Health Consultation

LEBANON GROUNDWATER CONTAMINATION SITE

LEBANON, OREGON

JANUARY 8, 2009

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

An ATSDR health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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HEALTH CONSULTATION

LEBANON GROUNDWATER CONTAMINATION SITE

LEBANON, OREGON

Prepared By:

Oregon Public Health Division
Environmental Health Assessment Program
Under Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

Foreword

The Environmental Health Assessment Program (EHAP) within the Oregon Public Health Division (PHD) has prepared this Health Consultation under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR is part of the U.S. Department of Health and Human Services, Public Health Service. The mission of ATSDR is to prevent or mitigate adverse human health effects and diminished quality of life resulting from exposure to hazardous substances in the environment. This Health Consultation was prepared in accordance with ATSDR methodology and guidelines.

ATSDR and its cooperative agreement partners review the available information about hazardous substances at a site, evaluate whether exposure to them might cause any harm to people, and provide the findings and recommendations to reduce harmful exposures in documents called Public Health Assessments and Health Consultations. ATSDR conducts a Public Health Assessment for every site on or proposed for the National Priorities List (the NPL, also known as the Superfund list). Health Consultations are similar to Public Health Assessments, but they usually are shorter, address one specific question, and address only one contaminant or one exposure pathway. Another difference is that Public Health Assessments are made available for public comment, while Health Consultations usually are not. Public Health Assessments and Health Consultations are not the same thing as a medical exam or a community health study.

Public Health Assessments and Health Consultations include conclusions that categorize environmental contaminants and conditions according to the likelihood that they will harm people. These categories are called "Hazard Categories." The five possible Hazard Categories are:

Urgent Public Health Hazard: This category is used for sites that have certain physical features or evidence of short-term (less than 1 year), site-related chemical exposure that could result in adverse health effects and require rapid intervention to stop people from being exposed.

Public Health Hazard: This category is used for sites that have certain physical features or evidence of chronic, site-related chemical exposure that could result in adverse health effects.

Indeterminate Public Health Hazard: This category is used for sites where important information is lacking (missing or has not yet been gathered) about site-related chemical exposures. In other words, this category is used when there is not enough information to decide whether or not a condition at a site poses a public health hazard.

No Apparent Public Health Hazard: This category is used for sites where exposure to site-related chemicals may have occurred in the past or is still occurring but the exposures are not at levels expected to cause adverse health effects.

No Public Health Hazard: This category is used for sites where there is evidence of an absence of exposure to site-related chemicals.

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Summary

The Environmental Health Assessment Program (EHAP), part of the Oregon Department of Human Services Office of Environmental Public Health, prepared this health consultation in order to evaluate the public health implications of groundwater contaminated with volatile organic compounds (VOCs) in the city of Lebanon, Oregon. The groundwater contamination in Lebanon was first identified in 1990. The Environmental Protection Agency (EPA) and the Oregon Department of Environmental Quality (DEQ) have conducted several investigations since that time, sampling over 120 domestic and irrigation wells for VOCs. The main contaminants of concern at this site are tetrachloroethylene (PCE) and trichloroethylene (TCE).

In 2007, EPA requested EHAP's assistance at this site during an expanded site investigation. The purposes of this investigation were to identify residences that use contaminated groundwater from private wells for their domestic water supply, to obtain updated information on contaminant levels, and to characterize the extent of the contaminant plumes. DEQ is currently overseeing environmental assessment and cleanup activities at the Lebanon Groundwater Contamination site.

Community concerns related to the groundwater contamination in Lebanon include:

- Health effects from exposure to contaminated water, particularly related to children's health
- Financial costs of abandoning wells and switching to the city water supply
- Uncertainty about the extent and boundaries of the groundwater plumes
- The potential for home buyers to unknowingly purchase a home with a contaminated well and become exposed to contaminated water
- The need to find a long-term solution that will reduce exposure to contaminated groundwater through the use of private wells

The conclusions, recommendations and public action plan in this health consultation are based on community health concerns, EHAP's assessment of environmental sampling data, potential exposure routes and exposed populations, and a review of toxicological and medical studies related to the contaminants at this site.

EHAP evaluated the potential health risks to residents who use water from wells contaminated with PCE, TCE, carbon tetrachloride and bromodichloromethane. EHAP concluded that these contaminants currently pose ***no apparent public health hazard*** to residents exposed through water from domestic or irrigation wells. These conclusions are based on current exposure scenarios, which assume that domestic well-users with VOC levels that exceed safe drinking water standards are currently receiving an alternate drinking water supply. These residents are no longer being exposed to VOCs through their drinking water supply, but could continue to inhale VOCs that evaporate from the water to the air and absorb small amounts through the skin.

EHAP also found that some residents may have had past exposures that resulted in elevated cancer risks. These risks were found among residents whose domestic wells are

contaminated with both PCE and TCE. These risks were found at the maximum detected levels of PCE (55.0 ppb) and TCE (14.0 ppb), which are well above DEQ's action level for providing an alternate water supply (5.0 ppb). However, this does indicate that PCE and TCE are present in Lebanon's groundwater at levels that could pose health risks to domestic well-users, which has implications for residents living in the contamination area who have not had their wells sampled. Therefore, EHAP recommends that DEQ conduct additional sampling in order to identify as many affected wells as is possible in order to prevent harmful exposures to VOCs in Lebanon's groundwater. EHAP recommends that Lebanon residents who have not had their wells tested and who live in or near the contamination area have their wells sampled by DEQ.

EHAP found that exposure to VOCs through vapor intrusion was an ***indeterminate public health hazard***. Lebanon residents and workers could potentially be exposed to VOCs through the vapor intrusion of contaminants migrating from the contaminated groundwater, through soil, and into indoor air. However, the environmental data needed to evaluate this pathway have not been collected. EHAP recommends an assessment of the vapor intrusion pathway at this site, which may include environmental sampling for VOCs in indoor air and soil from under houses. DEQ is planning on evaluating this exposure pathway in 2009.

In addition, EHAP recommends that DEQ implement measures that will reduce residents' exposures to VOCs from contaminated wells. DEQ should continue to offer alternate water supplies (bottled water) to residences whose domestic wells are found to have contaminant levels above the drinking water standard of 5 ppb; work with homeowners and the city of Lebanon to determine appropriate long-term solutions for a safe domestic water supply; and coordinate with EHAP to provide outreach to individuals affected by the groundwater contamination. DEQ plans to implement a number of measures intended to inform the public and reduce exposures to the groundwater contamination.

EHAP will work in collaboration with DEQ and other partner agencies to pursue the implementation of the recommendations outlined in this document.

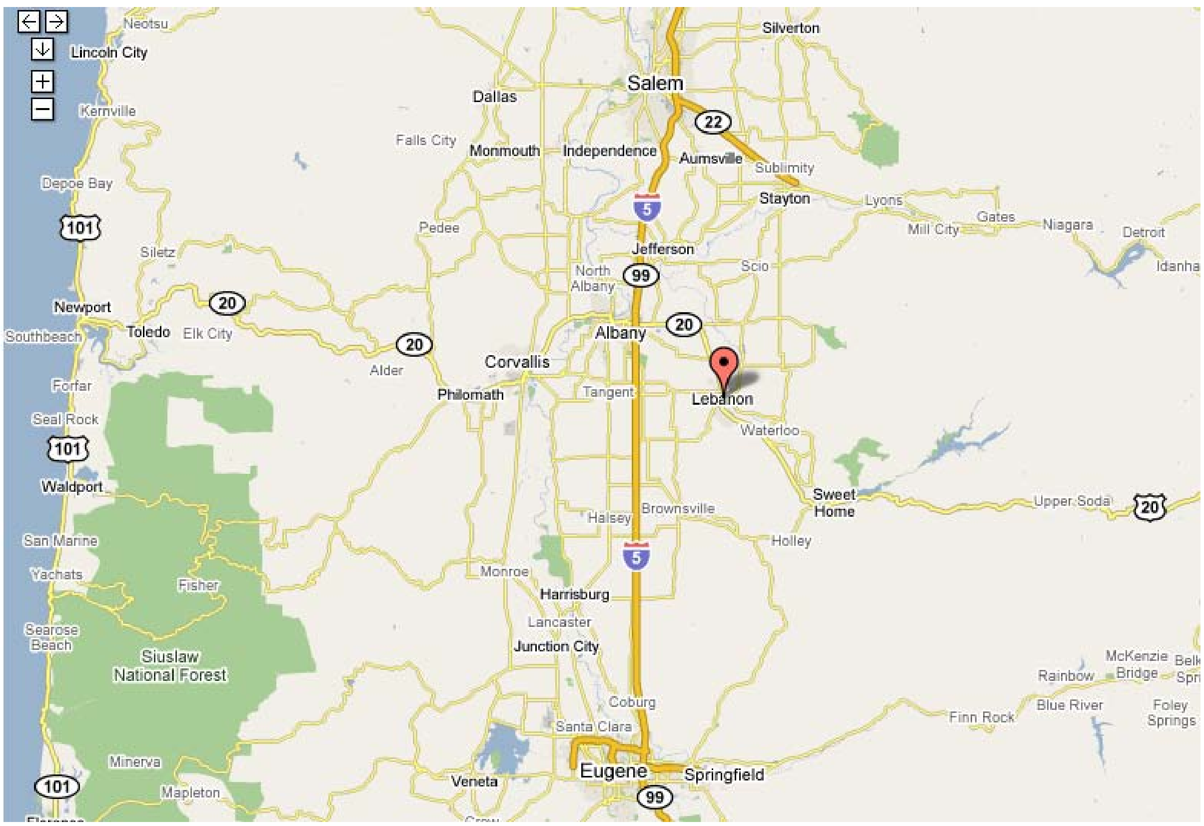
Purpose and Health Issues

This health consultation was prepared by the Environmental Health Assessment Program in cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). EHAP prepared this health consultation to determine whether residents in Lebanon, Oregon are being exposed to groundwater contaminated with volatile organic compounds at levels that could result in adverse health effects. EHAP became involved with the Lebanon Groundwater Contamination site when EPA requested technical assistance in addressing health concerns related to the contamination. ATSDR recommended that EHAP conduct a more in-depth evaluation of possible health risks at the site. The purpose of this health consultation is to determine if people are being exposed to the groundwater contamination, characterize the health risks associated with these exposures, and develop recommendations and a public health action plan that would limit any exposures that could result in adverse health effects.

Site Background

The city of Lebanon is located in Linn County, Oregon, approximately 37 miles southeast of Salem and 15 miles east of Albany on US-20 (Figure 1). The city has a total area of 5.4 square miles. The population of Lebanon was approximately 14,700 in 2007, which represented a 13% increase since 2000[1]. According to information from the 2000 Census, the median age of the population in Lebanon was 35.9 years, with 7.9% of the population under 5 years of age, and 17.8% of the population 65 years or older. In 2000, the median household income in Lebanon was $31,231, below the U.S. average of $41,994. An estimated 14.4% of families were living below the poverty level, compared to 9.2% of U.S. families[2]. More recent data show that unemployment rates in Linn County are higher compared to the State of Oregon average (6.4% compared to 5.2% in 2007)[3].

Figure 1. Map of Lebanon, Oregon.



Site History

Groundwater contamination in Lebanon was first identified in August 1990, when PCE was detected at a concentration of 15.0 ppb in an irrigation well in Lebanon’s Century Park. At the time, the City of Lebanon was exploring the development of a groundwater source to expand the municipal drinking water supply, which is provided by a surface water intake from the Lebanon-Santiam Canal[4]. Since the initial detection, there have been several sampling events and reports, with over 120 wells in Lebanon sampled for VOCs [4, 5]. Many of these are household wells that serve as the primary water source for residents.

The impacted area is approximately 0.6 square miles, and overlaps with downtown Lebanon. There appears to be two distinct groundwater plumes affecting the east and west side of the contamination area [6]. The area is primarily residential, though there are some small businesses and industrial operations in the area. Some of these business sites include former dry cleaning operations and other small industries that may be the source of the contamination. These sites are believed to have disposed solvents directly onto the soil and into groundwater, though the number and extent of these releases is not known. Though potentially responsible parties have been identified, none have taken responsibility for remediation at the site.

EPA and DEQ have been the lead agencies in providing oversight for sampling and remediation activities at the Lebanon Groundwater Contamination site (see Appendix A for a summary of DEQ's activities at the site between 1993 and 2000). The site is currently under DEQ's Orphan Site Program, which uses state funds to clean up high-priority contamination sites for which there are no responsible parties or where responsible parties are unable or unwilling to pay for investigation and cleanup. DEQ is currently overseeing cleanup at three of the former dry-cleaning sites [5].

In March 2007, EPA initiated an Expanded Site Inspection whose purposes were to identify any residences that were using contaminated well water for their domestic water source, provide updated information on contaminant levels, and characterize the extent of the contaminant plumes. EHAP became involved with the Lebanon Groundwater Contamination site at EPA's request, and provided assistance by reviewing the results of the sampling data and answering residents' questions about health risks related to VOCs in groundwater. Because of concerns that the contamination might pose health risks to some residents, ATSDR recommended that EHAP conduct a more thorough evaluation of the public health implications of the contamination at this site in a health consultation.

In November 2007, DEQ conducted an expanded Beneficial Water Use Assessment, which continued EPA's activities to identify residences that were using contaminated wells as a primary drinking source. DEQ's contractor, Hart Crowser, identified potential well-users by determining which addresses in the affected area did not receive a city water bill, and by conducting a door-to-door survey in the area. Hart Crowser identified at least 59 properties with wells in the contamination area, and collected and tested samples from 47 wells in May 2008.

DEQ is recommending that homeowners whose domestic water supply comes from wells with VOC levels above the State and Federal Safe Drinking Water Standard (known as a "maximum contaminant level" or MCL) use an alternate water supply in order to reduce exposures to these contaminants. As a temporary solution, DEQ is offering bottled water to residences with PCE or TCE levels above the MCL of 5 parts per billion (ppb). DEQ is currently developing a plan for a permanent solution to provide safe drinking water to these homes, which will involve coordination with home owners and the City of Lebanon. A likely solution will be to offer to connect these residences to the city water supply. DEQ is currently providing bottled water to five residences, and has paid to connect one residence to the city water supply. In addition, DEQ will be implementing a number of institutional controls to inform people about the groundwater contamination and recommend that people living in the affected area have their wells tested. These controls include: informing well drillers and realtors in the area of the contamination; notifying the local Watermaster (part of the Oregon Water Resources Department, which approves the construction of new wells in Oregon) of the contamination; and conducting public outreach through news releases, display ads and public postings.

Community Concerns

Though investigations at the Lebanon Groundwater Contamination Site have been in progress for approximately 18 years, EHAP has limited information on the concerns that local residents have about the contamination. Some concerns have been identified from discussions with partner agencies and local officials, site visits, and phone calls from affected residents. These concerns include:

- Health effects of contamination (particularly children's health) – Questions related to safe uses of well water, ways children can be exposed, health effects related to PCE and TCE, and ways to reduce exposure
- Cost of switching to city water – Homeowners with contaminated wells have expressed concerns about the financial costs of having to pay a city water bill and about the safety and taste of city water. These concerns may account for limited participation in recent sampling efforts and public information sessions.

During a site visit in April 2008, EHAP and DEQ met with local officials to discuss each agency's role in the investigation, outline plans for upcoming sampling efforts and EHAP's health consultation, and identify ways to reduce exposure to contaminated groundwater. City officials expressed concerns about children's health, the uncertainty about the extent and boundaries of the groundwater plumes, and the perceived lack of concern about the contamination by local residents.

Lebanon city officials and DEQ have also expressed concerns about the potential for home buyers to unknowingly purchase a home with a contaminated well and become exposed to contaminated water. This scenario has occurred at least once (to a family with young children) and highlights the need for a long-term solution for affected homes in this area. The City of Lebanon and DEQ have discussed the possibility of putting deed notices on properties with contaminated wells so that new home buyers will be alerted to the problem. DEQ's planned institutional controls (notifying well drillers, realtors, the Watermaster and the public) were developed in part to address this concern.

Discussion

In addition to considering community health concerns, EHAP evaluates several types of information in order to determine the public health implications of a contaminant release. This process includes an exposure pathway analysis, evaluation of environmental sampling data, an examination of health effects associated with exposure to a contaminant, and considerations about the health risks to children. EHAP's assessment of potential health risks at the Lebanon Groundwater Contamination site is described in detail in this section.

Summary of Well Sampling

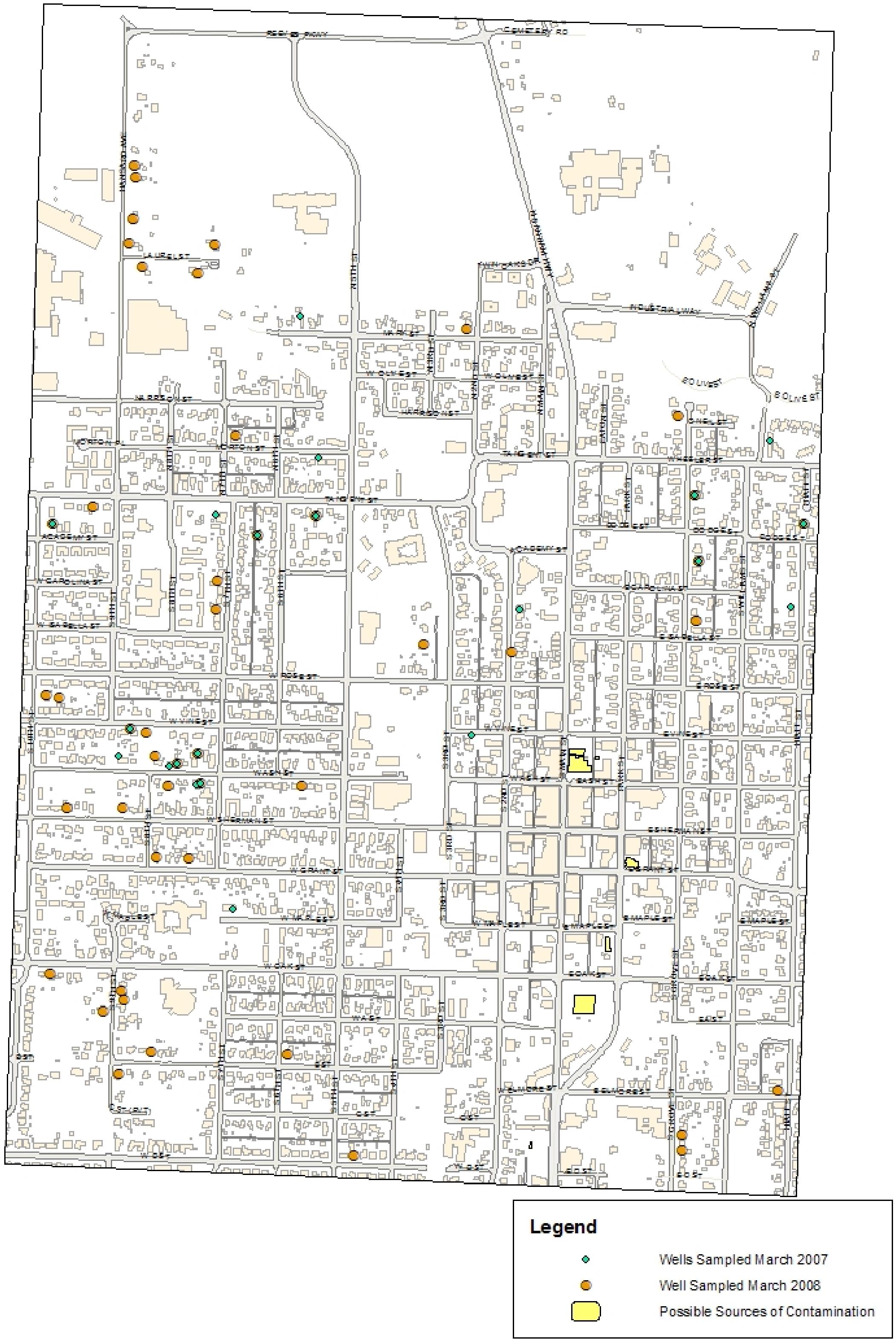
The data evaluated in this report are limited to data collected by EPA and DEQ in 2007 and 2008. Table 1 provides a summary of the wells sampled at the Lebanon Groundwater Contamination Site during this time [6]. A total of 58 wells were tested for VOCs, and wells sampled in May 2008 were also tested for nitrates. Figure 2 shows a map of wells sampled during the March 2007 and May 2008 sampling events. There were ten wells that were sampled during both events; in these cases, the highest measured level of any detected contaminant was included in the data analysis. Fourteen wells were identified as being used for irrigation purposes and 44 wells were used for domestic purposes such as drinking water, cooking and bathing (this includes 5 wells with unknown use). Data on well-depth were available for 30 of the 58 wells. DEQ is providing an alternate water supply to all residences whose wells have VOC levels over the MCL. Currently, five homes are receiving bottled water and one home has been connected to the municipal water supply.

Table 1. Summary of wells sampled at Lebanon Groundwater Contamination Site, March 2007 and May 2008.

Total Wells Tested for VOCs	58*
Total Wells Tested for Nitrates	48
Number Irrigation Wells	14
Number Domestic Wells	44**
Number of Wells with levels over MCL	6
Homes currently receiving bottled water	5
Homes connected to city water supply	1
Well Depth	
Deep	22
Intermediate	5
Shallow	3
Unknown	28

*Includes 10 wells tested during both sampling events
**Includes 5 wells with unknown use – assumed to be domestic wells.

Figure 2. Map of wells sampled at the Lebanon Groundwater Contamination Site, March 2007 and May 2008.



Exposure Pathway Analysis

Environmental contaminants must come into contact with a population in order to pose a public health risk. In order to understand potential exposures at a site, EHAP conducts an exposure pathway analysis by evaluating whether the following five elements are present:

- A source for the contaminant(s) or release
- Movement of contaminants in the environment
- A location or area where people can come into contact with contaminants
- A way for people to come into physical contact with contaminants
- A population that can come into contact with contaminants

If any of these five elements are known to be missing at a site, it is unlikely that the contaminants in that pathway pose a public health risk and those contaminants are eliminated from further evaluation. If all of the elements are known to be present, or could potentially be present, the contaminants in the pathway are further evaluated for potential risks to the exposed population.

EHAP identified three potential exposure pathways at the Lebanon contamination site (Table 2). The exact sources of the groundwater VOC contamination remain difficult to determine, though they are believed to be from past dumping or spills from dry cleaners and other sources in downtown Lebanon. Past and current sampling activities have confirmed that contaminants are present in groundwater. Surface water sources (which are the source for Lebanon's city water supply) have not shown any signs of VOC contamination.

Table 2. Exposure Pathway Analysis for Lebanon Groundwater Contamination Site.

Pathway	Source	Fate and Transport	Point of Exposure	Potentially Exposed Population	Route of Exposure	Time Frame
Groundwater Contamination in Domestic Wells	Possible VOC release by dry cleaners/other sources	Groundwater (Private Domestic Wells)	Residences (Taps/other water source points)	Residents using private wells for domestic/use	Ingestion Inhalation Dermal	Past Present Future
Groundwater Contamination in Irrigation Wells	Possible VOC release by dry cleaners/other sources	Groundwater (Private Irrigation Wells)	Residences (Taps/other water source points)	Residents using private wells for irrigation use	Ingestion	Past Present Future
Vapor Intrusion	Possible VOC release by dry cleaners/other sources	Migration of VOCs from groundwater to indoor air	Residences Businesses	Residents/workers in buildings above or near contaminated groundwater	Inhalation	Past Present Future

The pathway of most concern is contamination in wells used for domestic purposes. Residents who use contaminated wells for domestic purposes could be exposed through the ingestion, inhalation and dermal routes. Ingestion of contaminants can occur through drinking water, using water for cooking or drinks, and accidentally swallowing water during bathing or other activities. Inhalation of contaminants is also a significant route of exposure because of the nature of the contaminants at this site. Volatile organic compounds such as PCE and TCE can easily transition from the liquid phase to the gas phase, and air concentrations of these chemicals may reach high levels in indoor areas that are enclosed or poorly ventilated (such as bathrooms or basements). Some studies have shown that exposure to VOC-contaminated water during bathing and showering can result in an inhalation dose that is comparable to the ingestion dose [7-9]. Exposure through the dermal route (absorption through skin) is expected to result in a much smaller exposure dose compared to the ingestion and inhalation routes.

Lebanon residents also may be exposed to contaminants in irrigation wells. Assuming that these wells are used for outdoor irrigation or recreation purposes only, the main route of exposure would be by accidentally swallowing the water. Exposure doses from the inhalation and dermal absorption routes are expected to be negligible, since VOCs from the water would evaporate and disperse in ambient air.

Vapor intrusion is a potential pathway that should be considered at sites with VOC contamination. Vapor intrusion occurs when VOCs in sub-surface soil or groundwater migrate to the surface and enter into indoor buildings. Vapor intrusion can be affected by many factors, including the depth of the contamination, the concentration of VOCs, soil characteristics, and characteristics of affected buildings. Some information on well/groundwater depth and soil characteristics in Lebanon has been collected during the current and previous investigations. However, a more thorough assessment, which may include the collection of soil gas or indoor air data, is needed to evaluate whether vapor intrusion of VOCs is occurring at this site.

The scenarios and contaminant levels presented in this report are assumed to reflect current exposures. In some instances, current exposures may be different from past conditions due to actions by DEQ to limit harmful exposures to VOCs in drinking water, such as providing bottled water for drinking and cooking. These instances have been noted in the health effects evaluation section below. The exposure scenarios at this site may change in the future based on additional sampling information, remediation activities, and public health actions that result in changes in exposure.

Health Effects Evaluation

EHAP examines whether contaminants at a site could result in increased risks for both non-cancer and cancer health effects. This process involves an initial screening process using environmental screening guidelines; a comparison of site-specific exposure doses to health guidelines; and a more in-depth evaluation of health risks using information from toxicological and health studies.

Derivation of Environmental and Health Guidelines

The environmental screening and health guidelines used in this evaluation are based on information from studies on health effects observed in studies of animals and humans who have been exposed to the contaminants of concern at this site. The information from these studies is used to determine the lowest amounts of a substance that have resulted in adverse health effects (the Lowest Observed Adverse Effect Level, or LOAEL) and the amounts of a substance that have not been shown to cause any health effects (the No Observed Adverse Effect Level, or NOAEL). ATSDR and EPA apply a number of safety factors to the LOAELs and NOAELs to derive non-cancer health guidelines such as the Minimal Risk Level (MRL) and the Reference Dose (RfD). These guidelines represent the daily doses of a contaminant that people could be exposed to for a specified period of time without experiencing any health effects. These health guidelines are then used to derive environmental screening guidelines such as the Environmental Media Evaluation Guide (EMEG). These guidelines are the concentrations of a substance in a specific media (e.g., water, air or soil) that people could be exposed to without any risks for harmful non-cancer health effects.

Cancer risks are evaluated by first examining if there is scientific evidence that a substance causes cancer, and then determining if exposures at a site could theoretically result in increased cancer risk. The EPA, the National Toxicology Program (NTP) and the International Agency on Research of Cancer (IARC) classify substances in terms of whether they are known, probable, possible or unlikely carcinogens. For substances that are known, probable or possible carcinogens, the EPA has developed cancer slope factors (CSF) as an estimate of a substance's potential to result in additional cancer cases in a population. The CSF is used to calculate a theoretical cancer risk, which is an estimate of the number of additional cancer cases that would occur if a population was exposed to a contaminant assuming certain exposure conditions.

The theoretical cancer risk can never be zero (i.e., any exposure to a carcinogen could potentially have some cancer risk), so exposures are described in terms such as slight, low, moderate or high risks. For example, exposures that could cause one additional case of cancer in a population of one million are considered to have a slight cancer risk, while exposures that could cause one additional case in 10,000 have a low cancer risk. *It should be noted that the theoretical cancer risk does not predict if an exposed person will get cancer.* Instead, these risk numbers are used by public health officials to make decisions about appropriate measures to reduce exposures. ATSDR has developed an environmental screening guideline called the Cancer Risk Evaluation Guideline (CREG), which is the concentration of a substance in a specific media that could result in a one in one million increased cancer risk (or slight cancer risk).

Initial Screening: Comparison to Environmental Guidelines

EHAP initially screened the Lebanon groundwater sampling data using environmental screening guidelines to identify which contaminants needed to be evaluated for potential health risks. This involved comparing the maximum concentration of each contaminant to its corresponding environmental screening guideline. In cases where there was more than one environmental screening guideline (e.g., a non-cancer guideline and a CREG), EHAP chose the most conservative guideline. The maximum concentration of a contaminant was used as part of this screening process because it represents the worst-case scenario at a site. Therefore, if no health risks are found at the maximum concentration of a contaminant, it is reasonable to assume that there would be no expected risks at lower concentrations of that contaminant. If a contaminant's maximum concentration is below its environmental screening guideline, it is not expected to cause harmful health effects and is screened out from further evaluations. Contaminants with levels above their environmental screening values will not necessarily cause harmful health effects, but require more in-depth evaluation to determine if they could pose risks to exposed residents.

Table 3 shows a summary of the contaminants detected at the Lebanon Groundwater Contamination Site in 2007 and 2008. A total of 18 contaminants were detected in the well samples. Four contaminants were found to exceed their environmental screening values: bromodichloromethane, carbon tetrachloride, tetrachloroethylene (PCE) and trichloroethylene (TCE). PCE and TCE were the most commonly detected contaminants at this site, while bromodichloromethane and carbon tetrachloride affected a smaller number of wells. Appendix C has additional information on the sources, environmental fate and health effects associated with these contaminants.

Table 3. Summary of contaminants detected at Lebanon Groundwater Contamination Site.

Contaminant	Detection Frequency	Concentration (ppb)		Screening Value (ppb)	Screening Value Source	Above Screening Value?
		Average	Range			
1,1,1-trichloroethane (TCA)	1 / 58	1.0	ND – 1.0	200	LTHA	No
1,1-Dichloroethylene	1 / 58	1.5	ND – 1.5	90	Child Chronic EMEG	No
1,1-Dichloroethane	1 / 58	0.5	ND – 0.5	2.4	California EPA	No
1,2,3-Trichlorobenzene	1 / 58	0.1	ND – 0.1	None	-	No
Acetone	3 / 58	4.6	ND – 5.0	9,000	Child RMEG	No
Bromobenzene	1 / 58	1.2	ND – 1.2	23	EPA Region 6	No
Bromodichloromethane	1 / 58	2.3	ND – 2.3	0.6	CREG	Yes
Carbon Tetrachloride	2 / 58	0.3	ND – 0.5	0.3	CREG	Yes
Carbon-disulfide	1 / 58	0.3	ND – 0.3	1,000	Child RMEG	No
Chloroform	14 / 58	3.2	ND – 20.0	100	Child Chronic EMEG	No
cis-1,2-dichloroethene (DCE)	5 / 58	2.0	ND – 5.2	70	LTHA	No
Dibromodichloromethane	1 / 58	0.3	ND – 0.3	None	-	No
Dichlorodifluoromethane	1 / 58	0.1	ND – 0.1	1,000	LTHA	No
Methylene Chloride	2 / 58	0.6	ND – 0.6	5	CREG	No

Nitrates	41 / 48	2,159.9	ND – 6220.0	10,000	Infant RMEG	No
Tetrachloroethylene (PCE)	22 / 58	18.9	ND – 110.0	0.11	CREG (Used CSF = 0.54)	Yes
Toluene	1 / 58	0.1	ND – 0.1	200	Child Intermediate EMEG	No
Trichloroethylene (TCE)	9 / 58	5.3	ND – 14.0	0.03	CREG (Used CSF = 0.4)	Yes
ND = Non-Detect; ppb = parts per billion; LTHA = Long Term Health Advisory; EMEG = Environmental Media Evaluation Guide; EPA = Environmental Protection Agency; RMEG = Reference dose Media Evaluation Guide; CREG = Cancer Risk Evaluation Guide; CSF = EPA Cancer Slope Factor						

Calculation of Exposure Doses

EHAP evaluated the four contaminants identified in the initial screening process to determine if they posed any risks to affected Lebanon residents for non-cancer or cancer health effects. As a first step, EHAP calculated exposure doses for young children (6 years and younger) and adults (18 years and older) in order to estimate how much of a contaminant a person living in the affected area could potentially contact on a daily basis. The maximum concentrations of a contaminant were used to calculate these doses in order to represent the worst-case scenarios at this site; if no health risks were found at these concentrations, no risks would be expected at lower concentrations.

In calculating the exposure doses, EHAP used as much site-specific information as was available in order to accurately represent the residents' exposures. This information included the types and levels of contaminants in Lebanon, whether wells were used for domestic or irrigation purposes, and whether residents were currently using bottled water for drinking/cooking purposes. However, EHAP did not have information on some important factors, which resulted in some uncertainties in this analysis. For example, it is not known how long people have been exposed to the groundwater contaminants in Lebanon. The contamination was first detected in 1990, but could have occurred earlier. In addition, residents' exposures would have changed if they moved in or out of the contamination area, if they stopped using contaminated wells as a water supply for their home, or if the contaminant levels changed over time. In cases where these data gaps existed, EHAP made conservative assumptions about residents' exposures. For example, EHAP assumed that an adult living in the contamination area would have been exposed to contaminants in their water for 350 days a year for 30 years. Further, these adults were assumed to be exposed by drinking 2.3 liters of contaminated water a day, inhaling vapors over 30 minutes in the bathroom (during/after showering), and absorbing chemicals through their skin during 15 minutes of showering. These assumptions likely overestimate actual exposures at this site, which is a health protective approach to account for any uncertainties in the evaluation. The exposure assumptions used in this health consultation, and the formulas used to estimate the exposure doses, are shown in detail in Appendix B.

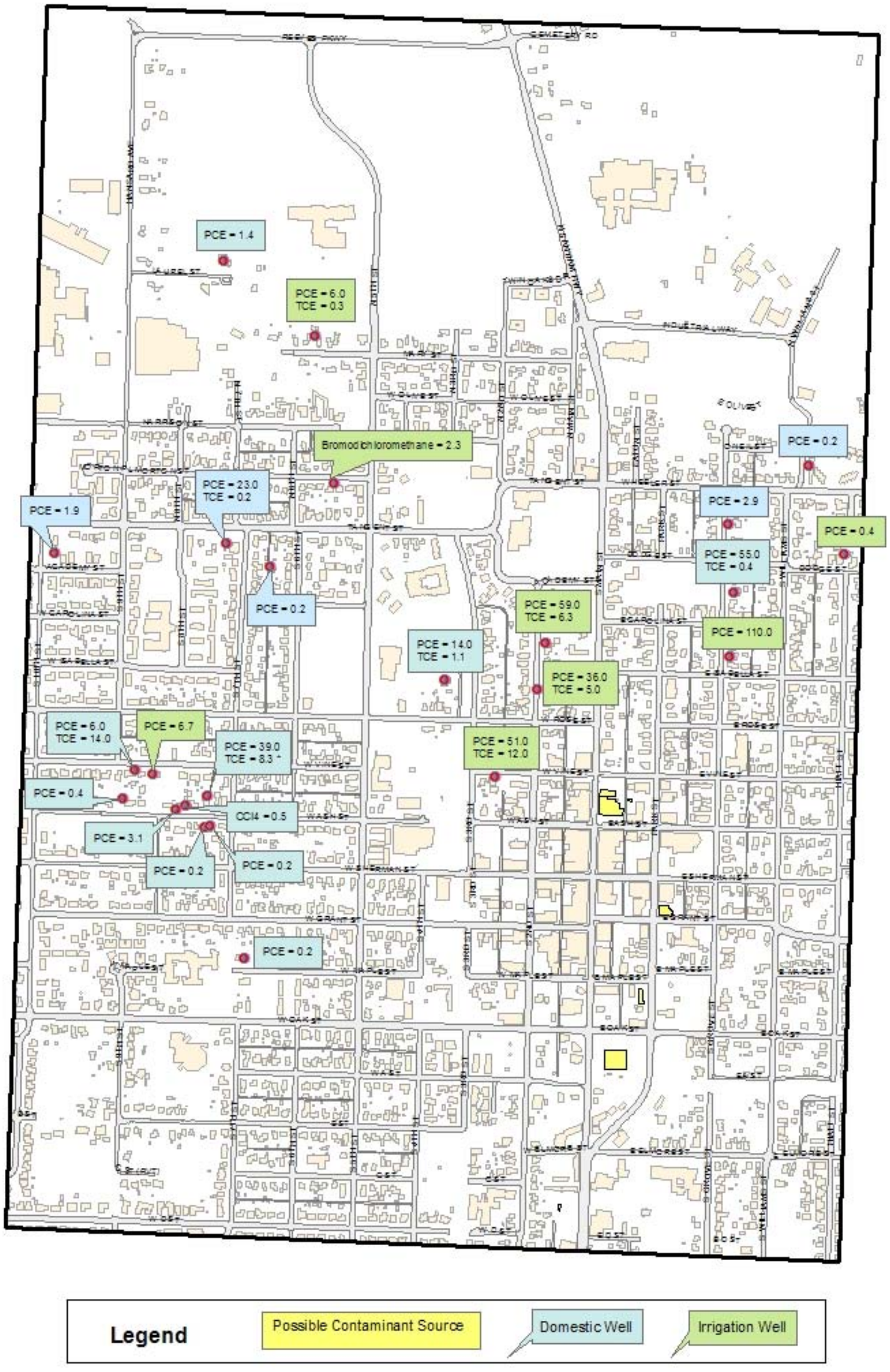
Health Guideline Comparison and In-depth Evaluation of Health Effects

To assess site-specific non-cancer health risks, the child and adult exposure doses for each contaminant at the Lebanon Groundwater Contamination site were compared to the health guideline for a contaminant. The EPA Reference Dose (RfD) was used as the non-cancer health guideline for the four contaminants evaluated for this site, and is the dose a person can be exposed to on a daily basis without having any adverse health effects. If the exposure dose for a substance exceeded its non-cancer health guideline, it was further evaluated for potential health risks.

All four of the contaminants that were identified in the initial screening are probable or possible carcinogens. Further, these contaminants were measured in Lebanon wells at concentrations above the CREG, which means they are at concentrations that exceed a slight level of increased cancer risk. To assess cancer risks at this site, EHAP calculated the theoretical cancer risk that would occur in a population exposed to these four contaminants under the same conditions as those assumed in Lebanon. Exposures that exceeded a low level of cancer risk (one additional case in a population of 10,000) were further evaluated to determine if they posed unacceptable cancer risks to exposed Lebanon residents.

DEQ identified 24 wells with contaminant levels above environmental screening values. Of these wells, 16 are used for domestic purposes, and 8 were used for irrigation purposes (Figure 3). EHAP evaluated these two groups separately.

Figure 3. Wells with contaminant levels exceeding environmental screening values, Lebanon Groundwater Contamination Site.



Domestic Wells

PCE Only

Ten of the 16 contaminated wells that are used for domestic purposes had only PCE detected. PCE concentrations range from 0.2 – 3.1 ppb, with an average of 1.1 ppb. The average depth of these wells is 67 feet (range 52 – 83 feet, with three wells with unknown depth). The PCE concentrations in these wells are below DEQ's action level of 5 ppb, and these homes have not been offered alternate water supplies. Therefore, this evaluation assumes that residents who use these wells are currently being exposed to PCE in well water through the ingestion, inhalation and dermal routes.

Table 4 shows the results of the health guideline comparison for homes using wells contaminated with PCE for domestic purposes. At the maximum concentration of PCE detected (3.1 ppb), the estimated exposure doses for both children and adults are below levels of health concern. When compared to the health guideline for non-cancer health effects, the child exposure dose is 19 times lower and the adult exposure dose is 57 times lower than RfD of 0.01 mg/kg/day. For cancer effects, adults exposed to the maximum concentration of PCE for thirty years would have an increased risk of 4 additional cases in a population of 100,000 (or 0.4 in 10,000). This represents a very low level of cancer risk.

In summary, there are no expected risks for non-cancer or cancer health effects even at the maximum concentration detected in the 10 PCE contaminated domestic wells. Therefore, EHAP concludes that the contamination in these wells currently poses **no apparent public health hazard** to exposed residents.

Table 4. Health guideline comparison for domestic wells contaminated with PCE.

Health Effects	Dose Comparison	Maximum Concentration PCE = 3.1 ppb		Average Concentration PCE = 1.1 ppb	
		Child	Adult	Child	Adult
Non-Cancer Risk	Total Dose* (mg/kg/day)	0.000526	0.000176	0.000219	0.000073
	Comparison Value (CV)¥ (mg/kg/day)	0.01	0.01	0.01	0.01
	Exceed CV?	No	No	No	No
Cancer Risk	Total Dose* (mg/kg/day)	0.000045	0.000075	0.000019	0.000031
	Cancer Risk ^	0.2 in 10,000	0.4 in 10,000	0.1 in 10,000	0.2 in 10,000
	Exceed 1 in 10,000 Risk?	No	No	No	No

*Total Dose is the sum of doses from ingestion, inhalation, and dermal routes (see Appendix B for calculations and doses from individual routes).
¥ Comparison Value:: EPA Reference Dose (RfD)
^ EPA Cancer Slope Factor for PCE = 0.54

PCE and TCE

Five of the 16 contaminated domestic wells had both PCE and TCE detected in the water. PCE concentrations in these wells range from 6.0 – 55.0 ppb, with an average of 27.4 ppb. TCE concentrations range from 0.2 – 14.0 ppb, with an average of 4.8 ppb. The average depth of these wells is 91 feet (range 63 – 121 feet, with two wells with unknown depth). Since the time the contamination was identified in these wells, all five of these residences have been provided bottled water for drinking and cooking water. Therefore, people living in these homes are assumed to be exposed to PCE and TCE through the inhalation and dermal routes, and not have significant exposures through the ingestion route.

Table 5 shows the results of the health guideline comparison for current exposures in homes using domestic wells contaminated with both PCE and TCE. At the maximum concentration of PCE detected (55.0 ppb), the estimated exposure doses for children and adults is lower than the non-cancer health guideline of 0.01 mg/kg/day. At the maximum concentration of TCE detected (14.0 ppb), both the child and adult exposure doses exceed the non-cancer health guideline of 0.0003 mg/kg/day. The child exposure dose at the average concentration of TCE in these five wells (4.8 ppb) is approximately equal to the health guideline. Based on these findings, EHAP further evaluated the potential for adverse health effects from exposure to TCE in these wells.

Table 5. Health guideline comparison for domestic wells contaminated with PCE and TCE.

Health Effects	**Dose Comparison**	**Maximum Concentration PCE = 55.0 ppb; TCE = 14.0**				**Average Concentration PCE = 27.4 ppb; TCE = 4.8**			
		Child		**Adult**		**Child**		**Adult**	
		PCE	**TCE**	**PCE**	**TCE**	**PCE**	**TCE**	**PCE**	**TCE**
Non-Cancer Risk	Total Dose* (mg/kg/day)	0.004559	0.001127	0.001561	0.000383	0.002280	0.000338	0.000780	0.000115
	Comparison Value (CV)¥ (mg/kg/day)	0.01	0.0003	0.01	0.0003	0.01	0.0003	0.01	0.0003
	Exceed CV?	No	**Yes**	No	**Yes**	No	No	No	No
Cancer Risk	Total Dose* (mg/kg/day)	0.000391	0.000097	0.000669	0.000164	0.000195	0.000029	0.000334	0.000049
	Cancer Risk	2 in 10,000	0.4 in 10,000	3.3 in 10,000	0.6 in 10,000	0.97 in 10,000	0.1 in 10,000	1.6 in 10,000	0.2 in 10,000
	Combined Cancer Risk	2.5 in 10,000		4.3 in 10,000		1.2 in 10,000		2.0 in 10,000	
	Exceed 1 in 10,000 Risk?	**Yes**		**Yes**		**Yes**		**Yes**	

*Total Dose is the sum of doses inhalation and dermal routes (see Appendix B for calculations and doses from individual routes).
¥ Comparison Value:: EPA Reference Dose (RfD)
^ EPA Cancer Slope Factor for PCE = 0.54, TCE = 0.4

The RfD of 0.0003 mg/kg/day is derived from the Lowest Observed Adverse Effect Level (LOAEL) for TCE, which is the lowest dose at which adverse health effects were observed in animal studies. These studies showed that mice who were orally exposed to the LOAEL dose of 1 mg/kg/day experienced adverse liver effects[10]. The RfD incorporates a series of uncertainty factors to account for differences between animals and humans, issues with experimental study design, and human variations that result in some populations being more sensitive to chemical exposures. These uncertainty factors resulted in a RfD for TCE that is 3,000 times lower than the LOAEL. The RfD for TCE is very conservative and is considered to be protective of the health of the most sensitive human populations.

In order to determine whether the residents who use these five contaminated domestic wells are currently being exposed to harmful levels of TCE, the margin of safety was calculated by dividing the LOAEL of 1 mg/kg/day by the maximum child and adult exposure doses. The child exposure dose (0.001127 mg/kg/day) had a margin of safety of 909 (i.e., the exposure dose was 909 times lower than the LOAEL), and the adult exposure dose (0.000383 mg/kg/day) had a margin of safety of 2,500. The large margins of safety indicate that current exposures to TCE even at the maximum detected concentrations are unlikely to put domestic well users at risk for non-cancer health effects.

PCE and TCE are both “reasonably anticipated to be human carcinogens” by the NTP and are classified as “probable human carcinogens” by the IARC. In 2001, EPA issued a draft health risk assessment for TCE that included a more conservative range for the cancer slope factor (from 0.02 – 0.4 per mg/kg/day). This revision was based on strong evidence from human and animal studies that exposure to TCE can increase the risk for several types of cancer, including kidney, liver, lympho-hematopoietic, cervical and prostate cancers in humans[10]. EHAP used the upper end of this range (0.4 per mg/kg/day) in this assessment, which is the most health-protective approach to assess cancer risks from TCE exposure. EPA is currently reviewing and updating its risk assessment for PCE, which will include an updated assessment of carcinogenic effects based on epidemiologic and experimental data. Epidemiological studies of human populations who have been exposed to PCE through inhalation or ingestion have shown increased risks for cancers of the liver, kidney, lung and bladder and childhood leukemia[11].

The cancer risks for children and adults at the maximum concentrations of PCE and TCE are 2.4 and 3.9 in 10,000 respectively (assuming 6 years of exposure for children and 30 years of exposure for adults). While these slightly exceed the 1 in 10,000 risk level, they still represent a low level of increased cancer risk. In addition, they represent the “worst-case scenario” for exposure, since they are based on the maximum detected concentrations at this site, conservative assumptions about how people are exposed, and utilize the most conservative estimates of cancer risks. Therefore, current exposures to PCE and TCE in these wells are unlikely to result in unacceptable cancer risks to the affected residents.

The residents in these five homes may have been exposed to higher amounts of PCE and TCE in well-water before receiving bottled water for their drinking water supply. The exposure doses from the ingestion, inhalation and dermal routes combined would have been approximately two times the exposure doses from the inhalation and dermal routes (see Table B.3 in Appendix). While the child and adult doses for past exposures to the maximum concentration of PCE were below health guidelines, the doses for exposures to the maximum concentration of TCE exceeded health guidelines. However, children and adults would have been exposed to TCE at levels that were 405 and 1,213 times lower than the LOAEL (respectively). Therefore, the risks for non-cancer health effects from past exposures would still have been very low, and no harmful health effects would have been expected.

There would have been elevated cancer risks from past exposures to the maximum concentrations of PCE and TCE, assuming that residents were exposed through the ingestion, inhalation and dermal routes. At these maximum concentrations, the cancer risks for children and adults would have been 5.4 and 9.0 additional cases in 10,000. This represents a low-to-moderate level of cancer risk. As noted previously, these are very conservative estimates of risks that are based on worst-case scenarios for exposure. The low level of cancer risk found at the average concentrations of PCE and TCE may be a more realistic estimate of past cancer risks to these exposed residents.

In summary, EHAP concludes that the PCE and TCE contamination in these five domestic wells currently poses **no apparent public health hazard** to exposed Lebanon residents**.** This conclusion assumes that these residents currently use an alternate water supply for drinking and cooking, and use well-water for all other domestic purposes. However, these residents’ past exposures (prior to receiving an alternate drinking water supply) could have resulted in elevated cancer risks. There may be other well-owners in the contamination area who are currently being exposed to VOCs in groundwater at levels that could put their health at risk. Therefore, EHAP recommends additional sampling of domestic wells in the area to identify any additional residents who could be exposed to unsafe levels of PCE and TCE in groundwater.

Carbon Tetrachloride

One of the 16 contaminated domestic wells had carbon tetrachloride detected above its environmental screening value. Carbon tetrachloride was detected at 0.5 ppb in this well, which is 68 feet in depth. This residence was not offered an alternate water supply, so this evaluation examines potential health risks from current exposures to carbon tetrachloride.

Table 6 shows the results of the health guideline comparison for this well. The estimated exposure doses for both children and adults are below the health guidelines for carbon tetrachloride. When compared to the health guideline for non-cancer health effects, the child exposure dose is 14 times lower and the adult exposure dose is 44 times lower than the RfD of 0.0007 mg/kg/day. The cancer risks are low enough to be considered negligible; an adult population exposed to 0.5 ppb of carbon tetrachloride for thirty years would have an increased risk of 5 additional cases in 10,000,000 (or 0.005 in 10,000). Exposure to carbon tetrachloride in this well is not expected to result in adverse health effects. Therefore, EHAP concludes that the contamination in this well currently poses **no apparent public health hazard** to exposed residents.

Table 6. Health guideline comparison for domestic wells contaminated with carbon tetrachloride, Lebanon Groundwater Contamination Site.

Health Effects	Dose Comparison	Concentration CCl_4= 0.5 ppb	
		Child	**Adult**
Non-Cancer Risk	Total Dose* (mg/kg/day)	0.000049	0.000016
	Comparison Value (CV)[¥] (mg/kg/day)	0.0007	0.0007
	Exceed CV?	No	No
Cancer Risk	Total Dose* (mg/kg/day)	0.000004	0.000007
	Cancer Risk	0.005 in 10,000	0.009 in 10,000
	Exceed 1 in 10,000 Risk?	No	No

*Total Dose is the sum of doses from ingestion, inhalation, and dermal routes (see Appendix B for calculations and doses from individual routes).
¥ Comparison Value:: EPA Reference Dose (RfD)
^ EPA Cancer Slope Factor for carbon tetrachloride = 0.13

<u>Irrigation Wells</u>

Eight of the 24 wells with contaminant levels exceeding environmental guidelines are used for irrigation purposes. Four of these wells had only PCE detected, three had both PCE and TCE detected, and one well had bromodichloromethane detected above screening values. One of the homes with PCE and TCE detected in the irrigation well has been connected to the city water supply; however, it is not known if this well has been completely abandoned.

EHAP assumed that these wells are currently being used for outdoor irrigation/recreation purposes only, and that the doses from the inhalation and dermal absorption routes would be negligible (since VOCs from the water would evaporate and disperse in ambient air). Therefore, the exposure doses are based on assumptions for incidental ingestion as the main exposure route (see Appendix B for exposure assumptions).

PCE and TCE

EHAP calculated child and adult exposure doses using the maximum and average detected concentrations of PCE and TCE in the irrigation wells. PCE concentrations in these wells range from 0.4 – 110.0 ppb, with an average of 38.4 ppb. TCE concentrations range from 0.0 – 12.0 ppb, with an average of 3.4 ppb. The average depth of these wells is 66 feet (range 35-105 feet).
Table 7 summarizes the health guideline comparison for incidental ingestion of water from irrigation wells. At the maximum concentrations of PCE and TCE detected in these wells, the child and adult exposure doses are well below the health guidelines for non-cancer health effects, and would result in a negligible level of increased cancer risk. Therefore, EHAP concludes that exposure to PCE and TCE from these wells currently poses **no apparent public health hazard**.

Table 7. Health guideline comparison for irrigation wells contaminated with PCE and TCE, Lebanon Groundwater Contamination Site.

Health Effects	Dose Comparison	Maximum Concentration PCE = 110.0 ppb; TCE = 12.0				Average Concentration PCE = 38.4 ppb; TCE = 3.4			
		Child		Adult		Child		Adult	
		PCE	TCE	PCE	TCE	PCE	TCE	PCE	TCE
Non-Cancer Risk	Total Dose (mg/kg/day)	0.000005	0.000001	0.000001	0.000000	0.000002	0.000000	0.000000	0.000000
	Comparison Value (CV)¥ (mg/kg/day)	0.01	0.0003	0.01	0.0003	0.01	0.0003	0.01	0.0003
	Exceed CV?	No	No	No	No	No	No	No	No
Cancer Risk	Total Dose (mg/kg/day)	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	Cancer Risk	0.002 in 10,000	0.002 in 10,000	0.003 in 10,000	0.002 in 10,000	0.0008 in 10,000	0.0005 in 10,000	0.0009 in 10,000	0.0006 in 10,000
	Combined Cancer Risk	0.004 in 10,000		0.005 in 10,000		0.001 in 10,000		0.001 in 10,000	
	Exceed 1 in 10,000 Risk?	**No**		**No**		**No**		**No**	

*Total Dose is the dose from incidental ingestion (see Appendix for calculations).
¥ Comparison Value:: EPA Reference Dose (RfD)
^ EPA Cancer Slope Factor for PCE = 0.54, TCE = 0.4

Bromodichloromethane

One of the 8 contaminated irrigation wells had bromodichloromethane detected above its environmental screening value. Bromodichloromethane was detected at 2.3 ppb in this well, which is 70 feet in depth. Table 8 shows the results of the health guideline comparison for this well. The estimated exposure doses for both children and adults are well below the guidelines for non-cancer health effects, and would result in a negligible level of increased cancer risk. Therefore, EHAP concludes that the contamination in this well currently poses **no apparent public health hazard.**

Table 8. Health guideline comparison for irrigation wells contaminated with bromodichloromethane, Lebanon Groundwater Contamination Site.

Health Effects	**Dose Comparison**	**Concentration Bromodichloromethane = 2.3 ppb**	
		Child	**Adult**
Non-Cancer Risk	Total Dose (mg/kg/day)	0.000000	0.000000
	Comparison Value (CV)¥ (mg/kg/day)	0.02	0.02
	Exceed CV?	No	No
Cancer Risk	Total Dose (mg/kg/day)	0.000000	0.000000
	Cancer Risk	0.000006 in 10,000	0.000006 in 10,000
	Exceed 1 in 10,000 Risk?	No	No

*Total Dose is the dose from incidental ingestion (see Appendix for calculations).
¥ Comparison Value:: EPA Reference Dose (RfD)
^ EPA Cancer Slope Factor for bromodichloromethane = 0.062

Vapor Intrusion

Vapor intrusion is a potential exposure pathway at the Lebanon Groundwater Contamination site. However, there are data gaps that prevent EHAP from fully evaluating whether this pathway poses health risks to affected Lebanon residents. The available information on the depths at which the PCE and TCE are migrating within the groundwater suggests that vapor intrusion may not be a source of significant exposure. The majority of contaminated wells with known depths were deep wells (55 feet or more), and the shallowest contaminated well was 35 feet (intermediate depth). Three of the wells sampled during this investigation were known to be shallow in depth, and none of these wells had contaminant detections. This indicates that the contamination may be affecting a deep groundwater aquifer[6]. A low concentration of VOC gases would be expected to migrate from a deep groundwater source to the surface, and would probably not result in significant exposure through the inhalation route. However, this exposure pathway cannot be eliminated, in part because of incomplete data on the depths of the sampled wells and because all residences in the affected area have not been sampled. In addition, there are currently no soil-gas or indoor air sampling data available to evaluate this exposure pathway. Because of these data gaps, EHAP concludes that exposure to contaminants through vapor intrusion poses an **indeterminate public health hazard**, and has developed recommendations to address these data gaps (see Recommendations section below).

Children's Health Considerations

EHAP and ATSDR recognize that infants and children may be more vulnerable to exposures than adults in communities faced with contamination of their air, water, soil, or food. This vulnerability is a result of the following factors:

- Children are more likely to play outdoors and bring food into contaminated areas.
- Children are shorter, resulting in a greater likelihood to breathe dust, soil, and heavy vapors close to the ground.
- Children are smaller, resulting in higher doses of chemical exposure per body weight.
- The developing body systems of children can sustain permanent damage if toxic exposures occur during critical growth stages.

Because children depend on adults for risk identification and management decisions, ATSDR is committed to evaluating their special interests at sites such as the Lebanon Groundwater Contamination Site where their behaviors or sensitivity to contaminants could put them at greater risk. EHAP addressed these considerations in this assessment by using conservative exposure assumptions and calculating exposure doses specifically for children. The screening and comparison guidelines used are highly protective of children and other sensitive populations. Finally, EHAP incorporated children's health considerations in the development of its recommendations and public health action plan.

Conclusions

Based on an evaluation of exposure, environmental and health effects information at the Lebanon Groundwater Contamination Site, EHAP reached the following conclusions:

- PCE, TCE and carbon tetrachloride contamination in domestic wells currently poses **no apparent public health hazard**. This conclusion assumes that well-owners with VOC levels exceeding safe drinking water standards are currently using an alternate water source (such as bottled water or city water) for their drinking water supply. These residents would not be exposed through their drinking water, but could inhale VOCs that evaporate from water to air and absorb small amounts through the skin.

- Some residents with both PCE and TCE in their domestic wells may have had past exposures that resulted in elevated cancer risks. These exposures would have occurred prior to these residents receiving an alternate drinking water supply. This indicates that VOCs have been measured in Lebanon's groundwater at levels that could pose health risks to domestic well-users.
- PCE, TCE and bromodichloromethane contamination in irrigation wells currently poses **no apparent public health hazard**.
- Exposure through vapor intrusion of VOCs into indoor air is **an indeterminate public health hazard**. While there is some evidence that vapor intrusion of VOCs may not be a significant source of exposure at this site, EHAP currently does not have the data needed to evaluate this pathway (such as VOC concentrations in indoor air and soil).

Recommendations

EHAP developed the following recommendations based on community health concerns and its assessment of the public health implications of contamination at the Lebanon Groundwater Contamination Site.

DEQ is the lead agency that currently oversees sampling and remediation activities at the Lebanon site. EHAP recommends that DEQ:

- Conduct additional sampling to identify as many affected domestic and irrigation wells as is possible, and further characterize the extent of the groundwater contamination. DEQ has identified this as a priority at this site, and is currently planning for additional sampling in Fall/Winter 2008.
- Assess whether residents and workers in buildings above or near the contaminant plumes could be exposed to VOCs through vapor intrusion. This assessment may include collecting data on VOC concentrations in indoor air and soil. DEQ is planning on evaluating this exposure pathway in 2009.
- Continue to work with homeowners and the city of Lebanon to determine appropriate long-terms solutions that will reduce exposures to contaminated wells. DEQ's proposed solution is to connect affected residences to the municipal water supply, and offer carbon filter systems in special circumstances. DEQ also may offer to pay to abandon contaminated wells, which will prevent these wells from being used in the future.
- Implement the proposed institutional controls to alert current and future homeowners in the affected area about the contamination in order to prevent the use of water from contaminated wells. These controls include notices to well drillers and realtors in the area; notifying the local Watermaster; public outreach; and putting Notices of Environmental Contamination on property deeds.
- In coordination with EHAP, provide appropriate outreach and resources to Lebanon residents who are affected by the groundwater contamination.

As part of the outreach mentioned above, EHAP will develop and disseminate a fact sheet to Lebanon well-owners affected by VOCs in their groundwater. This fact sheet will include information on steps that residents can take to reduce their exposure to contaminants in their well-water, including the following:

- Residents who have not had their wells tested and who live in or near the contamination area should contact DEQ for information about having their wells sampled.
- Residents affected by the groundwater contamination can take the following steps to reduce their exposure:
    - In homes with water exceeding the MCL of 5 ppb, continue using bottled water (or other alternate water supply) for drinking and cooking purposes.
    - Limit inhalation exposures during bathing and showering by making sure bathrooms are well-ventilated.
    - Limit inhalation exposures during other domestic activities (such as cooking).
    - Supervise children while bathing and showering to reduce incidental ingestion of water during these activities.
    - Homeowners who are currently or considering using a filtration system should ensure that it is appropriate for removing VOCs from water, and that is certified by a recognized third-party testing organization that meets the standards established by the American National Standards Institute (ANSI) and NSF International.

Public Health Action Plan

The Public Health Action Plan ensures that the public health consultation identifies public health risks along with providing a plan of action designed to reduce and prevent adverse health effects from exposure to hazardous substances in the environment. This plan includes a description of actions that will be taken by EHAP in collaboration with other agencies to pursue the implementation of the recommendations outlined in this document.

Public Health Actions that have been implemented to date:

- EHAP conducted a site visit in April 2008, which included a drive-through of the contamination area and a meeting with DEQ and Lebanon city officials.
- EHAP assisted DEQ with community outreach by reviewing letters to affected homeowners, reviewing press releases, communicating with homeowners with concerns about health effects related to PCE/TCE exposure, and planning for a public information session.
- EHAP and DEQ co-hosted a public information session in August 2008 to answer questions about the site investigation and encourage residents to have their wells tested.

Public Health Actions that will be implemented in the future:

- EHAP will work with DEQ to expand outreach efforts in Lebanon in order to increase community awareness about the contamination and encourage well-owners living in or near the contamination area to have their wells tested.
- EHAP will be available to answer questions and provide information to Lebanon residents on the health effects associated with PCE, TCE and other contaminants identified at the Lebanon Groundwater Contamination site.
- EHAP will be available for consultation on sampling plans for additional groundwater monitoring and/or assessments for vapor intrusion.
- EHAP will be available to evaluate additional environmental data in separate health consultation upon request.

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Certification

The Environmental Health Assessment Program of the Oregon Department of Human Services prepared the Lebanon Groundwater Contamination Site Health Consultation under a cooperative agreement with the Agency for Toxic Substances and Disease Registry. This document is in accordance with approved methodology and procedures. Editorial review was completed by the Cooperative Agreement partner.

Charisse J Walcott for Alan Crawford

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I have reviewed this health consultation, as the designated representative of the Agency for Toxic Substances and Disease Registry and concur with its findings.

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Appendix A: Summary of DEQ Activities at Lebanon Groundwater Contamination Site from 1993-2000, and current cleanup activities.

1993	• Conducted initial soil and groundwater sampling to try and locate sources of the contamination.
1995	• Collected seventy-six soil and groundwater samples using direct-push sampling techniques to provide additional information on possible sources of contamination. • Installed ten shallow and deep groundwater monitoring wells to help track the flow of the contamination. • Conducted a focused investigation at the Oregon Military Department Lebanon National Guard Armory.
1995-1996	• Conducted focused soil and groundwater investigations at seven dry cleaners (or former dry cleaners), the city Public works maintenance Shop, and at Alley's Truck and Auto Parts (which included a machine shop). • Initial investigations identified Johannsen Cleaners, Poly Clean Center cleaners, and NuWay II Cleaners as likely contributors to the area-wide contamination.
1998	• Drilled 19 additional new groundwater monitoring wells and conducted shallow soil and groundwater sampling to further define the extent of the groundwater contamination.
1999	• Attempted to provide alternate water supplies (bottled water, water filtration systems or city water) to seven residents with contaminated wells, and who were not on city water. Only one resident responded to this offer, and was provided bottled water. This residence has since reportedly hooked up to city water.
Current Cleanup Activities	• PCE contamination at Johannsen Cleaners is currently being cleaned up by DEQ's Dry Cleaner Program. The cleanup at Johannsen Cleaners has involved soil excavation, soil vapor extraction, and groundwater extraction and treatment (pump and treat). • DEQ is also conducting groundwater cleanup at the site of the former NuWay II Cleaners. Cleanup at NuWay II has involved groundwater pump and treat and bioremediation. • Under a DEQ Consent Decree, Safeway Incorporated is currently investigating and cleaning up PCE contamination from the former Poly Clean cleaners. Safeway's cleanup efforts to date have involved soil vapor extraction. • DEQ began overseeing additional site investigations at the former Union II Cleaners (which was a focus of the 1995/1996 focused investigations). The current property owners are participating in DEQ's Voluntary Program and will be collecting additional soil and groundwater samples to determine if this site could be contributing to the area-wide contamination.

Appendix B: Equations and Exposure Assumptions used in Dose Calculations

1. Domestic Wells

a. Ingestion Dose (mg/kg/day)

$$\text{Non-Cancer Dose} = \frac{Cw \times CF1 \times IRW \times EF \times ED}{BW \times AT_{nonc}}$$

$$\text{Cancer Dose} = \frac{Cw \times CF1 \times IRW \times EF \times ED}{BW \times AT_{c}}$$

b. Inhalation Dose (mg/kg/day)

$$\text{Concentration in Air (Cair)} = \frac{Cw \times k \times FR \times Ts}{Vair}$$

$$\text{Non-Cancer Dose} = \frac{Cair \times CF1 \times IR \times Tb \times EF \times ED}{BW \times Atnonc \times CF2}$$

$$\text{Cancer Dose} = \frac{Cair \times CF1 \times IR \times Tb \times EF \times ED}{BW \times AT_{c} \times CF2}$$

c. Dermal Dose (mg/kg/day)

$$\text{Non-Cancer Dose} = \frac{Cw \times (1-k) \times CF1 \times P \times SA \times CF3 \times Ts \times EF \times ED}{BW \times AT_{nonc}}$$

$$\text{Cancer Dose} = \frac{Cw \times (1-k) \times CF1 \times P \times SA \times CF3 \times Ts \times EF \times ED}{BW \times AT_{c}}$$

2. Irrigation Wells: Incidental Ingestion Dose (mg/kg/day)

$$\text{Non-Cancer Dose} = \frac{Cw \times CF \times IRWi \times RTx\ EFi \times Edi}{BW \times AT_{nonc} \times CF2}$$

$$\text{Cancer Dose} = \frac{Cw \times CF \times IRWi \times RTx\ EFi \times Edi}{BW \times AT_{c} \times CF2}$$

3. Cancer Risk = Cancer Dose x Cancer Slope Factor

Table B.1: Exposure assumptions used in calculating child and adult exposure doses.

Parameter	Value		Units	Notes
	Child (Less Than 6)	Adult		
Chemical Concentration in Water (Cw)	chemical specific		μg/L = ppb	Maximum/Average Detected Concentration
Conversion Factor (CF1)	0.001		mg/μg	Converts contaminant concentration from micrograms to milligrams
Ingestion Rate Water (IRW)	1.5	2.3	L/day	EPA Exp Factors Handbook
Exposure Frequency (EF)	350	350	days/year	DEQ Deterministic HHRA Guidance, Appendix B; Away for 2 weeks per year
Exposure Duration (ED)	6	30	years	DEQ Deterministic HHRA Guidance, Appendix B; Assuming average time at residence = 30 years
Body Weight (BW)	15	70	kg	EPA Exp Factors Handbook
Averaging Time - Noncancer (AT_{nonc})	2190	10950	Days	DEQ Deterministic HHRA Guidance, Appendix B - Child and Adult
Averaging Time - Cancer (AT_c)	25550		Days	DEQ Deterministic HHRA Guidance, Appendix B - Child and Adult; 70 years
Inhalation Rate (IR)	10,000	13,300	L/day	EPA Exp Factors Handbook; for child, used rate for child 6-8, for adults (19-65), averaged rate for women (11,300) and men (15,200)
Concentration in Air (Cair)	chemical specific		μg/L = ppb	Maximum/Average Detected Concentration
Time in bathroom (Tb)	0.42	0.5	Hr/day	EPA Exp Factors Handbook - assumed 25 min for child and 30 min for adult
Conversion Factor 2 (CF2)	24		Hr/day	Converts hours to days
Volatilization Factor - (K)	0.6		-	ATSDR Public Health Assessment Guidance Manual 2005 - G7
Flow Rate (FR)	480		L/hr	Assume shower flow rate of 8L/min, converted to L/hr - ATSDR Standard Assumptions
Air Volume of Bathroom (Vair)	10,000		L	ATSDR Standard Assumptions
Fraction of chemical in water (1-K)	0.4		-	Fraction of chemical remaining in water after volatilization, assuming 60% of chemical is volatilized
Permeability Coefficient (P)	PCE = 0.033, TCE = 0.012		Cm/hr	EPA Exp Factors Handbook
Exposed Body Surface Area (SA)	7280	19400	Cm^2	EPA Exp Factors Handbook; used 50th percentile for males
Conversion Factor 3 (CF3)	0.001		L/cm^3	Converts cm3 to liters
Time in shower (Ts)	0.25		Hr/day	Assuming 15 minute shower for children and adults
Incidental Ingestion Rate Water (IRWi)	0.1	0.05	L/day	Professional judgment
Recreation Time - Incidental Ingestion (RT)	1	1	Hr/day	Assume 1 hour/day
Exposure Frequency - Incidental Ingestion (Efi)	60	120	Days/year	Professional judgment
Exposure Duration - Incidental Ingestion (EDi)	6	30	Years	DEQ Deterministic HHRA Guidance, Appendix B; Assuming average time at residence = 30 years

Table B.2: Total dose calculation for domestic wells contaminated with PCE only.

Dose Calculation	Concentration	Population Group	Exposure Scenario			Total Dose
			Ingestion	Inhalation	Dermal	
Non-Cancer Dose	3.1 (Maximum)	Child	0.000297	0.000224	0.000005	0.000526
		Adult	0.000098	0.000076	0.000003	0.000176
	1.1 (Average)	Child	0.000105	0.000112	0.000002	0.000219
		Adult	0.000035	0.000038	0.000001	0.000073
Cancer Dose	3.1 (Maximum)	Child	0.000025	0.000019	0.000000	0.000045
		Adult	0.000042	0.000032	0.000001	0.000075
	1.1 (Average)	Child	0.000009	0.000010	0.000000	0.000019
		Adult	0.000015	0.000016	0.000000	0.000031

Table B.3: Total dose calculation for domestic wells contaminated with PCE and TCE.

Dose Calculation	Contaminant/ Concentration	Population Group	Exposure Scenario			Total Dose
			Ingestion	Inhalation	Dermal	
Non-Cancer Dose	PCE 55.0 (Maximum)	Child	0.005274	0.004475	0.000084	0.009833
		Adult	0.001733	0.001513	0.000048	0.003294
	PCE 27.4 (Average)	Child	0.002627	0.002237	0.000042	0.004907
		Adult	0.000863	0.000756	0.000024	0.001644
	TCE 14.0 (Maximum)	Child	0.001342	0.001119	0.000008	0.002469
		Adult	0.000441	0.000378	0.000004	0.000824
	TCE 4.8 (Average)	Child	0.000460	0.000336	0.000003	0.000799
		Adult	0.000151	0.000113	0.000002	0.000266
Cancer Dose	PCE 55.0 (Maximum)	Child	0.000452	0.000384	0.000007	0.000843
		Adult	0.000743	0.000648	0.000021	0.001412
	PCE 27.4 (Average)	Child	0.000225	0.000192	0.000004	0.000421
		Adult	0.000370	0.000324	0.000010	0.000704
	TCE 14.0 (Maximum)	Child	0.000115	0.000096	0.000001	0.000212
		Adult	0.000189	0.000162	0.000002	0.000353
	TCE 4.8 (Average)	Child	0.000039	0.000029	0.000000	0.000068
		Adult	0.000065	0.000049	0.000001	0.000114

Table B.4: Total dose calculation for domestic wells contaminated with Carbon Tetrachloride.

Dose Calculation	Concentration	Population Group	Exposure Scenario			Total Dose
			Ingestion	Inhalation	Dermal	
Non-Cancer Dose	0.5	Child	0.000048	0.000000	0.000001	0.000049
		Adult	0.000016	0.000000	0.000000	0.000016
Cancer Dose	0.5	Child	0.000004	0.000000	0.000000	0.000004
		Adult	0.000007	0.000000	0.000000	0.000007

Appendix C. Information on Contaminants of Concern at Lebanon Groundwater Contamination Site

Volatile Organic Compounds

Volatile organic compounds (VOCs) are a class of chemicals that easily transition from the solid or liquid phase to the gas phase. These compounds include greenhouse gases, petroleum products, and chemicals used in household products and for industrial purposes. VOCs are an important source of both indoor and outdoor air pollution. Common sources of VOCs that contribute to indoor air pollution include paint thinners, wood preservatives, office equipment (copiers and printers) certain cleaners and disinfectants, fuels and dry cleaning solvents[12]. Indoor air concentrations of VOCs can reach levels as much as five times those found in outdoor air, and can pose health risks to individuals with high exposures to VOCs that are known to be toxic to human health. The EPA recommends limiting exposure to certain VOCs that are found in common household products, including: methylene chloride (found in paint strippers, adhesive remover and aerosol spray paints); benzene (tobacco smoke, stored fuels/paints, automobile emissions); and tetrachloroethylene (dry cleaning solvents/newly dry cleaned clothes)[12].

Tetrachloroethylene (PCE)

Tetrachloroethylene (also known as perchloroethylene, or PCE) is a volatile organic compound that is commonly used as a dry cleaning solvent and as a metal degreaser. PCE usually enters the environment when it evaporates into the air during dry cleaning and industrial operations, but it also can contaminate the soil and groundwater from releases during dumping, or leaks from sewer lines, storage sites or waste sites. Exposure to PCE occurs in occupational settings (especially in dry cleaning operations), from coming in to contact with solvent-contaminated water or soil (by ingesting, inhaling or dermal contact with the contaminated media), and from the use of household products that contain PCE.

Most of the PCE that enters the body is not metabolized and leaves the body during exhalation. The liver metabolizes much of the remaining PCE. At high doses, exposure to PCE can cause dizziness, headaches, confusion and other effects to the central nervous system. The main health effects associated with chronic exposure to PCE include damage to the liver and kidney. Some animal studies have shown reproductive and developmental effects from PCE exposure. The EPA considers PCE to be a probable human carcinogen based on animal studies that have also shown an association with kidney and liver cancers [11]. The EPA has set a limit on the amount of PCE in public drinking water systems at 5 ppb.

Trichloroethylene (TCE)

Trichloroethylene (TCE) is a volatile organic compound that is used as a metal degreaser and as a solvent in paint removers and certain types of cleaners and adhesives. TCE enters the environment through improper use and disposal, and is known to affect many groundwater and surface waters sources in the U.S. TCE evaporates quickly from surface water, but can persist in contaminated soil and groundwater for long periods of time. Exposure to TCE can occur in occupational settings, from coming into contact with contaminated water through the ingestion, inhalation and dermal absorption routes, and breathing in vapors from shower water or indoor air sources (such as paint removers, correction fluid and spot removers)[13].

The health risks associated with exposure to TCE include effects to the central nervous system (including headaches, dizziness and difficulty concentrating), damage to the kidney and liver, impaired function of the cardiovascular and immune systems and nerve damage[14]. There is also evidence that TCE exposure can result in reproductive and developmental effects, including an increased risk for birth defects[10]. There is strong evidence that exposure to TCE can increase the risks for several types of cancer, including kidney, liver, lung, prostate, cervical and lympho-hematopoietic cancers.[10] The EPA has set a limit on the amount of TCE in public drinking water systems at 5 ppb.

Carbon Tetrachloride (CCl_4)

Carbon tetrachloride is a man-made chemical that was used as a fire extinguishing agent, a dry cleaning solvent, and also was found in refrigeration fluid, aerosol cans, pesticides, degreasers and cleaning solvents. Because of its toxicity to human health, it has been banned for most uses. It is highly volatile, evaporates quickly, and persists in the air as a gas for long periods of time. Exposure to CCl_4 usually occurs from inhalation, though ingestion and dermal exposures can also occur from drinking, cooking or showering with water contaminated with CCl_4. The main health effects that occur from high exposures to CCl_4 include damage to the liver, kidney and central nervous system. The toxic effects to the liver are particularly severe, and persons who consume alcohol may be more sensitive to these effects. There is limited information on the cancer risks associated with CCl_4 exposure, but the EPA considers it to be a probable human carcinogen. The EPA has set a limit on the amount of CCl_4 in public drinking water systems at 5 ppb.

Bromodichloromethane

Bromodichloromethane is part of a class of chemicals known as trihalomethanes. Most bromodichloromethane that is found in the environment is a by-product of water treatment and disinfection with chlorine. Most of the bromodichloromethane that is found in water will evaporate to the air, but small amounts can persist in water[15]. Exposure can occur from inhalation of vapors from chlorinated water (from swimming pools or during activities such as bathing, cooking etc), ingestion of chlorinated water and absorption through the skin during bathing or swimming. There are limited studies on the human health effects from exposure to bromodichloromethane. Studies in animals have shown that long-term exposure can affect the liver, kidney and central nervous system, and cause birth defects at very high doses. More recent studies on trihalomethanes as a class of chemicals have shown increased risks for reproductive and development effects, including menstrual disorders, miscarriage, stillbirth and birth defects[16]. The EPA considers bromodichloromethane to be a probable human carcinogen based on animal studies that have shown increased risks for liver, kidney and gastrointestinal cancers. There is also evidence that exposure to trihalomethanes can increase the risk for bladder cancer. The EPA has set a limit on the amount of total trihalomethanes in public drinking water systems at 80 ppb.

Appendix D. ATSDR Glossary of Environmental Health Terms

The Agency for Toxic Substances and Disease Registry (ATSDR) is a federal public health agency with headquarters in Atlanta, Georgia, and 10 regional offices in the United States. ATSDR serves the public by using the best science to take responsive public health actions and provides trusted health information to prevent harmful exposures and diseases related to toxic substances. ATSDR is not a regulatory agency, unlike the U.S. Environmental Protection Agency (EPA), which is the federal agency that develops and enforces environmental laws to protect the environment and human health.

This glossary defines words used by ATSDR in communications with the public. It is not a complete dictionary of environmental health terms. If you have questions or comments, call ATSDR's toll-free telephone number, 1-888-42-ATSDR (1-888-422-8737).

Absorption: How a chemical enters a person's blood after the chemical has been swallowed, has come into contact with the skin, or has been breathed in.

Acute Exposure: Contact with a chemical that happens once or only for a limited period of time. ATSDR defines acute exposures as those that might last up to 14 days.

Additive Effect: A response to a chemical mixture, or combination of substances, that might be expected if the known effects of individual chemicals, seen at specific doses, were added together.

ATSDR: The **A**gency for **T**oxic **S**ubstances and **D**isease **R**egistry. ATSDR is a federal health agency in Atlanta, Georgia that deals with hazardous substance and waste site issues. ATSDR gives people information about harmful chemicals in their environment and tells people how to protect themselves from coming into contact with chemicals.

Background Level: An average or expected amount of a chemical in a specific environment. Or, amounts of chemicals that occur naturally in a specific environment.

Bioavailability: See **Relative Bioavailability**.

Cancer: A group of diseases which occur when cells in the body become abnormal and grow, or multiply, out of control

Carcinogen: Any substance shown to cause tumors or cancer in experimental studies.

CERCLA: See **C**omprehensive **E**nvironmental **R**esponse, **C**ompensation, and **L**iability **A**ct.

Chronic Exposure:	A contact with a substance or chemical that happens over a long period of time. ATSDR considers exposures of more than one year to be *chronic*.
Completed Exposure Pathway:	See **Exposure Pathway**.
Comparison Value: **(CVs)**	Concentrations of substances in air, water, food, and soil that are unlikely, upon exposure, to cause adverse health effects. Comparison values are used by health assessors to select which substances and environmental media (air, water, food and soil) need additional evaluation while health concerns or effects are investigated.
Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA):	**CERCLA** was put into place in 1980. It is also known as **Superfund**. This act concerns releases of hazardous substances into the environment, and the cleanup of these substances and hazardous waste sites. This act created ATSDR and gave it the responsibility to look into health issues related to hazardous waste sites.
Concern:	A belief or worry that chemicals in the environment might cause harm to people.
Concentration:	How much or the amount of a substance present in a certain amount of soil, water, air, or food.
Contaminant:	See **Environmental Contaminant**.
Delayed Health Effect:	A disease or injury that happens as a result of exposures that may have occurred far in the past.
Dermal Contact:	A chemical getting onto your skin. (see **Route of Exposure**).
Dose:	The amount of a substance to which a person may be exposed, usually on a daily basis. Dose is often explained as "amount of substance(s) per body weight per day".
Dose / Response:	The relationship between the amount of exposure (dose) and the change in body function or health that result.
Duration:	The amount of time (days, months, years) that a person is exposed to a chemical.

Environmental Contaminant:	A substance (chemical) that gets into a system (person, animal, or the environment) in amounts higher than the **Background Level**, or what would be expected.
Environmental Media:	Usually refers to the air, water, and soil in which chemicals of interest are found. Sometimes refers to the plants and animals that are eaten by humans. **Environmental Media** is the second part of an **Exposure Pathway**.
U.S. Environmental Protection Agency (EPA):	The federal agency that develops and enforces environmental laws to protect the environment and the public's health.
Epidemiology:	The study of the different factors that determine how often, in how many people, and in which people will disease occur.
Exposure:	Coming into contact with a chemical substance.(For the three ways people can come in contact with substances, see **Route of Exposure**.)
Exposure Assessment:	The process of finding the ways people come in contact with chemicals, how often and how long they come in contact with chemicals, and the amounts of chemicals with which they come in contact.
Exposure Pathway:	A description of the way that a chemical moves from its source (where it began) to where and how people can come into contact with (or get exposed to) the chemical. ATSDR defines an exposure pathway as having 5 parts: 1. Source of Contamination, 2. Environmental Media and Transport Mechanism, 3. Point of Exposure, 4. Route of Exposure, and 5. Receptor Population. When all 5 parts of an exposure pathway are present, it is called a **Completed Exposure Pathway**. Each of these 5 terms is defined in this Glossary.
Frequency:	How often a person is exposed to a chemical over time; for example, every day, once a week, twice a month.
Hazardous Waste:	Substances that have been released or thrown away into the environment and, under certain conditions, could be harmful to people who come into contact with them.

Health Effect:	ATSDR deals only with **Adverse Health Effects** (see definition in this Glossary).
Indeterminate Public Health Hazard:	The category is used in Public Health Assessment documents for sites where important information is lacking (missing or has not yet been gathered) about site-related chemical exposures.
Ingestion:	Swallowing something, as in eating or drinking. It is a way a chemical can enter your body (See **Route of Exposure**).
Inhalation:	Breathing. It is a way a chemical can enter your body (See **Route of Exposure**).
LOAEL:	**L**owest **O**bserved **A**dverse **E**ffect **L**evel. The lowest dose of a chemical in a study, or group of studies, that has caused harmful health effects in people or animals.
MRL:	**M**inimal **R**isk **L**evel. An estimate of daily human exposure – by a specified route and length of time -- to a dose of chemical that is likely to be without a measurable risk of adverse, noncancerous effects. An MRL should not be used as a predictor of adverse health effects.
NPL:	The **N**ational **P**riorities **L**ist. (Which is part of **Superfund**.) A list kept by the U.S. Environmental Protection Agency (EPA) of the most serious uncontrolled or abandoned hazardous waste sites in the country. An NPL site needs to be cleaned up or is being looked at to see if people can be exposed to chemicals from the site.
NOAEL:	**N**o **O**bserved **A**dverse **E**ffect **L**evel. The highest dose of a chemical in a study, or group of studies, that did not cause harmful health effects in people or animals.
No Apparent Public Health Hazard:	The category is used in ATSDR's Public Health Assessment documents for sites where exposure to site-related chemicals may have occurred in the past or is still occurring but the exposures are not at levels expected to cause adverse health effects.
No Public Health Hazard:	The category is used in ATSDR's Public Health Assessment documents for sites where there is evidence of an absence of exposure to site-related chemicals.
PHA:	**P**ublic **H**ealth **A**ssessment. A report or document that looks at chemicals at a hazardous waste site and tells if people could be harmed from coming into contact with those chemicals. The PHA also tells if possible further public health actions are needed.

Point of Exposure:	The place where someone can come into contact with a contaminated environmental medium (air, water, food or soil). Some examples include: the area of a playground that has contaminated dirt, a contaminated spring used for drinking water, or the backyard area where someone might breathe contaminated air.
Population:	A group of people living in a certain area; or the number of people in a certain area.
PRP:	**P**otentially **R**esponsible **P**arty. A company, government or person that is responsible for causing the pollution at a hazardous waste site. PRP's are expected to help pay for the clean up of a site.
Public Health Assessment(s):	See **PHA**.
Public Health Hazard:	The category is used in PHAs for sites that have certain physical features or evidence of chronic, site-related chemical exposure that could result in adverse health effects.
Public Health Hazard Criteria:	PHA categories given to a site which tell whether people could be harmed by conditions present at the site. Each are defined in the Glossary. The categories are: – Urgent Public Health Hazard – Public Health Hazard – Indeterminate Public Health Hazard – No Apparent Public Health Hazard – No Public Health Hazard
Reference Dose (RfD):	An estimate, with safety factors (see **safety factor**) built in, of the daily, life-time exposure of human populations to a possible hazard that is <u>not</u> likely to cause harm to the person.
Relative Bioavailability:	The amount of a compound that can be absorbed from a particular medium (such as soil) compared to the amount absorbed from a reference material (such as water). Expressed in percentage form.
Route of Exposure:	The way a chemical can get into a person's body. There are three exposure routes: – breathing (also called inhalation), – eating or drinking (also called ingestion), and – getting something on the skin (also called dermal contact).

Safety Factor:	Also called **Uncertainty Factor**. When scientists don't have enough information to decide if an exposure will cause harm to people, they use “safety factors” and formulas in place of the information that is not known. These factors and formulas can help determine the amount of a chemical that is <u>not</u> likely to cause harm to people.
SARA:	The **S**uperfund **A**mendments and **R**eauthorization **A**ct in 1986 amended CERCLA and expanded the health-related responsibilities of ATSDR. CERCLA and SARA direct ATSDR to look into the health effects resulting from chemical exposures at hazardous waste sites.
Sample Size:	The number of people that are needed for a health study.
Sample:	A small number of people chosen from a larger population (See **Population**).
Source (of Contamination):	The place where a chemical comes from, such as a landfill, pond, creek, incinerator, tank, or drum. Contaminant source is the first part of an **Exposure Pathway**.
Special Populations:	People who may be more sensitive to chemical exposures because of certain factors such as age, a disease they already have, occupation, sex, or certain behaviors (like cigarette smoking). Children, pregnant women, and older people are often considered special populations.
Statistics:	A branch of the math process of collecting, looking at, and summarizing data or information.
Superfund Site:	See **NPL**.
Survey:	A way to collect information or data from a group of people (**population**). Surveys can be done by phone, mail, or in person. ATSDR cannot do surveys of more than nine people without approval from the U.S. Department of Health and Human Services.
Toxic:	Harmful. Any substance or chemical can be toxic at a certain dose (amount). The dose is what determines the potential harm of a chemical and whether it would cause someone to get sick.
Toxicology:	The study of the harmful effects of chemicals on humans or animals.
Tumor:	Abnormal growth of tissue or cells that have formed a lump or mass.
Uncertainty Factor:	See **Safety Factor**.

Urgent Public Health Hazard: This category is used in ATSDR's Public Health Assessment documents for sites that have certain physical features or evidence of short-term (less than 1 year), site-related chemical exposure that could result in adverse health effects and require quick intervention to stop people from being exposed.