388	FOURTH PLAIN CHEVRON	4100 E 4TH PLAIN BLVD	98661
-122.5970	45.6456	PLAID PANTRY NO. 109	7513 4TH PLAIN RD NE	98661

Table 58: City of Vancouver Wells.

X_long	Y_lat	Well	Depth (ft.)	gpm	Population
-122.5850	45.6495	WS #15 Well #2 WW	124	500	170,056
-122.6210	45.6214	WS #4 Well #9 WW	108	600	170,056
-122.6420	45.6373	WS #1 Well #8 WW	265	2,100	170,056

Figure 42: Yakima.



Yakima

Sixteen (16) LUST sites within 1-mile of the nine (9) High Susceptibility Wells.

Table 59: Yakima LUST Sites.

X_Lon	Y_Lat	Lust Site	Address	Zip
-120.5182	46.6026	5TH AVE SHELL	216 N 5TH AVE	98902-2644
-120.5120	46.6181	ALLEN & ENNIS	1216-1218 N 1ST ST	98902
-120.5106	46.6241	BEKINS MOVING & STORAGE CO.	1891 N 1ST ST	98901-1731
-120.5109	46.6235	BIG VALLEY MOTEL	1504 N 1ST ST	98901
-120.5200	46.6213	C.M. HOLTZINGER FRUIT CO. INC.	1312 N 6TH AVENUE	98902-1424
-120.5340	46.6153	CASCADE FRUIT PRODUCTS, INC	1819 W J ST	98902-9999
-120.4804	46.6045	CHEVRON 93883	1602 TERRACE HEIGHTS RD	98901-2130
-120.5397	46.6128	CITY OF YAKIMA PUBLIC WORKS DEPT	2301 FRUITVALE BLVD	98902-1225
-120.5181	46.6025	DYNAMART YAKIMA FIFTH AVENUE	202 5TH AVE S	98902
-120.4069	46.5625	EAST VALLEY MARKET	7208 POSTMA RD	98901
-120.6498	46.5821	HARWOOD GROCERY	10605 WIDE HOLLOW RD	98908-9119
-120.5119	46.6139	MICHELSON PACKAGING	902 N 1ST STREET	98901
-120.5155	46.6144	NAKANO FOODS	115 WEST "I" STREET	98902-1431
-120.5177	46.6144	RH BOWLES COMPANY INC	401 W I ST	98902-1434
-120.4804	46.6045	SUNFAIR CHEVROLET, INC.	1600 E YAKIMA AVE	98907-1262
-120.5126	46.6239	TIGER MART	1808 1ST ST N	98901

Yakima

Table 60: Yakima Wells.

X_Lon	Y_Lat	Water System Name	Well	Depth (ft.)	Gpm	Population
-120.5344	46.6082	COMMUNITY PUMPING ASSN.	Well #1 - AFL762	35	25	18
-120.4053	46.5582	COUNTRY MOBILE ESTATES	Well #2 - AFK902	79	140	180
-120.4044	46.5578	COUNTRY MOBILE ESTATES	Well #1 - AFK901	115	85	180
-120.5469	46.6149	RAYBUNG COMMUNITY WELL	Well #1 - AFK937	86	20	107
-120.4644	46.6057	SNOKIST GROWERS-CANNERY DIV.	Well #3	380	1,500	700
-120.4640	46.6049	SNOKIST GROWERS-CANNERY DIV.	Well #2	355	1,000	700
-120.6651	46.5904	TIETON HILLS WATER CO	Well #2 - AFK907	311	30	75
-120.6649	46.5904	TIETON HILLS WATER CO	Well #1 - AFK906	220	32	75
-120.4645	46.6072	YAK CO - TERRACE HEIGHTS	WELL 3	1,725	1,500	3,805
-120.5135	46.6275	WOODLAND PARK MOBILE COURT	Well #1	76	45	75

Appendix A - LUST Within 1-Mile of a High Susceptibility Well (Data Tables)

DISLCAIMER – PLEASE READ!!

Notes on the Information in Appendix A

The Appendix A LUST sites data tables are based on a Nov-05 query of Ecology's "ISIS" (Integrated Site Information System) data base. **This information was then used in GIS to locate LUST sites that are within 1-mile of high susceptibility water well.** There are 368 LUST sites listed in Appendix A and they are sorted by county. ***Please note and understand that this is a "living" data base – it is constantly changing as sites get cleaned-up. You may find sites that have since been cleaned-up or closed out. Also, please note and understand that property transfers and other real estate transactions may result in name changes.***

Appendix A - LUST Within 1-Mile of a High Susceptibility Well

X_LON	Y_LAT	SITE	ADDRESS	CITY	COUNTY
-119.8210	46.2364	B & B EQUIPMENT COMPANY	HWY 12 & WILGUS RD	Prosser	Benton
-119.0345	46.1684	CHEVRON CHEMICAL COMPANY	BOWLES RD E OF FINLEY RD	Kennewick	Benton
-119.3460	46.3432	RICHLAND LANDFILL	3302 GROSSCUP RD	Richland	Benton
-119.1171	46.2119	PUMP PAK & EATERY	3 W COLUMBIA DR	Kennewick	Benton
-119.2821	46.2759	NEW CITY CLEANERS	747 STEVENS	Richland	Benton
-119.1294	46.2169	U-HAUL CENTER OF KENNEWICK	800 W. COLUMBIA DR	Kennewick	Benton
-119.1049	46.2107	CONSOLIDATED FREIGHTWAYS	900 E BRUNEAU AVE	Kennewick	Benton
-119.2815	46.2747	FORMER CHEVRON STATION 9-8944	1323 LEE BLVD	Richland	Benton
-119.4844	46.2639	BENTON CITY MAINTENANCE YARD	509 7TH STREET	Benton City	Benton
-119.2724	46.2725	FOOD MART 056	500 GEORGE WASHINGTON WAY	Richland	Benton
-119.2820	46.2746	P & K AUTO SERVICE INC.	1415 GILLESPIE	Richland	Benton
-119.1264	46.2120	BNRR DAIRYGOLD	229 N FRUITLAND	Kennewick	Benton
-119.2821	46.2753	US BANK FACILITY	701 STEVENS DRIVE	Richland	Benton
-119.2815	46.2747	COLUMBIA OIL COMPANY	1345 LEE BLVD	Richland	Benton
-119.2828	46.2785	RICHLAND CITY EQUIPMENT MAINTENANCE SHOP	965 GOETHALS DR	Richland	Benton
-119.2817	46.2774	COFFEE BEAN ESPRESSO	840 STEVENS	Richland	Benton
-119.2867	46.2843	U S DEPARTMENT OF ENERGY	825 JADWIN	Richland	Benton
-119.3679	46.3027	DAVE'S PIT STOP	6197 W VAN GIESEN	West Richland	Benton
-119.1277	46.2075	SMITTY'S CONOCO #240	33 S GARFIELD	Kennewick	Benton
-119.2752	46.3006	7 ELEVEN 2304 25821/CLOSED	1824 GEORGE WASHINGTON WY	Richland	Benton
-119.2805	46.2747	LEO'S LINE-UP + TIRES AUTO EXPRESS	1315 LEE BLVD	Richland	Benton
-119.2813	46.2739	GRANT LAND COMPANY	1333 GILLESPIE	Richland	Benton
-119.2753	46.2779	FEDERAL BUILDING	825 JADWIN AVE	Richland	Benton
-119.8239	46.2887	WYCKOFF FARMS MAIN SHOP	WILGUS RD & EVANS RD	Prosser	Benton
-119.9994	47.8395	CHELAN SCHOOL DIST BUS GARAGE	1055 WOODIN AVE	Chelan	Chelan
-120.0908	47.8398	PAT & MIKE'S FOOD MOOD	53 S SHORE DR	Chelan	Chelan
-120.7143	47.8083	HEADWATERS INN / SPORTSMAN'S PUB	21328 STATE HIGHWAY 207	Leavenworth	Chelan
-120.0178	47.8399	CHELAN SELF SERVE TEXACO	101 E WOODIN AVE	Chelan	Chelan
-120.0153	47.8396	CHELAN CHEVRON	232 E WOODIN AVE	Chelan	Chelan
-124.4288	48.3051	RAY'S GROCERY	7621 HWY 112	Sekiu	Clallam
-122.5321	45.7807	BATTLE GROUND CHEVRON	409 E MAIN	Battle Ground	Clark
-122.5891	45.6587	CHEVRON STATION #205412	9414 VANCOUVER MALL DR	Vancouver	Clark
-122.5580	45.7807	RAY S GROESBECK	1912 W MAIN	Battle Ground	Clark
-122.6004	45.6444	CONOCOPHILLIPS COMPANY-2611044	3105 NE ANDERSEN	Vancouver	Clark

Appendix A - LUST Within 1-Mile of a High Susceptibility Well

X_LON	Y_LAT	SITE	ADDRESS	CITY	COUNTY
-122.6181	45.6286	CHEVRON 96185	5005 E MILL PLAIN BLVD	Vancouver	Clark
-122.3584	45.5812	HI-WAY FUEL	1250 E ST	Washougal	Clark
-122.5302	45.7809	MINIT MART 102	805 MAIN ST	Battle Ground	Clark
-122.5350	45.7808	BATTLE GROUND FARM & HOME	210 E MAIN	Battle Ground	Clark
-122.3792	45.9280	CHELATCHIE PRAIRIE GENERAL STORE	42411 NE YALE BRIDGE RD	Amboy	Clark
-122.6255	45.6388	FOURTH PLAIN CHEVRON	4100 E 4TH PLAIN BLVD	Vancouver	Clark
-122.6526	45.7167	EXXON STATION 7-3594	13204 NE HIGHWAY 99	Vancouver	Clark
-122.6511	45.7161	A. TRAIL MART #607	13117 W HWY 99	Vancouver	Clark
-122.5406	45.7809	BATTLE GROUND SCHOOL DISTRICT 119	204 W MAIN ST	Battle Ground	Clark
-122.6583	45.7185	EXPRESSWAY FOOD STORE NO 609	1309-A NE 134TH ST.	Vancouver	Clark
-122.5970	45.6456	PLAID PANTRY NO. 109	7513 4TH PLAIN RD NE	Vancouver	Clark
-122.3459	45.5801	WILLIAM H NEDER (EXXON STATION)	2507 E STREET	Washougal	Clark
-117.9922	46.3124	DAYTON MAINTENANCE SITE	SR12,MP366.5,SOUTHSIDE	Dayton	Columbia
-117.9823	46.3166	CITY OF DAYTON CITY SHOP	302 SOUTH COTTONWOOD STREET	Dayton	Columbia
-122.9964	46.1415	LONGVIEW ALUMINUM, LLC	4029 INDUSTRIAL WAY	Longview	Cowlitz
-122.7446	45.9080	TOAD'S EXPRESS MART & DELI	1455 HOFFMAN	Woodland	Cowlitz
-122.9087	46.1444	ARCO 4093	406 ALLEN STREET	Kelso	Cowlitz
-122.9110	46.1420	TROY PROPERTY	407 ASH STREET	Kelso	Cowlitz
-122.7356	45.9038	COPELAND GROCERY	RT4 BOX 587	Woodland	Cowlitz
-122.7492	45.9008	NANCY A MILLER	233 DAVIDSON PO BOX 238	Woodland	Cowlitz
-122.9225	46.1343	QUICK SHOP MINIT MART #39	1246 3RD AVE	Longview	Cowlitz
-122.9323	46.1465	HANDY ANDY #2 108	1310 OCEAN BEACH HIGHWAY	Longview	Cowlitz
-122.9121	46.1427	HOLT'S QUICK CHECK	400 PACIFIC N	Kelso	Cowlitz
-122.9332	46.1466	BP	1410 OCEAN BEACH HWY	Longview	Cowlitz
-120.1941	47.7017	AUVIL FRUIT CO INC RANCH #1	HC 78 BOX 42	Orondo	Douglas
-119.6946	48.0586	GK'S COUNTRY MARKET	557 STATE RT 173	Brewster	Douglas
-118.7384	48.6475	WAYNE'S CENTRAL SERVICE	615 S CLARK	Republic	Ferry
-118.7379	48.6465	ANDERSON'S GROCERY & FLOUR MILL	711 S CLARK AVE	Republic	Ferry
-119.1953	46.4594	MATHEWS CORNER MARKET	11284 TAYLOR FLATS RD	Pasco	Franklin
-117.6035	46.4747	INDUSTRIAL POWER CORPORATION	5TH AND MAIN ST	Pomeroy	Garfield
-119.2785	47.1382	SUN MART #24	640 N STRATFORD RD	Moses Lake	Grant
-119.8529	47.2339	Former Gas Station	500 CENTRAL AVENUE SOUTH	Quincy	Grant
-119.3233	47.1884	PORT OF MOSES LAKE	7810 ANDREWS ST NE	Moses Lake	Grant
-119.2572	47.1321	MOSES LAKE SOC 070705	418 N CLOVER DR	Moses Lake	Grant
-118.9953	47.9342	HICO # 1664	311 GRAND COULEE AVE	Grand Coulee	Grant

Appendix A - LUST Within 1-Mile of a High Susceptibility Well

X_LON	Y_LAT	SITE	ADDRESS	CITY	COUNTY
-119.3415	47.1037	COUNTRY STORE	4421 PRICHARD RD	Moses Lake	Grant
-119.8349	47.2390	QUINCY ALFALFA CO (LESEE)	901 E DIVISION ST	Quincy	Grant
-119.8606	47.0829	GEORGE EXXON GROCERY	226 ROYAL ANNE AVE	George	Grant
-124.1123	46.9082	MASCO PETROLEUM	361 E DOCK ST	Westport	Grays Harbor
-122.6554	48.3223	OAK HARBOR PLANT	3199 NORTH OAK HARBOR ROAD	Oak Harbor	Island
-122.6238	48.4002	MARINE CREW YARD	5256 N CORNET BAY RD	Oak Harbor	Island
-122.6262	48.3983	CORNET BAY PARTNERSHIP	200 NO CORNET BAY ROAD	Oak Harbor	Island
-122.6546	48.2859	SANITATION TREATMENT PLANT	1501 SE CITY BEACH ST PLANT	Oak Harbor	Island
-122.6581	48.2868	CHEVRON 91981	1359 W PIONEER WY	Oak Harbor	Island
-122.6584	48.2869	GERARD JOHN BAWYN	1366 W PIONEER WAY	Oak Harbor	Island
-122.7690	48.0461	PORT TOWNSEND PAPER CORP	FOOT OF 1ST AVE	Hadlock	Jefferson
-122.2317	47.3101	DON SMALL AND SONS OIL DISTRIBUTOR CO.	112 3RD NW	Auburn	King
-122.2253	47.3004	CENEX HARVEST STATES COOPERATIVES	238 8TH SE	Auburn	King
-122.2186	47.4832	UNOCAL 5024	59 RAINIER AVE	Renton	King
-122.1001	47.4665	TARGET EQUIPMENT RENTALS	18017 SE RENTON-MAPLE VALLEY HWY	Renton	King
-122.0211	47.3613	CONOCOPHILLIPS COMPANY-2603144	26821 MAPLE VALLEY HWY	Maple Valley	King
-122.2098	47.4849	77 Burnett Ave South	77 BURNETT AVE S	Renton	King
-122.1276	47.6798	REDMOND NIKE SITE 13/14		Redmond	King
-122.2311	47.3071	WICKHAM & SONS AUTO & TRUCK REPAIR	23 A STREET SW	Auburn	King
-122.2074	47.4737	GULL 1201	509 SOUTH GRADY WAY	Renton	King
-122.2386	47.4906	Skyway Market Former	12640 RENTON AVE S	Seattle	King
-122.2147	47.4756	PUGET SOUND CHRY-PLY INC.	585 RAINIER AVE S	Renton	King
-122.0736	47.5532	HENRY BACON BUILDING MATERIALS, INC.	5210 E. LK SAMMAMISH PKWY SE	Issaquah	King
-122.0709	47.7205	BEAR CREEK COUNTRY CLUB	13737 202ND AVE NE	Woodinville	King
-122.3931	47.7779	BULK PLANT	20500 RICHMOND BEACH DR NW	Shoreline	King
-122.2035	47.4869	RENTON EAGLE MART	401 PARK AVE N	Renton	King
-122.1285	47.6741	SHULTZ DISTRIBUTING INC.	7822 180TH AVE NE	Redmond	King
-122.2185	47.4802	WALKER'S RENTON SUBARU USED CARS	250 RAINIER AVE S	Renton	King
-122.2186	47.4816	ARCO AM/PM MINI MARKET	175 RAINIER AVE S	Renton	King
-122.2181	47.4853	CASTAWAYS RESTAURANT	1101 W PERIMETER RD	Renton	King
-122.1867	47.6660	CONOCOPHILLIPS COMPANY-2611061	5100 NE 25TH AVE	Seattle	King
-122.2569	47.2725	PACIFIC ARCO	401 ELLINGSON RD	Pacific	King
-122.2157	47.4808	COOKS CHEVRON MART II	201 S 3RD ST	Renton	King
-122.2161	47.4749	RENTON 1	621 RAINIER AVE S	Renton	King
-122.2216	47.3211	ASPI DBA PDQ OIL CO #94998	1501 AUBURN WAY N	Auburn	King

Appendix A - LUST Within 1-Mile of a High Susceptibility Well

X_LON	Y_LAT	SITE	ADDRESS	CITY	COUNTY
-122.2328	47.3076	AUBURN COLLISION CENTER	233 W MAIN ST	Auburn	King
-122.4593	47.4477	VASHON EAST SHOPPING CTR OLD CHEVRON	9740 SW BANK RD & VASHON HWY	Vashon	King
-122.1232	47.6747	ARCO #6067/5076	8009 164TH AVE NE	Redmond	King
-122.2216	47.3205	TEXACO STAR MART #63-232-1409	1439 AUBURN WAY N	Auburn	King
-122.0467	47.5519	BROWN BEAR CAR WASH	22121 SE 56TH ST	Issaquah	King
-122.1442	47.6546	7-ELEVEN (CHEVRON) # 2306-19339T	5040 148TH AVE NE	Redmond	King
-122.4605	47.4448	VASHON MART	17803 VASHON HWY SW	Vashon	King
-121.7694	47.4860	FRANK PADAVICH	1130 E NORTH BEND WAY	North Bend	King
-122.1256	47.6742	REDMOND CHEVRON	16010 REDMOND WAY	Redmond	King
-122.2269	47.3112	JACKPOT FOOD MART 309	415 AUBURN WAY NE	Auburn	King
-122.0919	47.4618	FORMER KING CNTY SHOPS SITE	18825 SE MAPLE VALLEY RD	Maple Valley	King
-122.1977	47.4160	CIRCLE K NO. 1602	20727 108TH AVE	Kent	King
-122.2215	47.3231	DOUGS AUTO ROW 76	1725 AUBURN WAY N	Auburn	King
-122.1981	47.4309	FRIENDLY FOOD MART	19044 108TH AVE SE	Renton	King
-122.2281	47.3130	AUBURN PRINT33 LS051 3RDSUB MP21.5	T21N R4EWM	Auburn	King
-122.2318	47.3075	V DUB CENTRAL	123 W MAIN	Auburn	King
-122.2074	47.4701	EXXON STATION - BERKWITH	3100 BENSON RD. SOUTH	Renton	King
-122.1017	47.6671	TWIN PEAKS EQUIPMENT	17950 REDMOND WAY	Redmond	King
-122.2177	47.4732	SOUND FORD INC	750 RAINIER AVE S	Renton	King
-122.2017	47.4764	SEARS ROEBUCK & COMPANY	359 RENTON CENTER WAY S.W.	Renton	King
-122.2497	47.4989	CONOCOPHILLIPS COMPANY-2603161	11655 S RENTON AVE	Seattle	King
-122.2147	47.4848	SDS PARTNERS	307 AIRPORT WY S	Renton	King
-122.3337	47.2674	CLARKS PAYLESS OIL COMPANY	215 373RD STREET S	Federal Way	King
-121.9911	47.2313	STOP N SHOP	41604 264TH AVE SE	Enumclaw	King
-122.2036	47.4926	RENTON PLANT	800 PARK AVE N	Renton	King
-122.2214	47.3267	7-ELEVEN 2303-27219	2202 AUBURN WAY N	Auburn	King
-122.1001	47.6754	UNITED PARCEL SERVICE-REDMOND	18001 NE UNION HILL RD	Redmond	King
-122.1974	47.6664	SHELL OIL PRODUCTS	10801 NE 68TH ST	Kirkland	King
-122.1404	47.6477	HOBART CORPORATION	4600 150TH AVE N.E.	Redmond	King
-122.2497	47.2646	CITY OF PACIFIC	100 3RD AVE SE	Pacific	King
-121.7518	47.4779	(FORMER) UNOCAL SERVICE STN 2237 / AKA NOBLE PROPERTY	330 & 354 E NORTH BEND WY	North Bend	King
-121.7895	47.4964	BRYAN'S ONE STOP	302 W NORTH BEND WAY	North Bend	King
-121.7849	47.4936	NORTH BEND TEXACO	225 E NORTH BEND WAY	North Bend	King
-122.2279	47.4273	SCARSELLA BROS. INC.	19440 84TH AVE S	Kent	King
-122.1147	47.6724	US NATIONAL BANK OF WA-BEAR CREEK	17000 AVONDALE WAY NE	Redmond	King

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X_LON	Y_LAT	SITE	ADDRESS	CITY	COUNTY
-122.2279	47.4295	MASTER-HALCO INC.	19240 E VALLEY HWY	Kent	King
-122.2167	47.4733	USA MINI MART #115	765 RAINIER AVE S	Renton	King
-122.2080	47.4806	RENTON CO 070276	225 WILLIAMS AVE SO	Renton	King
-122.1677	47.6398	BELLEVUE PETROLEUM, INC.	3204 129TH PL SE	Bellevue	King
-122.2166	47.4787	SAFEWAY	103 S 3RD	Renton	King
-122.6270	47.6987	NUWC DIVISION, KEYPORT	COMMANDER NAVY REGION NW	Keyport	Kitsap
-122.6309	47.5047	BETHEL TEXACO (FORMER)	BETHEL RD & SEDGWICK RD	Port Orchard	Kitsap
-122.5239	47.6359	BAINBRIDGE ISLAND HIGH SCHOOL	9330 HIGH SCHOOL RD NE	Bainbridge Island	Kitsap
-122.6192	47.6515	LYNN'S MARKET INC.	9730 BROWNSVILLE HWY NE	Bremerton	Kitsap
-122.5172	47.6247	CHEVRON 96142	353 VILLAGE PLAZA	Bainbridge Island	Kitsap
-122.6316	47.4873	BETHEL GARAGE	6750 BETHEL RD SE	Port Orchard	Kitsap
-122.6487	47.8024	MASCO PETROLEUM, INC.	26484 ST HWY 3	Poulsbo	Kitsap
-122.5143	47.6246	UNOCAL STATION 4388	101 OLYMPIC WAY	Bainbridge Island	Kitsap
-122.7845	47.5198	ACE PAVING	4795 WILKERSON ROAD	Bremerton	Kitsap
-122.7066	47.6543	CIRCLE K/76 #2705522	10023 OLD FRONTIER RD NW	Silverdale	Kitsap
-122.6327	47.5048	SEDGWICK ONE STOP BP	1701 SEDGWICK RD	Port Orchard	Kitsap
-122.5168	47.6357	CAR WASH	1220 HILDEBRAND LN NE	Bainbridge Island	Kitsap
-120.6663	47.0528	BINGO FUEL STOP	EXIT 101 ON I-90	Thorp	Kittitas
-120.5384	46.9709	BROADWAY TRUCK STOP/SERVICE	2300 CANYON RD	Ellensburg	Kittitas
-120.9565	47.1962	G & W OIL AND WOOD, INC	CEMETARY RD	Cle Elum	Kittitas
-120.9298	47.1940	B & G SERVICE	517 EAST FIRST STREET	Cle Elum	Kittitas
-120.5322	46.9624	MILLPOND MANOR MOBILE HOME PARK	2900 CANYON ROAD	Ellensburg	Kittitas
-120.9410	47.1949	D & J FOOD MART	201 W 1ST ST	Cle Elum	Kittitas
-120.9411	47.1951	CLE ELUM CITY	202 FIRST ST W	Cle Elum	Kittitas
-121.1796	47.2379	CB GENERAL STORE AND SERVICES	111 RAILROAD AVE	Easton	Kittitas
-120.9317	47.1969	CLE ELUM SHELL, INC.	207 W 1ST ST	Cle Elum	Kittitas
-120.4177	46.9859	WIRTS SERVICE	319 N MAIN	Kittitas	Kittitas
-121.4809	45.7262	TOWN PUMP GAS STATION	521 EAST JEWETT BLVD	White Salmon	Klickitat
-121.4555	45.7172	HUNSAKER OIL COMPANY, INC.	102 E STEUBEN	Bingen	Klickitat
-121.1518	45.8173	KLICKITAT TRADER INC.	101 N MAIN ST	Klickitat	Klickitat
-121.4597	45.7197	UNOCAL BULK PLANT 0046	217 E STEUBEN ST	Bingen	Klickitat
-121.5073	45.7400	KLICKITAT COUNTY SHOP WHITESALMON	1330 SW CHILDS RD	White Salmon	Klickitat
-122.8883	46.5849	EAGLE PLAZA TRUCK STOP	110 ESTEP RD	Chehalis	Lewis
-122.9566	46.7149	CENTRALIA MARKET SQUARE	SHOPPING CENTER	Centralia	Lewis
-122.9898	46.7363	Parkway Mobile Home Park	1740 HARRISON AVE	Centralia	Lewis

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X_LON	Y_LAT	SITE	ADDRESS	CITY	COUNTY
-122.8469	46.4442	SHORT STOP GROCERY	560 5TH ST N	Toledo	Lewis
-122.9791	46.6528	WEYERHAEUSER COMPANY	1100 SW SYLVENUS ST	Chehalis	Lewis
-122.9742	46.7115	BRUCE BISHOP	1221 MELLEN & I-5	Centralia	Lewis
-122.9817	46.6492	ANDERSON CONSTRUCTION	644 SHOREY RD	Chehalis	Lewis
-122.9412	46.4945	SCHOOL BUS GARAGE	KING RD AND BYHAM RD	Winlock	Lewis
-122.2751	46.5588	MC KENZIE AUTOMOTIVE/SHELL MART	103 2ND ST	Morton	Lewis
-122.8490	46.4416	TOLEDO SCHOOL DISTRICT NO. 237	155 FIFTH/PO BOX 469	Toledo	Lewis
-121.9243	46.5340	RANDLE ONE STOP	10114 HWY 12	Randle	Lewis
-122.9724	46.6606	CENEX SUPPLY & MARKETING, INC.	158 STATE ST	Chehalis	Lewis
-122.9684	46.7186	FOOD MART 381	102 HARRISON	Centralia	Lewis
-122.9400	46.4931	HANDI STORE	503 KERRON ST	Winlock	Lewis
-122.9385	46.4904	FRED SHELL	111 KERRON	Winlock	Lewis
-122.9777	46.7276	CHEVRON 93124	1050 HARRISON	Centralia	Lewis
-122.9537	46.7206	CITY OF CENTRALIA FIRE DEPT	512 N PEARL	Centralia	Lewis
-123.0598	46.6281	ADNA GROCERY	109 BUNKER CREEK RD	Chehalis	Lewis
-122.9724	46.6606	CENEX HARVEST STATES COOPERATIVES	153 NW STATE ST	Chehalis	Lewis
-122.8551	46.5942	LEWIS COUNTY CENTRAL SHOP	109 FOREST NAPAVINE RD	Chehalis	Lewis
-122.9704	46.6616	LEWIS COUNTY CAR POOL	476 W MAIN	Chehalis	Lewis
-122.9734	46.7112	FREEWAY MART	1232 MELLEN ST	Centralia	Lewis
-122.9579	46.7169	APEX GROCERY II	402 W MAIN STREET	Centralia	Lewis
-122.9897	46.6593	CHEHALIS SUBSTATION	1140 STATE HWY 603	Chehalis	Lewis
-122.9652	46.6571	CHEHALIS SCHOOL DISTRICT NO 302	261 SW 3RD ST	Chehalis	Lewis
-122.9805	46.7285	TEXACO 63-802-1033	1111 HARRISON STREET	Centralia	Lewis
-122.9361	46.6350	MODULINE INTERNATIONAL, INC.	124HABIEN RD	Chehalis	Lewis
-122.9071	46.6079	CHEHALIS SHELL TRUCK STOP	1366 RUSH RD	Chehalis	Lewis
-122.9739	46.6616	FOOD MART 383	614 W MAIN ST	Chehalis	Lewis
-122.9790	46.7277	BORST PARK BP	1010 BELMONT ST	Centralia	Lewis
-123.1243	47.2386	MASON COUNTY TRANSPORTATION COOPERATIV	3740 SHELTON SPRINGS RD	Shelton	Mason
-123.0091	47.2652	DEER CREEK STORE	5881 E HWY 3	Shelton	Mason
-123.1427	47.4062	HOODSPORT RANGER STATION	N 150 LAKE CUSHMAN RD	Hoodsport	Mason
-123.1418	47.4042	ROBERT VELKOV	W 24151 HWY 101	Hoodsport	Mason
-122.8770	47.4318	PARK PLACE ON HOOD CANAL	NE 3150 HWY 300	Belfair	Mason
-119.4350	48.9394	QUICK MART	1501 MAIN ST	Oroville	Okanogan
-119.6340	48.8219	LOOMIS KWIK STOP	18 E PALMER AVE	Loomis	Okanogan
-119.5285	48.4130	PACIFIC COCA-COLA BOTTLING COMPANY	123 N MAIN STREET	Omak	Okanogan

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X_LON	Y_LAT	SITE	ADDRESS	CITY	COUNTY
-119.4348	48.9401	JACKPOT 081	1518 MAIN ST	Oroville	Okanogan
-119.5375	48.4021	OMAK GULL #611	607 OKOMA DR	Omak	Okanogan
-119.4354	48.9405	DALES TEXACO	1714 MAIN ST	Oroville	Okanogan
-119.5299	48.4101	OMAK CHEVRON	30 S MAIN	Omak	Okanogan
-119.4477	48.6964	WA DOT TONASKET MAINTENANCE SITE	SR97, MP 314.3	Tonasket	Okanogan
-119.4305	48.9354	ORO FRUIT CO.	224 APPLEWAY AVE	Oroville	Okanogan
-124.0482	46.4911	GUELFI'S WEST	1702 BAY AVE	Ocean Park	Pacific
-117.0441	48.1812	UNOCAL SERVICE STATION 0794	FIRST & WASHINGTON	Newport	Pend Oreille
-117.0555	48.1821	MUZZY OIL COMPANY	131 WEST PINE	Newport	Pend Oreille
-122.3979	47.0537	WAGON WHEEL SHELL	22321 MOUNTAIN HWY	Spanaway	Pierce
-122.4804	47.2281	NALLEY'S FINE FOODS	3303 SO. 35TH ST. PO BOX 11046	Tacoma	Pierce
-122.3563	47.2433	UNOCAL 4836	2001 54TH AVE E	Tacoma	Pierce
-122.0471	47.1043	Wilkeson City Hall	519 CHURCH ST	Wilkeson	Pierce
-122.6054	47.3393	PAPE & SONS CONSTRUCTION, INC.	9512 STATE HWY 16 NW	Gig Harbor	Pierce
-122.2647	46.8677	ELWYN R RAHIER	100 WASH. AVE. N/PO BOX 217	Eatonville	Pierce
-122.6682	47.2898	ARLETTA FOODS	3520 RAY NASH DR NW	Gig Harbor	Pierce
-122.4628	47.1795	TEXACO STATION #63-232-0400	8433 SOUTH HOSMER	Tacoma	Pierce
-122.3758	47.0548	CAR WASH ENTERPRISES	11722 MERIDIAN E	Puyallup	Pierce
-122.3615	47.2439	CAC INC	5018 PAC HWY E	Tacoma	Pierce
-122.4675	47.1564	ARCO AM/PM MINI MARKET	11109 STEELE ST	Tacoma	Pierce
-122.4343	47.1367	TEXACO STATION #63-232-0349	13221 PACIFIC AVE	Tacoma	Pierce
-122.3908	47.0442	ELK PLAIN COUNTY SHOP	23101 MOUNTAIN HWY E	Spanaway	Pierce
-122.4359	47.1072	JACKPOT STATION 320	16521 PACIFIC AVE S	Spanaway	Pierce
-122.4877	47.2136	BURLINGTON NORTHERN RAILROAD	4802 BURLINGTON WAY	Tacoma	Pierce
-122.3189	47.2056	JACKPOT 315	6112 RIVER ROAD	Puyallup	Pierce
-122.3582	47.1542	BP 11087	11201 CANYON ROAD EAST/112TH	Puyallup	Pierce
-122.3184	47.1905	PIONEER SERVICE	1707 PIONEER W	Puyallup	Pierce
-122.4629	47.1812	BP 03113	1830 SO 84TH	Tacoma	Pierce
-122.4754	47.2291	PARKER PAINT	3003 SOUTH TACOMA WAY	Tacoma	Pierce
-122.2935	47.1036	SHELL OIL PRODUCTS	16104 MERIDIAN E	Puyallup	Pierce
-122.3583	47.2392	CHEVRON	5319 20TH ST E	Tacoma	Pierce
-122.6263	47.3842	PURDY 76	13818 PURDY DR	Gig Harbor	Pierce
-122.4341	47.0980	CHEVRON STATION #95851	17519 PACIFIC AVE	Spanaway	Pierce
-122.3565	47.2432	CIRCLE K/76 #2705486	5405 PACIFIC HWY E	Fife	Pierce
-122.4840	47.1639	CIRCLE K/76 #2705525	10302 S TACOMA WAY	Lakewood	Pierce

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X_LON	Y_LAT	SITE	ADDRESS	CITY	COUNTY
-122.4845	47.1901	SOUTH TACOMA 76	7404 S TACOMA WAY	Tacoma	Pierce
-122.3573	47.2387	CONOCOPHILLIPS COMPANY-2603139	2002 E 54TH	Fife	Pierce
-122.4873	47.2078	PIONEER BUILDERS SUPPLY CO.	5401 S BURLINGTON WAY	Tacoma	Pierce
-122.3566	47.2473	WORMALD FIRE SYSTEMS	1106 54 AVE E	Tacoma	Pierce
-122.2690	47.1918	BUNCE U-RENT	1812 E MAIN ST	Puyallup	Pierce
-122.4790	47.2268	SHULTZ DISTRIBUTING INC.	3224 SOUTH TACOMA WAY	Tacoma	Pierce
-122.7603	47.2059	LONGBRANCH MERCANTILE - K ALAN CARLSON	5210 KEY PENINSULA HWY S	Longbranch	Pierce
-122.2616	47.1888	BEST PARKING LOT CLEANING TRUST	2412 INTERURBAN AVE	Puyallup	Pierce
-122.4799	47.2326	PETROCARD	3059 S LAWRENCE ST	Tacoma	Pierce
-122.3564	47.2391	TEXACO STATION #63-232-0500	5501 20TH ST E	Fife	Pierce
-122.3576	47.1396	COLLINS GROCERY	12724 CANYON ROAD EAST	Puyallup	Pierce
-122.2937	47.1183	CONOCOPHILLIPS COMPANY - 2705504	15202 MERIDIAN AVE S	Puyallup	Pierce
-122.4629	47.1815	CONOCOPHILLIPS COMPANY-2611090	8235 S HOSMER	Tacoma	Pierce
-122.8895	48.7030	ORCAS POWER AND LIGHT COMPANY	2 MT BAKER RD (PLANT)	Eastsound	San Juan
-121.9977	48.5300	CROWN PACIFIC	MP 77 HWY 20	Hamilton	Skagit
-122.0633	48.5293	ASSOCIATED PETROLEUM PRODUCTS, INC.	31387 HWY 20	Lyman	Skagit
-122.3662	48.4300	FOOD MART 155	1559 MEMORIAL HWY	Mount Vernon	Skagit
-121.8811	45.6950	HUNSAKER OIL - STEVENSON STATION	2ND & COLUMBIA	Stevenson	Skamania
-122.1218	48.1963	ARLINGTON SCHOOL DISTRICT #16	410 GIFFORD	Arlington	Snohomish
-121.7044	47.8577	GOLD BAR MARKET	109 CROFT W	Gold Bar	Snohomish
-122.1278	48.1979	FRONTIER BANK	525 N OLYMPIC	Arlington	Snohomish
-117.2538	47.6871	GOBER'S OIL INC.	11215 E TRENT	Spokane	Spokane
-117.5232	47.6199	SPOKANE AIRWAYS INC	3727 S. DAVISON BLVD, BLDG 701	Spokane	Spokane
-117.4765	47.9448	QWIK STOP #635	SOUTH MALL	Deer Park	Spokane
-117.5774	47.6438	HAYFORD CONOCO	10724 W SUNSET HWY	Spokane	Spokane
-117.1959	47.5194	FREEMAN SCHOOL DISTRICT #358	14626 S JACKSON RD	Freeman	Spokane
-117.3960	47.6834	WATER YARDS (WATER DEPARTMENT)	914 E NORTH FOOTHILLS DR	Spokane	Spokane
-117.6010	47.6433	TESORO 2GO #62131	14024 W SUNSET HWY	Medical Lake	Spokane
-117.3205	47.6685	EXXON SPOKANE TERMINAL	6311 E SHARP AVE	Spokane Valley	Spokane
-117.2088	47.6890	KAISER ALUMINUM & CHEMICAL INC	15000 E EUCLID AVENUE PO BOX 151	Spokane	Spokane
-117.6016	47.6432	HEIGHTS MINI MART	13722 W SUNSET HWY	Airway Heights	Spokane
-117.1967	47.5213	FREEMAN STORE	14510 S STAR RR 27	Valleyford	Spokane
-117.2580	47.6574	A TO Z RENTALS & SALES, INC.	10903 E SPRAGUE	Spokane	Spokane
-117.2973	47.6566	QWIK STOP #1635	8119 SPRAGUE AVE E	Spokane	Spokane
-117.6204	48.0604	LOON LAKE SELF-SERVICE	3937 GARDENSPOT RD	Loon Lake	Stevens

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X_LON	Y_LAT	SITE	ADDRESS	CITY	COUNTY
-117.7250	48.1750	J & P'S SERVICE	3080 HWY 231	Valley	Stevens
-122.8463	47.0811	MICKS MOBIL SERVICE & TOWING	3427 SCHINCKE RD	Olympia	Thurston
-122.9180	46.9810	EQUILON ENTERPRISES LLC	7370 LINDERSON WAY SW	Tumwater	Thurston
-122.9762	47.0077	BLACK LAKE GROCERY	4409 BLACK LAKE BLVD SW	Olympia	Thurston
-122.9407	46.9527	RESTOVER TRUCKSTOP	2725 93RD AVE SW	Olympia	Thurston
-122.9179	46.9688	AIRPORT FUEL STOP	8220 CENTER ST SW	Tumwater	Thurston
-122.9155	47.0001	CHEVRON 90956	670 TROSPER RD SW	Tumwater	Thurston
-122.9531	47.0467	LEW RENTS WEST, INC.	405 MCPHEE SW	Olympia	Thurston
-122.7647	47.0570	CIRCLE K/76 #2705496	1105 MARVIN RD NE	Lacey	Thurston
-122.8983	46.9773	PEARSON AIR INC.	7529 OLD HWY 99	Olympia	Thurston
-122.9957	47.0463	MUD BAY EQUIPMENT STORAGE AREA	DELPHI RD SW 300 FT OFF MUD BAY RD	Olympia	Thurston
-122.9138	46.9997	CIRCLE K/76 #2705577	501 TROSPER RD SW	Tumwater	Thurston
-122.7843	47.0528	TANGLEWILD CHEVRON	7291 MARTIN WAY E	Olympia	Thurston
-122.7218	47.0656	NISQUALLY AUTOMOTIVE & TOWING	10246 MARTIN WAY E	Olympia	Thurston
-122.8354	46.9669	EAST OLYMPIA GROCERY #617	8245 RICH RD SE	Olympia	Thurston
-122.9101	46.9995	7-ELEVEN FOOD STORE #2303-14479-M	5310 CAPITOL BLVD S	Tumwater	Thurston
-118.3897	46.0443	THE EXPRESS	406 S COLLEGE AVE	College Place	Walla Walla
-118.6464	46.2949	EUREKA FARM	MILE POST 20 ON STATE HWY 124	Prescott	Walla Walla
-118.1533	46.2707	WAITSBURG CITY SHOP	130 COPPEI AVE	Waitsburg	Walla Walla
-122.5646	48.8181	FRIESE HIDE & TALLOW CO. INC.	1524 SLATER RD.	Ferndale	Whatcom
-122.5820	48.8448	FERNDALE EXPRESS LANE	1846 MAIN	Ferndale	Whatcom
-122.2885	48.8434	DODSON'S MARKET	3705 MOUNT BAKER HWY	Everson	Whatcom
-122.5738	48.8460	STARVIN' SAM'S MINI MART NO. 4	5639 BARRETT AVE	Ferndale	Whatcom
-122.4858	48.8920	MIDWAY CHEVRON AND MINI MART	6905 GUIDE MERIDIAN	Lynden	Whatcom
-122.5766	48.8469	FERNDALE TRUCK STOP	1678 MAIN ST # 3	Ferndale	Whatcom
-122.5799	48.8450	FERNDALE TEXACO	1811 MAIN ST	Ferndale	Whatcom
-122.3427	48.9201	W MAIN ST & S WASHINGTON ST	101 W MAIN	Everson	Whatcom
-117.0773	46.9098	PALOUSE PRODUCERS INC	E MAIN & J STREET	Palouse	Whitman
-122.5926	45.6367	OLD JENSEN TEXACO	6TH & WHITMAN	Rosalia	Whitman
-117.6856	46.9285	ENDICOTT SCHOOL DIST. #38-308	SW1/4,SE1/4,SECT.30,T17N,R41E	Endicott	Whitman
-117.0703	46.9123	PALOUSE SCHOOL DISTRICT 301	EAST 600 ALDER	Palouse	Whitman
-117.2417	47.1281	LARRY'S SERVICE	107 E STEPTOE ST	Oakesdale	Whitman
-117.0754	46.9098	LONESOME PINE SMALL ENG REPAIR	205 E MAIN	Palouse	Whitman
-117.3699	47.2366	THE TIRE SHOP/ROSALIA CHEVRON	412 SOUTH WHITMAN	Rosalia	Whitman
-117.1796	46.7296	U.S. BANK SITE (LESSEE)	339 E. MAIN	Pullman	Whitman

Appendix A - LUST Within 1-Mile of a High Susceptibility Well

X_LON	Y_LAT	SITE	ADDRESS	CITY	COUNTY
-117.1407	47.0135	GARFIELD SCHOOL DISTRICT 302	BOX 398	Garfield	Whitman
-117.0719	47.2242	DORSEY CHEVROLET	N 201 BROADWAY PO BOX 1049	Tekoa	Whitman
-117.1766	46.7363	2GO TESORO #62160	770 GRAND AVE N	Pullman	Whitman
-117.1777	46.7295	RENNIE KEASAL'S SERVICE	485 E MAIN	Pullman	Whitman
-117.1919	46.7319	SCHOOL BUS GARAGE	NW 935 OLSEN STREET	Pullman	Whitman
-117.1710	46.7394	CAMPUS CHEVRON	NE 400 STADIUM WAY	Pullman	Whitman
-117.1805	46.7374	PULLMAN MOSCOW REGIONAL AIRPORT	ROUTE 3 BOX 850	Pullman	Whitman
-120.0118	46.3239	JOHNNY'S MOBIL	636 E EDISON	Sunnyside	Yakima
-120.0206	46.3035	ARTHUR LEYENDEKKER/DBA KELLOGGS KORNER	270 MIDVALE RD	Sunnyside	Yakima
-120.5126	46.6239	TIGER MART	1808 1ST ST N	Yakima	Yakima
-120.0141	46.3252	CASCADE NATURAL GAS CORP DISTRICT OFC	512 DECATUR AVE	Sunnyside	Yakima
-120.6994	46.7283	PIT STOP	10121 HWY 12	Naches	Yakima
-120.4804	46.6045	CHEVRON 93883	1602 TERRACE HEIGHTS RD	Yakima	Yakima
-119.8952	46.2562	RE POWELL DISTRIBUTING	501 E WINE COUNTRY RD	Grandview	Yakima
-119.9999	46.3279	PIK A POP #11	1524 YAKIMA VALLEY HWY	Sunnyside	Yakima
-120.0103	46.3290	CIRCLE L	809 HWY 12	Sunnyside	Yakima
-120.0034	46.3269	ROZA IRRIGATION DISTRICT	125 13TH ST	Sunnyside	Yakima
-120.5376	46.5993	US ARMY	YAKIMA FIRING CENTER	Yakima	Yakima
-120.5182	46.6026	5TH AVE SHELL	216 N 5TH AVE	Yakima	Yakima
-120.0133	46.3293	JERRY'S STEEL SUPPLY, INC.	232 N SIXTH ST.	Sunnyside	Yakima
-120.5340	46.6153	CASCADE FRUIT PRODUCTS, INC	1819 W J ST	Yakima	Yakima
-120.5106	46.6241	BEKINS MOVING & STORAGE CO.	1891 N 1ST ST	Yakima	Yakima
-120.5397	46.6128	CITY OF YAKIMA PUBLIC WORKS DEPT	2301 FRUITVALE BLVD	Yakima	Yakima
-119.9984	46.2113	MABTON MINI MART	MAIN & STATE HWY 22	Mabton	Yakima
-120.0205	46.3164	VALLEY VIEW GAS MART 068	107 W LINCOLN	Sunnyside	Yakima
-120.5309	46.6558	ROADRUNNER DELI MART INC	103 W FREMONT	Selah	Yakima
-120.0154	46.3092	SUN KING FRUIT COMPANY	325 E SOUTH HILL ROAD	Sunnyside	Yakima
-120.0098	46.3237	THE FRY BUILDING/CLOSED	111 N 6TH STREET	Sunnyside	Yakima
-120.5200	46.6213	C.M. HOLTZINGER FRUIT CO. INC.	1312 N 6TH AVENUE	Yakima	Yakima
-120.5120	46.6181	ALLEN & ENNIS	1216-1218 N 1ST ST	Yakima	Yakima
-120.5181	46.6025	DYNAMART YAKIMA FIFTH AVENUE	202 5TH AVE S	Yakima	Yakima
-120.0147	46.3237	UNION PACIFIC RAILROAD-SUNNYSIDE	S 5TH AVE & EDISON	Sunnyside	Yakima
-120.0073	46.3167	BOB'S AUTO CLINIC	1006 LINCOLN	Sunnyside	Yakima
-120.6498	46.5821	HARWOOD GROCERY	10605 WIDE HOLLOW RD	Yakima	Yakima
-120.0004	46.3169	JACKPOT FOOD MART 066	1121 S 16TH ST	Sunnyside	Yakima

Appendix A - LUST Within 1-Mile of a High Susceptibility Well

X_LON	Y_LAT	SITE	ADDRESS	CITY	COUNTY
-120.5109	46.6235	BIG VALLEY MOTEL	1504 N 1ST ST	Yakima	Yakima
-120.4044	46.5620	MOXEE CITY SHOP & STP	7520 POSTMA RD	Moxee	Yakima
-120.7196	46.7335	LAYMAN LUMBER COMPANY, INC.	11160 HWY 12	Naches	Yakima
-119.9868	46.3223	PET HEALTH CLINIC	2210 A E EDISON RD	Sunnyside	Yakima
-120.4804	46.6045	SUNFAIR CHEVROLET, INC.	1600 E YAKIMA AVE	Yakima	Yakima
-119.9978	46.3257	BLEYHL FARM SERVICE, INC.	EASTWAY SHOP CTR	Sunnyside	Yakima
-120.7006	46.7284	SUN MART # 21	10171 HWY 12	Naches	Yakima
-120.5155	46.6144	NAKANO FOODS	115 WEST "I" STREET	Yakima	Yakima
-120.0151	46.3136	SUNNYSIDE VALLEY IRRIGATION DISTRICT-SHOP	1433 SO 4TH STREET	Sunnyside	Yakima
-120.7197	46.7334	JAMES G LAYMAN INC	10920 HIGHWAY 12	Naches	Yakima
-120.4069	46.5625	EAST VALLEY MARKET	7208 POSTMA RD	Yakima	Yakima
-120.3853	46.5553	JAY LACOURSIERE	106 EAST MOXEE A	Moxee	Yakima
-120.0109	46.3296	BURLINGTON NORTHERN RAIL TERMINAL	MP.54.5 12TH SUB. PORTLAND DIV.	Sunnyside	Yakima
-120.0133	46.3201	BARGAIN HUT	515 HARRISON	Sunnyside	Yakima
-120.5119	46.6139	MICHELSON PACKAGING	902 N 1ST STREET	Yakima	Yakima
-119.8943	46.2594	SUNNYSIDE VALLEY IRRIGATION DISTRICT	405 N ELM ST	Grandview	Yakima
-119.9016	46.2560	GRANDVIEW MARKET 070	100 E WINE COUNTRY RD	Grandview	Yakima
-120.5177	46.6144	RH BOWLES COMPANY INC	401 W I ST	Yakima	Yakima
-119.9021	46.2559	DEBOCKS MAIN STREET TEXACO	100 W WINE COUNTRY RD	Grandview	Yakima

Appendix B – MTBE LUST Site Information

Appendix B MTBE LUST Site Information

Appendix B contains information on LUST sites where MTBE was detected in ground water. Two data sets were used for Appendix B: 1) the Ecology 2000 MBE study, and 2) ground water monitoring data from 43 Washington Chevron LUST sites (2001-04). These two data sets were then combined and a GIS search was used to identify MTBE LUST sites within 1-mile of a high susceptibility well. Please be aware that MTBE is highly soluble in water and concentrations often decrease rapidly over time. Thus, MTBE data from several years ago may not be representative of current conditions.

Table 61: MTBE LUST Sites Within 1-Mile of a High Susceptibility Well.

X_LON	Y_LAT	Site	MTBE[46] 8021 (ug/l)	MTBE[47] 8260 (ug/l)	Date[48]	Address	City
-122.1677	47.6398	Bellevue Petroleum Inc.	36	34	16-Sep-03	3204 129th Place Southeast	Bellevue
-122.5168	47.6357	Car Wash	30	26	3-Jan-04	1220 Hildebrand Lane NE	Bainbridge Island
-122.3583	47.2392	Chevron 9-7135	17	18	15-Jan-04	5319 20th Street East	Fife
-122.2647	46.8677	Chevron Bulk Plant 206394	8.3	6	28-Jan-04	117 N. Washington Ave.	Eatonville
-119.5299	48.4101	Coleman Oil Company	173	3	8-Nov-01	30 South Main Street	Omak
-122.6004	45.6444	Conoco Phillips Co.-2611044	--	5.5	1-Oct-00	3105 NE Andersen	Vancouver
-120.9410	47.1949	D & R Food Mart	18	19	27-Feb-04	201 W 1ST ST	Cle Elum
-122.6575	45.7178	Expressway Food Store No. 609	--	36	1-Oct-00	1309-A NE 134th St.	Vancouver
-122.4856	48.8919	Midway Chevron & Mini Mart	--	1	1-Oct-00	6905 Guide Meridian	Lynden
-117.1777	46.7295	Rennie Keasal's Service	2.5	31	13-Aug-01	485 East Main St.	Pullman
-122.2150	47.4750	Renton 1	--	4.6	1-Oct-00	621 Rainier Ave. S.	Renton
-122.3615	47.2439	Taco Bell Former Chevron 9-7376	3.2	3	14-Jan-03	5018 Pacific Highway East	Fife
-122.7447	45.9075	Toad's Express Mart and Deli	--	113	1-Oct-00	1455 Hoffman	Woodland
-122.5891	45.6587	Vancouver Mall East Chevron	310	300	18-Jan-04	9414 NE Vancouver Mall DR	Vancouver
-122.0445	47.3898	Wilderness Chevron	48	37	24-Apr-04	23701 Maple Valley Hwy	Maple Valley

NOTE: DECIMAL LAT / LON = NAD_27

[46] MTBE by EPA Method 8021.
[47] MTBE by EPA Method 8260.
[48] Date of MTBE sampling. The Oct-00 dates are data from the Ecology 2000 MTBE study. The 2001-04 dates are data from Chevron LUST sites.

Table 62: MTBE LUST Site High Susceptibility Well Data.

X_LON	Y_LAT	Site	Nearest Well(s)	Distance (ft.)	Direction	*Type	Well Depth (ft.)	Pumping Rate (gpm)
-122.1677	47.6398	Bellevue Petroleum Inc.	Trails End Well #1	5,000	NE	Group A	71	100
			Trails End Well #2	5,000	NE	Group A	90	100
-122.5168	47.6357	Car Wash	Bainbridge Island Commodore Well	1,300	NW	Group A	380	100
-122.3583	47.2392	Chevron 9-7135	Fife Public Works Well #5	5,000	NE	Group A	687	250
-122.2647	46.8677	Chevron Bulk Plant 206394	Eatonville Water Dept Well #1	3,200	SE	Group A	52	175
			Eatonville Water Dept Well #2	3,200	SE	Group A	44	150
			Eatonville Water Dept Mashell River	3,200	SE	Group A	0	500
-119.5299	48.4101	Coleman Oil Company	Omak Apple	1,000	SW	Group A	20	480
			Omak Kenwood Well	800	NE	Group A	30	500
-122.6004	45.6444	Conoco Phillips Co.-2611044	City of Vancouver WS #15 Well #1 WW	4,700	NE	Group A	141	480
			City of Vancouver WS #15 Well #2 WW	4,700	NE	Group A	124	500
-120.9410	47.1949	D & R Food Mart	Cle Elum Water Department River Well	2,000	SW	Group A	0	1,000
-122.6575	45.7178	Expressway Food Store No. 609	Clark Public Utilities Well #19	3,700	SW	Group A	32	960
			Clark Public Utilities Well #17	4,600	SE	Group A	80	800
			Clark Public Utilities Well #9	5,200	SE	Group A	80	800
-122.4856	48.8919	Midway Chevron & Mini Mart	Pole Road Water Assn. Well #2	3,000	W	Group A	48	200
			Pole Road Water Assn. Well #1	3,500	E	Group A	70	400
			Pole Road Water Assn. Well #1A	3,500	E	Group A	57	53
			Pole Road Water Assn. Well #1B	3,500	E	Group A	61	74
-117.1777	46.7295	Rennie Keasal's Service	Pullman Water Department Well #3	1,100	NW	Group A	160	1,200
-122.2150	47.4750	Renton 1	City of Renton Well #1	4,500	NE	Group A	57	2,200
			City of Renton Well #2	4,500	NE	Group A	52	2,200
			City of Renton Well #3	4,500	NE	Group A	50	2,200
-122.3615	47.2439	Taco Bell Former Chevron 97376	Fife Public Works Well #5	4,800	NE	Group A	687	250
-122.7447	45.9075	Toad's Express Mart and Deli	City of Woodland Lewis River	2,200	NE	Group A	0	1,400
-122.5891	45.6587	Vancouver Mall East Chevron	City of Vancouver WS #15 Well #1 WW	3,500	SE	Group A	141	480
			City of Vancouver WS #15 Well #2 WW	3,500	SE	Group A	124	500
-122.0445	47.3898	Wilderness Chevron	Dorre Don Water System	5,000	NE	Group A	0	100

NOTE: DECIMAL LAT / LON = NAD_27

*See Group A Water Systems and Monitoring Requirements, p. 21

Table 63: Ecology MTBE Study Results (2000).

City	X_LON	Y_LAT	MTBE (ug/L)
Auburn	-122.2219	47.3431	126
Bellevue	-122.1431	47.6083	0.14
Bellevue	-122.1536	47.6308	0.45
Bellevue	-122.2039	47.6175	8
Bellevue	-122.1847	47.6172	16
Blaine	-122.7378	48.9981	455
Davenport	-118.1350	47.6539	7,150
Hazel Dell	-122.6614	45.6819	0.3
Hazel Dell	-122.6617	45.6786	2
Kent	-122.2019	47.3725	6.9
Kent	-122.3036	47.3681	47
Kirkland	-122.1767	47.7036	0.6
Kirkland	-122.1772	47.7086	3.3
Linden	-122.4856	48.8919	1
Point	-123.0672	48.9869	105
Port	-122.6689	47.5311	1
Port	-122.5775	47.5339	51
Renton	-122.1511	47.5036	3.4
Renton	-122.2150	47.4750	4.6
Renton	-122.2206	47.4700	31
Rockford	-117.1181	47.4497	5,150
Seattle	-122.3381	47.6239	0.22
Seattle	-122.3314	47.7083	1
Seattle	-122.3875	47.6731	1
Seattle	-122.3336	47.5728	9.4
Seattle	-122.3533	47.6183	37
Seattle	-122.3172	47.7081	128
Seattle	-122.3089	47.7578	164
Seattle	-122.3286	47.5836	364
Tukwila	-122.2931	47.5106	22
Vancouver	-122.6028	45.6742	5.5
Vancouver	-122.6575	45.7178	36
Vancouver	-122.6247	45.6858	112
Woodland	-122.7447	45.9075	113

Decimal latitude / longitude = NAD_27.

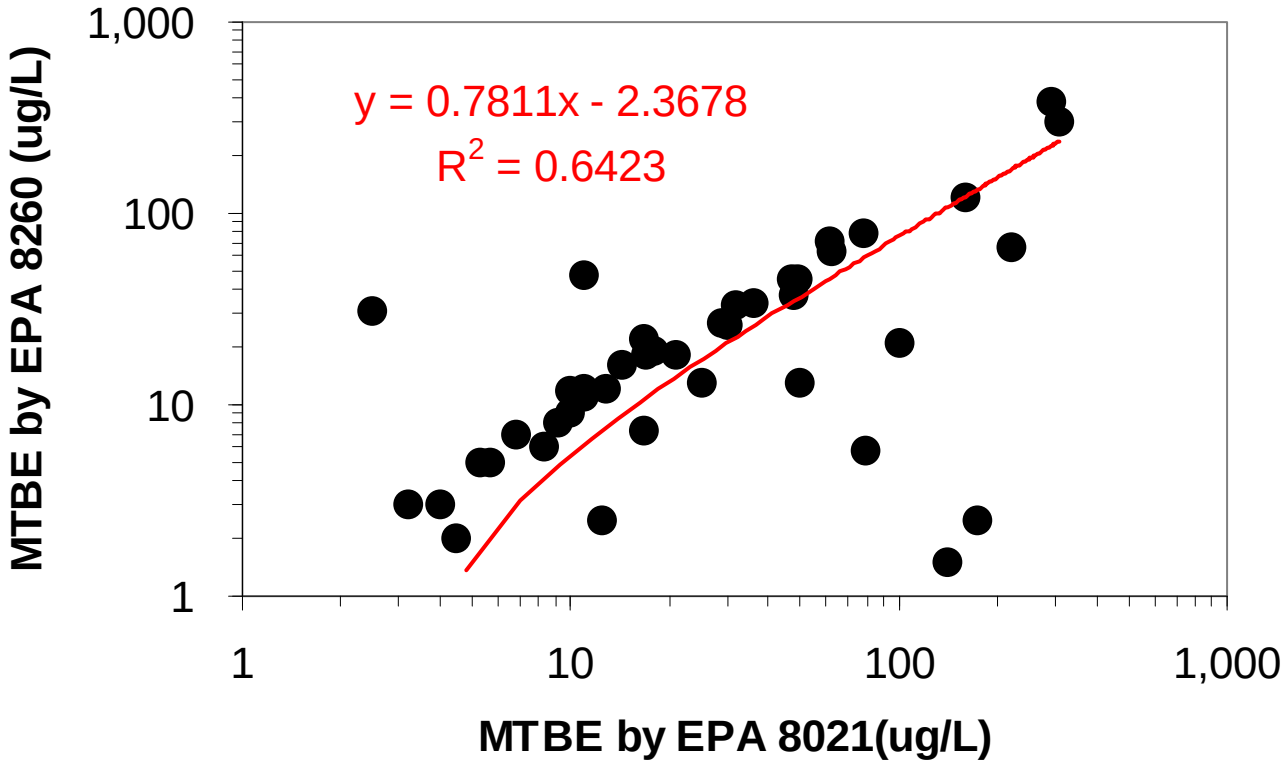
Table 64: MTBE Ground Water Monitoring Results (43 Washington Chevron Stations, 2001-04).

X_LON	Y_LAT	Name	Address	City	Date	MTBE by EPA 8021 (ppb)	MTBE by EPA 8260 (ppb)
-121.9847	47.2002	Jerry's Chevron Svc	435 Griffin Ave	Enumclaw	24-Jul-04	--	9
-122.3358	48.4753	Skagit Big Mini Mart 1	157 Burlington Blvd	Burlington	22-Jul-04	6.8	7
-122.9630	46.1478	Ocean Beach Chevron	3002 Ocean Beach Highway	Longview	19-Jul-04	290	380
-122.6628	45.6745	Chevron 9-2097	7220 NW HWY 99	Vancouver	19-Jul-04	4.5	2
-122.2946	47.1874	Chevron 9-7618	516 Meridian St. South	Puyallup	5-Jul-04	47	45
-122.35781	47.15608	APSI 1124-200587	10918 Canyon Road	Puyallup	5-Jul-04	29	27
-122.3308	47.7087	Chevron 92815	2150 N Northgate Way & Corliss	Seattle	1-Jul-04	5.3	5
-122.1788	47.7115	Chevron 9-2767	11601 98th Ave NE	Kirkland	24-Jun-04	11	12
-122.2029	47.6339	Chevron USA Inc SS 97451	2626 Bellevue Way	Bellevue	14-Jun-04	11	47
-122.3119	47.7337	145th Street Chevron - Shoreline 76	1554 NE 145th St.	Shoreline	5-Jun-04	11	11
-122.2168	47.4715	Chevron 9-9114	301 S Grady Way	Renton	12-May-04	50	13
-122.2930	47.7934	Mount Lake Terrace Chevron	22801 44th Ave.	Mount Lake Terrace	10-May-04	10	9
-122.3023	47.8465	Chevron 9-4953	20000 44th Avenue West	Lynwood	6-May-04	62	64
-122.0445	47.3898	Wilderness Chevron	23701 Maple Valley Hwy	Maple Valley	24-Apr-04	48	37
-122.3159	47.6629	WASU Chevron	4700 Brooklyn Ave NE	Seattle (U-District)	21-Apr-04	78	78
-117.9055	48.5401	Colville Auto Repair	505 South Main St.	Colville	23-Mar-04	61.3	71.5
-122.1989	47.5957	Chevron 9-9269	1649 Bellevue Way SE	Bellevue	16-Mar-04	100	21
-122.1737	47.6791	Bedrock Northwest Inc.	12607 NE 8th	Kirkland	13-Mar-04	140	1.5
-122.1060	48.00268	Chevron 9-1708	621 Hwy 9	Lake Stevens	8-Mar-04	49	45
-120.9410	47.1949	D & R Food Mart	201 W 1ST ST	Cle Elum	27-Feb-04	18	19
-122.2621	47.4556	Chevron 9-1557	220 Strander Blvd	Tukwila	26-Feb-04	5.7	5
-122.2992	47.5779	Chevron 9-0333	2802 Rainier Ave. S.	Seattle	23-Feb-04	160	120
-122.7516	48.9954	Chevron 9-1122	568 Peace Portal DR & G ST	Blaine	7-Feb-04	220	66
-122.2647	46.8677	Chevron Bulk Plant 206394	117 N. Washington Ave.	Eatonville	28-Jan-04	8.3	6
-122.5891	45.6587	Vancouver Mall East Chevron	9414 NE Vancouver Mall DR	Vancouver	18-Jan-04	310	300
-122.3583	47.2392	Chevron 9-7135	5319 20th Street East	Fife	15-Jan-04	17	18
-122.5168	47.6357	Car Wash	1220 Hildebrand Lane NE	Bainbridge Island	3-Jan-04	30	26
-122.6367	47.7328	Chevron 9-4265	18764 HWY 305	Poulsbo	16-Dec-03	4	3
-122.3131	47.3219	Chevron USA Inc SS 98538	31204 Pacific Hwy South	Federal Way	4-Dec-03	25	13
-122.2913	47.5060	Boeing Field Chevron	10805 E. Marginal Way South	Tukwila	13-Nov-03	21	18
-122.1677	47.6398	Bellevue Petroleum Inc.	3204 129th Place Southeast	Bellevue	16-Sep-03	36	34

X_LON	Y_LAT	Name	Address	City	Date	MTBE by EPA 8021 (ppb)	MTBE by EPA 8260 (ppb)
-122.3615	47.2439	Taco Bell Former Chevron 97376	5018 Pacific Highway East	Fife	14-Jan-03	3.2	3
-123.4352	48.1148	Former Chevron 9-3220	517 S Lincoln St.	Port Angeles	17-Dec-01	14.4	16
-122.3149	47.2894	Broadway Truck Stop Service	1511 South 348th Street	Federal Way	14-Dec-01	16.6	7.4
-122.1247	47.6170	Crossroads Chevron	16256 NE 8th St.	Bellevue	8-Dec-01	16.8	22.1
-122.2382	47.8819	PDQ Oil 1112 90445	214 128th Street Southwest	Everett	28-Nov-01	12.4	2.5
-122.2566	47.8494	Chevron USA Inc SS 95493	1606 164th St. SW	Alderwood	26-Nov-01	9.1	7.98
-119.5299	48.4101	Coleman Oil Company	30 South Main Street	Omak	8-Nov-01	173	2.5
-122.3523	48.2418	Chevron 9-5257	8808 271ST ST NW	Stanwood	26-Sep-01	10	11.7
-117.1777	46.7295	Rennie Keasal's Service	485 East Main St.	Pullman	13-Aug-01	2.5	31
-120.5414	46.9757	Chevron 9-5179	1710 Canyon Street	Ellensburg	12-Aug-01	79.5	5.8
-122.2323	47.3859	James Chevron	631 North Central Ave.	Kent	5-Jun-01	12.8	12

Note: the Table 64 data was electronically submitted to Ecology by Gettler-Ryan Inc. on behalf of Chevron (e-mail communication, Deanna Harding, Gettler-Ryan to Charles San Juan, Ecology). Results in red font = laboratory detection limit. Decimal lat / lon = NAD_27.

Figure 43: MTBE by EPA 8021 vs. MTBE by EPA 8260.



Key Point – Use EPA 8260 for MTBE
This plot is based on Chevron ground water monitoring data (43 sites, 2001-04; Table 64, p. 115). If you use EPA 8021 to quantify MTBE, then it may result in a value that is biased-high or inaccurate. There are two reasons for this: 1) the high ionization energy of many oxygenates and 2) coelution interferences. For example, substances like MTBE tend to co-elute with other gasoline components, especially at high gasoline concentrations (i.e. > 50 mg/l). Lastly, photo ionization detectors (PID) are not very sensitive to tertiary butyl alcohol (TBA) and other alcohols. This is because alcohols are highly soluble in water, which makes it much harder to purge or extract them for analysis.

Table 65: Oxygenate Names, CAS #'s, Chemical Formulas and Molecular Weights[49].

OXYGENATE	NAMES	CAS #	CHEMICAL FORMULA	MOLECULAR WEIGHT
DIPE	Diisopropyl ether, Diisopropyl oxide, 2-isopropoxy propane, Isopropyl ether, 2,2'-Oxybispropane	108-20-3	$C_6H_{14}0$ $(CH_3)_2CH\text{-}O\text{-}CH(CH_3)_2$	102.18
ETBE	Ethyl tertiary-butyl ether, Ethyl tert-butyl ether, 2-Methyl-2-ethoxypropane, tert-butyl ethyl ether, Ethyl tert-butyl oxide, 2-ethoxy-2-methylpropane	637-92-3		102.18
Ethanol	Ethyl alcohol, Anhydrol, Alcohol, Methyl carbinol, Ethyl hydrate, Ethyl hydroxide, Denatured alcohol, Grain alcohol	64-17-5		46.069
Methanol	Methyl alcohol, Carbinol, Methylol Methyl Hydroxide, Monohydroxy methane, Wood alcohol	67-56-1	CH_40 $CH_3\text{-}0H$	32.042
MTBE	Methyl t-butyl ether, 2-methoxy-2-methylpropane, Methyl tertiary-butyl ether, Methyl tert-butyl ether	1634-04-4	$C_5H_{12}0$ $CH_3\text{-}O\text{-}C(CH_3)_3$	88.149
TAME	Methyl 1,1-dimethyl propyl ether, Methyl tert-amyl ether, Methyl 2-methyl-2-butyl ether, tertiary-amyl methyl ether, tert-Pentyl methyl ether, Butane, 2-methoxy-2-methyl, 2-methoxy-2-methyl Butane	994-05-8	$C_6H_{14}0$ $C_2H_5C(CH_3)_2\text{-}O\text{-}CH_3$	102.18
TBA	2-methylpropan-2-ol, tert-Butanol, t-butyl hydroxide, Trimethyl methanol, Dimethyl ethanol, Methyl-2-propanol, tertiary-butyl alcohol, tert-butyl alcohol, t-butyl alcohol, 2-Methyl-2-propanol 1,1-Dimethyl ethanol, Trimethyl carbinol	75-65-0	$C_4H_{10}0$ $(CH_3)_3C\text{-}OH$	74.122

Table 66: Oxygenate Physical Chemical Properties[50].

Oxygenate	Pure Phase Solubility (mg/L)	log K_{oc} (l/kg)	Vapor Pressure (mm Hg)	Henry's Law Constant (dimensionless)	Specific Gravity
Methanol	Miscible	0.44 - 0.92	121.6	0.00011	0.791
Ethanol	Miscible	0.20 - 1.21	49 - 56.5	0.00021 - 0.00026	0.789
TBA	Miscible	1.57	40 - 42	0.00048 - 0.00059	0.786
MTBE	43,000 - 54,300	1.0 - 1.1	245 - 256	0.023 - 0.12	0.741
DIPE	2,039 - 9,000	1.46 - 1.82	149 - 151	0.195 - 0.41	0.724
ETBE	26,000	1.0 - 2.2	152	0.11	0.7519
TAME	20,000	1.3 - 2.2	68.3	0.052	0.764

[49] Source: API Publication 4699.

[50] Source: API Publication 4699. Strategies for Characterizing Subsurface Releases of Gasoline Containing MTBE, Prepared for API by: Eric M. Nichols, LFR Levine-Fricke; Murray D. Einarson, Consulting Hydrogeologist; Steven C. Beadle, LFR Levine-Fricke.

Appendix C – EPA January 2000 Memo on Oxygenates

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

JAN 18, 2000

OFFICE OF
SOLID WASTE AND EMERGENCY
RESPONSE

MEMORANDUM

SUBJECT: Monitoring and Reporting of MTBE and Other Oxygenates at UST Release Sites

FROM: Sammy Ng, Acting Director
Office of Underground Storage Tanks

TO: Regional UST Program Managers, Regions 1-10
State UST/LUST Program Managers

I am writing to strongly urge and recommend all state UST/LUST program managers immediately begin monitoring and reporting of methyl tertiary butyl ether (MTBE) and other oxygenates in groundwater at all underground storage tank (UST) release sites nationwide. If you detect MTBE or other oxygenates during monitoring at sites, EPA strongly advises that states take immediate and aggressive remedial action to address the contamination. To promote nationwide consistency, I am also advocating that EPA staff follow this approach for sites where EPA is undertaking or overseeing corrective actions such as sites in Indian Country.

Background

As you are well aware, U.S. EPA Administrator Carol Browner in November 1998 appointed a Blue Ribbon Panel on Oxygenates in Gasoline to investigate air quality benefits and water quality concerns associated with oxygenates in gasoline. In July 1999, the Blue Ribbon Panel provided the Administrator with findings and recommendations, and provided suggested actions for a number of programs in EPA, including the UST program. One particular recommendation in the prevention area suggested that EPA "require monitoring and reporting of MTBE and other ethers in groundwater at all UST release sites".

In the past, EPA has worked cooperatively with the Association of State and Territorial Solid Waste Management Officials (ASTSWMO) and other organizations to provide states with various opportunities and forums (such as the annual national UST conference) to raise states' awareness of the MTBE issue. Additionally, EPA has recommended that states routinely analyze at sites for MTBE and encouraged states to take proactive steps in assessing their sites for MTBE. To date, approximately 25 states have established cleanup levels for MTBE in

groundwater; EPA encourages those other states which have not yet done so, to take similar action and establish cleanup levels.

Monitoring and Reporting Are Appropriate Actions

Provisions of the Clean Air Act require the use of oxygenates in fuel. These oxygenated fuels are also referred to as reformulated gasoline (RFG) or oxy-fuels. MTBE is merely one of many possible oxygenates that may be present in petroleum fuels. While MTBE has received most of the publicity recently, it is by no means the only chemical of concern for which you should be monitoring and reporting. For example, the oxygenate TBA is both a degradation product of MTBE and a fuel additive in its own right; it is also potentially more toxic than MTBE. You should also carefully consider assessing for other oxygenates (that include, but are not limited to, TAME, DIPE, ETBE, ethanol, and methanol).

For many years, MTBE has been recognized as a potential human carcinogen. Even though studies to establish an exposure limit are still incomplete, EPA's Office of Water (OW) issued a drinking water advisory for MTBE in December 1997. This advisory specifies a range of 20-40 micrograms per liter, which should be low enough to both protect human health and eliminate objectionable taste and odor in drinking water. Because of the many steps involved in establishing a regulation that sets the drinking water standard to control the level of contaminants (such as MTBE) in drinking water, OW believes it could take approximately 10 years for EPA to issue a regulation determining the maximum contaminant level for MTBE.

Even though the use of gasoline containing MTBE or other oxygenates of any type is required in relatively few areas of the country, it is possible that it may be present in other areas as well. It is reasonable to assume that, even though your state does not require the use of oxygenated fuels, those types of fuels are, or most probably have been, sold and used in your state. In fact, MTBE has been found in some fuels (for example, heating oil) in which it was never intended to be used.

MTBE and other oxygenates behave differently in the environment than do the aromatic hydrocarbons, such as benzene, toluene, ethylbenzene, and xylene (BTEX). Therefore, conventional or traditional site characterization strategies and techniques designed to assess BTEX plumes may fail to detect MTBE plumes. MTBE is significantly less biodegradeable than is BTEX, and MTBE does not sorb to aquifer material. As a result, MTBE moves farther and faster than does BTEX. Plumes tend to move deeper into aquifers as they move away from the source. Because MTBE plumes move farther from the source, MTBE may occur deeper in aquifers than does BTEX. Wells with short screens installed across the water table may fail to sample MTBE plumes. Conversely, wells with long screens may yield greatly diluted samples that mask the presence of MTBE and other contaminants.

To adequately characterize an MTBE plume, the focus must be on identifying its three-dimensional characteristics. Monitoring wells should be "nested" (that is, several wells installed

close together with narrow screened intervals). The vertical distribution of hydraulic conductivity should be determined before a nest of permanent monitoring wells are installed at a new location. This can be done by examining core samples, by pressure dissipation tests with a cone penetrometer, or by miniature specific capacity tests in temporary push wells. The screens of permanent monitoring wells should be installed across the depth intervals with the highest hydraulic conductivity. If plumes appear to dive into the aquifer as they move down gradient of the source, the deepest well in the cluster should either be free of MTBE contamination, or be screened in material with low hydraulic conductivity that acts as an effective confining layer for the plume.

Because the potential area of the MTBE plume is much larger than for BTEX, there's an increased probability of encountering preferential migration pathways, such as sand stringers, fractures, and utility conduits. These pathways should be identified as they may provide avenues for plume migration that are either in unanticipated directions or at greatly increased rates over what is commonly expected based on ambient conditions. Monitoring well networks should be organized in transects that are perpendicular to ground water flow. Well spacing in the transects should be relatively closely spaced to minimize the possibility of the MTBE plume migrating across the transect undetected.

As with most work to identify and solve a problem, the earlier you identify the problem, the easier the solution may be. That scenario exists with monitoring and identifying MTBE contamination. If you identify the presence of MTBE in the early stages, remediating the site may be less costly and less complex than if you learn of (and remediate) the contamination at later stages.

Recommended Action and Next Steps

The MTBE problem is a national issue, even though we do not currently know the magnitude of the problem. Few states currently perform routine sampling and monitoring; there is too little information sharing and networking about the problem. EPA and states together need to make a concerted effort to share experiences and learn from each other. Currently there is little existing information as to the effectiveness of technologies for groundwater remediation and drinking water treatment. EPA is encouraging states which have that information to share it via the Internet with other states. Using Internet web sites can be a simple and cost-effective means for sharing information. The MTBE problem also emphasizes the need for long-term management strategies and land-use planning. A graphical information system (GIS) is a flexible and useful personal computer and Internet tool that states can use as they strive to better protect public water supplies from UST releases.

OUST is encouraging state UST/LUST programs to: begin (and for those states already doing so, continue) to monitor and report MTBE and other oxygenates in groundwater at all UST release sites; aggressively remediate sites where MTBE is found; and coordinate information sharing using their respective web sites. OUST will take the lead to link the information from

states' web sites and provide graphics which depict states' activities on the MTBE section of OUST's homepage (http://www.epa.gov/oust/mtbe/). This effort will serve as a clearinghouse for MTBE information. Our combined sharing efforts will provide appropriate, correct information to interested and affected parties and, as a result, should help offset misconceptions about this important issue. It will also improve public understanding and appreciation of activities underway by EPA and states to protect human health and the environment from all chemicals of concern.

In the near future, OUST will develop an optional form you may use (if you so choose) as a guide to help you gather and share your state's information about MTBE on your web site. We will share that form with you as soon as it is available. If you have policy questions about work OUST is undertaking regarding MTBE, please call me at 703-603-9900. For other MTBE information, talk with Hal White (703-630-7177) for technical questions and information sharing inquiries or Steve McNeely (703-603-7164) to discuss how MTBE fits into risk based decision making (RBDM) programs.

cc: Tim Fields
Bob Perciasepe
Cynthia Dougherty

Appendix D – EPA Fact Sheet on Analytical Methods for Oxygenates

Environmental Fact Sheet

Analytical Methods for Fuel Oxygenates

Purpose of Fact Sheet

EPA designed this fact sheet to provide state and federal regulators, laboratory analysts, consultants, and contractors with technical information about appropriate sample collection, handling, and analytical procedures for the suite of common fuel oxygenates. This fact sheet provides a brief background of fuel oxygenates and then discusses the problem, analytical obstacles and how to overcome them, ether hydrolysis and how to prevent it, and recommended protocols to improve the quality of data reported about oxygenates in groundwater samples. Affected parties are encouraged to immediately begin following the recommendations outlined herein.

Background on Fuel Oxygenates

Fuel oxygenates are oxygen-containing compounds (*e.g.*, ethers and alcohols) that are added to gasoline to either boost the octane rating, make the fuel burn cleaner by increasing the oxygen content, or a combination of both. The most commonly used oxygenates are methyl tertiary-butyl ether (MTBE) and ethanol. Other oxygenates include tertiary-amyl methyl ether (TAME), ethyl tertiary-butyl ether (ETBE), diisopropyl ether (DIPE), tertiary-amyl ethyl ether (TAEE), tertiary-butyl alcohol (TBA), tertiary-amyl alcohol (TAA), and methanol. Ethanol has been used in automotive fuel blends since the 1930s, and ethers (primarily MTBE) have been used increasingly since the late 1970s. Primarily due to mixing during transport, oxygenates have also been detected in some fuels (*e.g.*, diesel, heating oil, aviation fuel) which were never intended to contain oxygenates. Fuels containing oxygenates have been transported, stored, and used nationwide and any release of fuel to the environment can potentially result in groundwater being contaminated with oxygenates in addition to petroleum hydrocarbons (*e.g.*, benzene, toluene, ethylbenzene, and [the three isomers of] xylene, collectively referred to as "BTEX").

The Problem

An enormous amount of oxygenate data from leaking UST sites has been generated over the past several years, yet there is understandable concern as to whether these data are valid. In general, these concerns derive from two issues: analytical obstacles and ether hydrolysis (particularly MTBE to TBA). Conventional analytical procedures designed for petroleum hydrocarbons (usually BTEX) can also detect MTBE and the other ethers, but they have very poor sensitivity for TBA and the other alcohols. Although there are analytical methods available that are capable of detecting low levels of oxygenates, they are rarely calibrated for ethers (other than MTBE), and in order to be able to analyze for TBA and the other alcohols, sample preparation procedure would have to be modified to increase the sensitivity sufficiently to satisfy regulatory concerns. Under normal environmental conditions ethers do not undergo hydrolysis (breakdown) at significant rates, but it is now recognized that they may be hydrolyzed during storage and analysis of groundwater samples preserved with acid. Unless steps are taken to prevent hydrolysis of the ethers, these analytical errors can cause errors in risk assessment, they can lead to the

implementation of a remedial technology that is not necessary, and they can bias an evaluation of monitored natural attenuation (MNA) in that the time required for MNA to achieve cleanup goals may be significantly under predicted.

Analytical Obstacles

One of the greatest impediments to understanding the extent of contamination caused by fuel oxygenates is the perceived lack of a single analytical method for the determination of fuel oxygenates as a group. However, the capability to conduct the analyses necessary to determine all of the fuel oxygenates at the concentrations of regulatory concern does exist in the current marketplace, although availability of this service is limited because standard operating procedures don't require calibration for oxygenates as routine practice. Some analytical methods utilize detectors that are not designed to respond well to oxygenates, and although they shouldn't be used for the analysis of oxygenates they are used sometimes. These include the electrolytic conductivity detector (ELCD) and the photoionization detector (PID). In particular, Method 8021 (PID) cannot be regarded as a consistently reliable analytical tool for the analysis of oxygenates because it is susceptible to both false positives (misidentifying the presence of an oxygenate) and false negatives (failing to identify the presence of an oxygenate). These problems are primarily due to the high ionization energies of many oxygenates and coelution interferences. Another important concern is the method detection limit or the reporting limits of current analytical protocols for the alcohol oxygenates, and TBA in particular. The analysis of alcohols is a more difficult challenge than analyzing for BTEX (or even MTBE). Because alcohols are so highly soluble in water, extracting them for analysis is difficult and reporting limits are much higher than those for BTEX and MTBE. Typical reporting limits for TBA may be as high as 100 or 1,000 ppb which is higher than levels of regulatory concern in many states.

Overcoming Analytical Obstacles

Of the several widely used determinative methods published in SW-846 (U.S. EPA, 1997), the two most appropriate for oxygenates are Method 8260 (GC/MS) and Method 8015 (GC/FID). Method 8260 is somewhat more expensive than Method 8015, but Method 8260 provides positive confirmation of the chemical identity of the analyte that is detected while Method 8015 does not. Using either of these two methods with an appropriate GC column and an appropriate sample preparation technique, it is possible to detect oxygenates at concentrations of 5 ppb or less. It is not necessary to modify either of these determinative methods, only the sample preparation and method calibration steps need to be modified. If calibration curves are run for all of the other ethers, then concentrations of all of these oxygenates can be determined for the same samples and in some of the same analytical runs used to determine BTEX and MTBE, provided that the concentrations of all target compounds fall within the operational calibration range of the respective detector. Appropriate sample preparative methods include Method 5021 (static headspace), Method 5030 (purge-and-trap), or Method 5032 (vacuum distillation). TBA can also be recovered for analysis using the azeotropic distillation technique (Method 5031). Method 5030 at ambient temperature (rather than heated) is adequate to determine concentrations of ether oxygenates that are greater than 5 ppb, however, if alcohols are analytes of concern, then the water sample must be heated to attain adequate recovery in order to lower the detection limit from 100 ppb (or higher) to around 10 ppb.

EPA recently completed a study designed to demonstrate that the recoveries of low levels of fuel oxygenates can be improved over current practice. The project was conducted in two phases: the first with laboratory spiked samples, and the second with samples collected

from a fuel release site on Long Island. For the laboratory phase, water samples both with and without BTEX interferences in the form of gasoline spiked at 600 ppb were analyzed for MTBE, TBA, DIPE, ETBE, TAME, TAEE, and acetone. The target sensitivity was 5 ppb. The most consistent oxygenate recoveries were obtained using a heated (80º C) purge-and-trap (Method 5030) then determinative analysis by Method 8260 using a DB-Wax capillary column. BTEX interferences did not adversely affect the chromatographic separation, quantitation, and recovery of oxygenates. For the second phase, field samples were analyzed by three laboratories, but this time using static headspace (Method 8021) as the preparative method. There was good agreement between concentrations of MTBE, TAME, and ETBE measured by the three laboratories in the study, and the agreement between measured concentrations of TBA was also good for two of the three laboratories–the third laboratory set too high a detection limit for the concentration of TBA in the samples.

Ether Hydrolysis

It is essential that both a chemical preservative and refrigeration are used to preserve groundwater samples, especially if they are to be analyzed for BTEX compounds. Refrigeration by itself isn't sufficient to effectively retard biodegradation of the sample, but it is effective at inhibiting the chemical deterioration of the sample. Groundwater samples from permanent wells typically contain microorganisms that are capable of degrading BTEX relatively quickly when oxygen is available. Contaminants may persist in groundwater because the plume is devoid of dissolved oxygen, but groundwater samples from wells invariably contain dissolved oxygen, particularly if samples were collected with a bailer. In samples that have not been chemically preserved, BTEX, MTBE and TBA may be completely degraded within two weeks Most protocols for the preservation of groundwater samples call for the addition of a sufficient volume of hydrochloric acid to adjust the pH of the sample to less than 2 and that they be chilled to 4°C. Typically, more acid is added than is needed to preserve the samples and the majority of groundwater samples that have been preserved with acid probably have a pH of between 1 and 2. Ethers present in groundwater samples have been observed to hydrolyze when the samples are preserved with acid to a pH of around 1 and at elevated temperatures. In order for samples to be analyzed for alcohols, the samples must be prepared for analysis at an elevated temperature in order to increase the method sensitivity. However, during this heating step, ether bonds may be hydrolyzed destroying the ether and forming alcohol. As a consequence, ether concentrations originally present in the sample may be underestimated, and the concentration of the hydrolysis products may be overestimated (e.g., TBA formed from the MTBE hydrolysis).

EPA/ORD recently completed a two-part study of the effect of heating and acidification on MTBE in groundwater samples. The first part involved measurement of the rate of MTBE hydrolysis at 80º C using samples acidified to a pH of 1 versus a pH of 2. Samples were prepared using Method 5021 (heated headspace). After 30 minutes at a pH of 2, 6 percent of the MTBE was hydrolyzed to TBA; at a pH of 1, 57 percent of the MTBE was hydrolyzed to TBA. The second part involved analysis of diluted and undiluted replicate samples from an MTBE plume in California. Samples were preserved in the field with hydrochloric acid to a pH of less than 2 and then analyzed using a static headspace sampler (Method 5021). For each tenfold dilution, the concentration of acid used as a preservative was correspondingly diluted tenfold, which (as expected) reduced the rate of MTBE hydrolysis to TBA. In undiluted samples the fraction of MTBE that was hydrolyzed during

analysis varied from 22 percent to 89 percent, with a median of 62 percent. In the samples diluted 1:10 the fraction of MTBE hydrolyzed ranged from 1 percent to 18 percent with an average of about 9 percent.

Preventing Ether Hydrolysis

As stated above, it is essential to use both a chemical preservative and refrigeration for groundwater samples to be analyzed for BTEX and oxygenates. However, to avoid hydrolyzing the ethers, iInstead of using an acid to lower the pH, samples should be preserved with a base to a pH greater than 11. The elevated pH effectively prevents the biodegradation of organic compounds in the sample. The ethers are not subject to base-catalyzed hydrolysis, and a basic pH has no adverse effect on BTEX or the alcohol oxygenates. This also avoids sample integrity problems caused by effervescence in samples with high carbonate alkalinity. To achieve an elevated pH, the salt of a weak acid (*e.g.*, trisodium phosphate dodecahydrate or "TSP") is added to the sample instead of a solution of a more dangerous strong base (*e.g.*, potassium hydroxide). In the laboratory, between 0.40 and 0.44 gram of TSP is added to each 40-mL sample vial. Because it is more convenient to measure the required amount of TSP on a volume basis rather than by weight, EPA recommends use of a precalibrated spoon (Hach # 907-00 or equivalent). In the field, each vial is filled with the groundwater sample and sealed without headspace (the same as is done if the sample were preserved with acid).

If it is necessary to analyze samples that have already been preserved with acid, the acid can be destroyed with TSP prior to analysis. An amount of TSP sufficient to raise the pH of the sample to greater than 10 is added to the sample vial, which is quickly resealed without headspace and gently shaken to dissolve the salt. Generally about 0.7 gram of TSP is sufficient for a 40-mL VOA vial, but sometimes (depending upon the pH of the sample) more must be added. It is prudent to check the pH of the sample with indicator paper to ensure that the pH is greater than 11 prior to introducing it into the purge vessel or the headspace sampler for analysis.

Recommended Protocol

To properly implement this protocol, groundwater samples should be collected from locations where oxygenates are most likely to occur, based on their chemical and physical behavior. Because oxygenates are more soluble than petroleum hydrocarbons and can be more recalcitrant, oxygenate plumes may be longer than typical BTEX plumes. Groundwater samples should be analyzed for the entire suite of oxygenates (*i.e.*, MTBE, TAME, ETBE, DIPE, TAEE, TAA, and TBA). Samples should be prepared for analysis, preferably using EPA Method 5030 heated to 80º C (although either Method 5021 or Method 5032 may be used if the laboratory can demonstrate appropriate performance with these methods). The determinative method (*e.g.*, Method 8260, 8015, or other appropriate method) should be calibrated for the entire suite of oxygenates, and these analytes should be reported for every sample analyzed. With the understanding that ethanol and methanol are potentially present at fuel release sites, it is also advisable to have samples analyzed for these alcohol oxygenates using appropriate preparative and determinative methods.

EPA Method 8260 (or another method that provides *confirmatory identification* of all of the fuel oxygenates and can be demonstrated to meet project data quality objectives) is the preferred determinative analytical method for fuel oxygenates (and other contaminants of concern) when the analyses will be used to (1) characterize the three-dimensional extent of a contaminant plume, (2) determine whether a site requires active remediation, (3) select an

active remedy, (4) design an active remedy, (5) determine whether a site has met site-specific clean up objectives, or (6) determine if it is no longer necessary to continue monitoring a site.

Although EPA Method 8260 is more expensive than methods that do not provide confirmatory identification, the temptation to substitute cheaper methods should be resisted. Attempting to save money by relying on such methods may end up having exactly the opposite effect in the long run. After all of the oxygenates (and other contaminants of concern) present at a site have been identified and their concentration and extent determined, future analyses might then be conducted using a less expensive determinative method (*e.g.*, 8015). Situations that might not require confirmatory analysis would include routine long-term performance monitoring as part of a MNA remedy or exposure management strategy.

To prevent constituents in the samples from being chemically and/or biologically degraded during storage and transport, samples should be preserved with both a chemical preservative and refrigeration. To prevent chemical hydrolysis of the ether oxygenates during storage, the samples should be preserved with a base delivered as a salt (TSP), rather than as a strong acid, and also refrigerated. Preservation with TSP will also eliminate the possibility that ethers will be hydrolyzed during sample preparation. Stored samples should be refrigerated at 4º C and analyzed within the holding period.

Contacts

For additional information about analytical methods, call the Methods Information Communication Exchange (MICE) hotline at 703-6764690, or visit the MICE web site at *http://www.epa.gov/SW-846/mice.htm*. For information about the Underground Storage Tank program, visit *http://www.epa.gov/oust*. For information about this Fact Sheet, email Hal White (EPA/OUST) at *white.hal@epa.gov*.