

Health Consultation

Pacific Cleaners Site

Evaluation of Follow-Up Indoor Air Sample Taken at Randy's Nutrition Center, Adjacent to Pacific Cleaners Site

City of Olympia, Thurston County, Washington

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Prepared by

**The Washington State Department of Health
Under a Cooperative Agreement With the
U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry**



Foreword

The Washington State Department of Health (DOH) prepared this health consultation in cooperation with the Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR is part of the U.S. Department of Health and Human Services. It is the principal federal public health agency responsible for health issues related to hazardous waste. This health consultation was prepared in accordance with methodologies and guidelines developed by ATSDR.

The purpose of this health consultation is to identify and prevent harmful human health effects resulting from exposure to hazardous substances in the environment. Health consultations focus on specific health issues so that DOH can respond to requests from concerned residents or agencies for health information on hazardous substances. DOH evaluates sampling data collected from a hazardous waste site, determines whether exposures have occurred or could occur, reports any potential harmful effects, and recommends actions to protect public health. The findings in this report are relevant to conditions at the site during the time of this health consultation. They should not necessarily be relied upon if site conditions or land use changes in the future.

For additional information or questions regarding DOH or the contents of this health consultation, please call the health advisor who prepared this document:

Gary Palcisko
Washington State Department of Health
Office of Environmental Health Assessments
P.O. Box 47846
Olympia, WA 98504-7846
(360) 236-3377
1-877-485-7316
Website: www.doh.wa.gov/consults

For more information about ATSDR, contact the ATSDR Information Center at 1-888-422-8737 or visit the agency's Web site: www.atsdr.cdc.gov/.

Glossary

Acute	Occurring over a short time [compare with chronic].
Agency for Toxic Substances and Disease Registry (ATSDR)	The principal federal public health agency involved with hazardous waste issues, responsible for preventing or reducing the harmful effects of exposure to hazardous substances on human health and quality of life. ATSDR is part of the U.S. Department of Health and Human Services.
Aquifer	An underground formation composed of materials such as sand, soil, or gravel that can store and/or supply groundwater to wells and springs.
Cancer risk evaluation guide (CREG)	The concentration of a chemical in air, soil or water that is expected to cause no more than one excess cancer in a million persons exposed over a lifetime. The CREG is a <i>comparison value</i> used to select contaminants of potential health concern and is based on the <i>cancer slope factor</i> (CSF).
Cancer slope factor (CSF)	A number assigned to a cancer causing chemical that is used to estimate its ability to cause cancer in humans.
Carcinogen	Any substance that causes cancer.
Chronic	Occurring over a long time (more than 1 year) [compare with acute].
Comparison value (CV)	Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.
Contaminant	A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.
Dose (for chemicals that are not radioactive)	The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An “exposure dose” is how much of a substance is encountered in the environment. An “absorbed dose” is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.

Environmental Protection Agency (EPA)	United States Environmental Protection Agency.
Epidemiology	The study of the occurrence and causes of health effects in human populations. An epidemiological study often compares two groups of people who are alike except for one factor, such as exposure to a chemical or the presence of a health effect. The investigators try to determine if any factor (i.e., age, sex, occupation, economic status) is associated with the health effect.
Exposure	Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term [acute], of intermediate duration, or long-term [chronic].
Groundwater	Water beneath the earth's surface in the spaces between soil particles and between rock surfaces [compare with surface water].
Hazardous substance	Any material that poses a threat to public health and/or the environment. Typical hazardous substances are materials that are toxic, corrosive, ignitable, explosive, or chemically reactive.
Inhalation	The act of breathing. A hazardous substance can enter the body this way [see route of exposure].
Lowest-observed-adverse-effect level (LOAEL)	The lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals.
Media	Soil, water, air, plants, animals, or any other part of the environment that can contain contaminants.
Minimal risk level (MRL)	An ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncancerous effects. MRLs are calculated for a route of exposure (inhalation or oral) over a specified time period (acute, intermediate, or chronic). MRLs should not be used as predictors of harmful (adverse) health effects.
Model Toxics Control Act (MTCA)	The hazardous waste cleanup law for Washington State.
Monitoring wells	Special wells drilled at locations on or off a hazardous waste site so water can be sampled at selected depths and studied to determine the movement of groundwater and the amount, distribution, and type of contaminant.

No-observed-adverse-effect level (NOAEL)	The highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on people or animals.
Organic	Compounds composed of carbon, including materials such as solvents, oils, and pesticides that are not easily dissolved in water.
Parts per billion (ppb); parts per million (ppm)	Units commonly used to express low concentrations of contaminants. For example, 1 ounce of trichloroethylene (TCE) in 1 million ounces of water is 1 ppm. 1 ounce of TCE in 1 billion ounces of water is 1 ppb. If one drop of TCE is mixed in a competition-size swimming pool, the water will contain about 1 ppb of TCE.
Route of exposure	The way people come into contact with a hazardous substance. Three routes of exposure are breathing [inhalation], eating or drinking [ingestion], or contact with the skin [dermal contact].
Volatile organic compound (VOC)	Organic compounds that evaporate readily into the air. VOCs include substances such as benzene, toluene, methylene chloride, and methyl chloroform.

Purpose

This health consultation evaluates health risks from exposure to tetrachloroethylene (PCE or perc) and trichloroethylene (TCE) associated with the operation and/or contamination at Pacific Cleaners. The owners of an adjacent health food store, Randy's Nutrition Center, and the Thurston County Public Health and Social Services Department (TCHD) had raised concerns regarding potential exposure to PCE and TCE in indoor air. The Washington State Department of Health (DOH) prepared this health consultation in response to those concerns. DOH prepares health consultations under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). This health consultation is a follow-up to a previous indoor air-sampling event that revealed elevated levels of PCE and TCE in indoor air at this location.

Background and Statement of Issues

Pacific Cleaners is located at 3530 Pacific Avenue SE in Olympia, Washington (Figure 1). It is one of several businesses located in the Olympia Square strip mall. Its immediate neighbor, until early 2004, was Randy's Nutrition Center (Randy's). The owner of Randy's opted to move to another location due in part to health concerns.

Until recently, dry cleaning at Pacific Cleaners has been accomplished using PCE as a solvent. Pacific Cleaners has had a history of odor and health complaints. In October 1992, the Olympic Region Clean Air Agency (ORCAA) was contacted by a nearby business about odor and health concerns associated with Pacific Cleaners (1). In December 2002 and January 2003, the owner of Randy's contacted ORCAA with similar concerns (2). Because of these recent concerns, ORCAA conducted numerous inspections at Randy's and Pacific Cleaners, and confirmed the reported odors. During one of the inspections, using a portable halogen leak detector, PCE was detected throughout Pacific Cleaners and outside the open shop doors. ORCAA also observed vapor leaks, open containers, and possible faulty temperature gauges that resulted in a number of violation notices and at least one fine (2).

Because odors continued at Randy's after ORCAA was notified, the owner contacted TCHD. In January 2003, TCHD sampled Randy's and Pacific Cleaners using a portable photo ionization detector (PID) calibrated for PCE. The PID detected contaminant vapor levels that exceeded health comparison values in both Pacific Cleaners and Randy's.

Following the PID sampling, TCHD collected indoor air samples using 6-liter Summa® canisters with preset flow control devices. That allowed time-weighted samples to be collected over a 24-hour period. Samples were collected in the back of Randy's and in a classroom located between Randy's and Pacific Cleaners, from January 29–30, 2003. The samples were analyzed for volatile organic compounds (VOCs), including PCE. Atmospheric Analysis & Consulting, Inc. analyzed the samples for VOCs using EPA Method TO-15 (3).

The canister sampling indicated that levels of PCE, trichloroethylene (TCE), methylene chloride, and numerous other VOCs exceeded corresponding health comparison values (4). Methylene chloride and many of the other VOCs are most likely associated with localized sources, such as office supplies and nearby automobile emissions.

DOH evaluated the indoor air data in a health consultation dated February 2, 2004(5). One of the recommendations of the health consultation was to conduct follow-up indoor air sampling at Randy’s Nutrition Center to ensure that repairs to Pacific Cleaners’ machine were effective.

A consultant hired by Pacific Cleaners determined that the source of the PCE was a leak from the business’s dry-cleaning machine. As a result of the leak, ORCAA directed Pacific Cleaners to repair the equipment. In late February, after repairs were made to correct the leak, the Washington Department of Labor and Industries inspected Pacific Cleaners, and did not detect any PCE (R. Christian, Washington State Department of Labor and Industries, personal communication; February 27, 2003).

Follow-up air sampling was conducted by TCHD and DOH in January 2004. This sampling round collected air from a backroom and compounding area (work area) within Randy’s Nutrition Center. Samples were collected using SiloCan 6-L, stainless steel canisters with a passive flow regulator and analyzed for VOCs using EPA method TO-15.

Discussion

Air sampling data were screened using ATSDR, U.S. Environmental Protection Agency (EPA), and Washington State Department of Ecology health-based criteria or comparison values (Appendix A). Contaminant concentrations below comparison values are unlikely to pose a health threat and were not further evaluated. Contaminant concentrations exceeding comparison values do not necessarily pose a health threat, but were further evaluated to determine whether they are at levels that could result in adverse human health effects.

PCE and TCE levels in indoor air at Randy’s exceeded respective health comparison values and were evaluated for both cancer and noncancer health effects. PCE and TCE levels from both 2002 and 2004 sampling events are presented in Table 1. Results indicated continued migration of PCE and TCE from Pacific Cleaners to Randy’s.

Table 1. Results of Air Samples Taken 2002 and 2004 from Randy’s Nutrition Center Adjacent to Pacific Cleaners, Olympia, Washington (6).

Location	Chemical	Winter 2002 Concentration (µg/m ³)	January 2004 Concentration (µg/m ³)	Background Concentration (indoor median µg/m ³) (7)
Randy’s (backroom)	PCE	8,113	11,528	5
	TCE	468	380	0.7
Randy’s (classroom)	PCE	4,617	NA	5
	TCE	397	NA	0.7
Randy’s (compounding area)	PCE	NA	7,459	5
	TCE	NA	280	0.7

NA= not applicable (not sampled); µg/m³ = micrograms per cubic meter

Sources of PCE and TCE

The source of elevated levels of PCE detected at Randy's through the 2002 sampling event was likely the dry cleaning machine. ORCAA inspectors found that PCE was escaping from the dry cleaning machine from a corroded pipe. Pacific Cleaners was fined, but the fine was suspended so that the owner could use the money to correct the problem. The problem seemed to be corrected for a brief time, but workers and customers at Randy's began to notice odors again. As shown by the high levels of PCE and TCE in January 2004, the problem was not permanently fixed. Randy's Nutrition Center vacated the neighboring space and moved to another location.

On March 1, 2004, Pacific Cleaners opted to remove its old dry cleaning machine and replace it with a new machine that uses an alternative solvent (8). The alternative dry cleaning solvent, DF-2000™, is a petroleum-based solvent (synthetic aliphatic hydrocarbon produced by Exxon Chemical). (9) The new solvent is supposedly less toxic than PCE, but its components are also likely to be toxic.

Background Levels

The wide use of natural and synthetic chemicals is a part of modern life. As a result, ambient and indoor air always contain low levels of these chemicals. Therefore, background levels of TCE and PCE must be examined to determine whether or not levels found at Randy's are typical of urban indoor air. Table 1 shows that levels of PCE and TCE at Randy's are well above typical background levels of indoor air. That indicates that operations at Pacific Cleaners affected air quality at the neighboring business.

Evaluating Noncancer Health Effects

To evaluate possible noncancer effects from exposure to PCE and TCE in indoor air, measured sample levels were compared to their respective noncancer comparison value [EPA inhalation reference concentration (RfC) or ATSDR chronic minimal risk level (MRL)]. The MRL and RfC are concentrations in air below which noncancer health effects are not expected.

RfCs and MRLs are set well below toxic effect levels to provide an added measure of safety. The more the chemical concentration exceeds the RfC or MRL, the closer it will be to an actual toxic effect level.

Because RfCs and MRLs are based on a continuous exposure, an adjustment was made to account for the fact that people working in the businesses are typically exposed for only 8 hours per day 5 days per week. This adjustment is shown in Appendix B.

EPA Reference Concentration (RfC) and ATSDR Chronic Minimal Risk Level (MRL)

Inhalation reference concentrations (RfCs) and chronic minimal risk levels (MRLs) are concentrations of a chemical in air below which adverse noncancer health effects are not expected to occur over a lifetime of continuous (i.e., 24 hours per day) exposure.

Table B3 in Appendix B provides noncancer risk comparisons for PCE and TCE. These comparisons assume that a worker is exposed to PCE and TCE for 8 hours per day at levels that do not vary. The highest exposure to VOCs occurred in Randy's backroom, where indoor air levels of PCE were nearly 10 times above the MRL and TCE levels were about 2 times the RfC.

Levels of PCE and TCE in indoor air at the compounding area of Randy's also resulted in excessive exposures.

Evaluating Cancer Risk

Some chemicals can cause cancer. Cancer risk is estimated by calculating a dose that a person would receive, assuming they breathed PCE and TCE at levels measured in each of the businesses. That dose is then multiplied by a cancer potency factor, also known as the cancer slope factor. Some cancer slope factors are derived from human population data. Others are derived from laboratory animal studies involving doses much higher than are encountered in the environment. Use of animal data requires extrapolation of the cancer potency obtained from these high dose studies down to real-world exposures. This process involves much uncertainty.

Current regulatory practice suggests that there is no "safe dose" of a carcinogen and that a very small dose of a carcinogen will give a very small cancer risk. Cancer risk estimates are, therefore, not "yes/no" answers, but measures of chance (probability). Such measures, however uncertain, are useful in determining the magnitude of a cancer threat because any level of a carcinogenic contaminant carries an associated risk. The validity of the "no safe dose" assumption for all cancer-causing chemicals is not clear. Some evidence suggests that certain chemicals considered to be carcinogenic must exceed a threshold of tolerance before initiating cancer. For such chemicals, risk estimates are not appropriate. More recent guidelines on cancer risk from EPA reflect the potential that thresholds for some carcinogenesis exist. However, EPA still assumes no threshold unless sufficient data indicate otherwise (10).

This document describes cancer risk that is attributable to site-related contaminants in qualitative terms: low, very low, slight, and no significant increase in cancer risk. These terms can be better understood by considering the population size required for such an estimate to result in a single cancer case. For example, a *low* increase in cancer risk indicates an estimate in the range of 1 cancer case per 10,000 persons exposed over a lifetime. A *very low* estimate might result in one cancer case per several tens of thousands exposed over a lifetime. A *slight* estimate would require an exposed population of several hundreds of thousands to result in a single case. DOH considers cancer risk to be *not significant* when the estimate results in less than 1 cancer per 1 million exposed over a lifetime. The reader should note that these estimates are for excess cancers that might result in addition to those normally expected in an unexposed population. Cancer risks quantified in this document are an upper-bound theoretical estimate. Actual risks are likely to be much lower.

Cancer is a common illness and its occurrence in a population increases with age. Depending on the type of cancer, a population with no known environmental exposure could be expected to have a substantial number of cancer cases. There are many different forms of cancer that result from a variety of causes; not all are fatal. Approximately 25% to 33% of people living in the United States will develop cancer at some point in their lives (11).

A range of cancer risks was calculated for exposures occurring at Randy's, reflecting low and high estimates of cancer slope factors for both PCE and TCE (see Table B4). Cancer risk at Randy's ranges from a low-end estimate of 3×10^{-4} to a high-end estimate of 6×10^{-3} , where

TCE and PCE contribute similarly to overall risk. These risks exceed what EPA considers acceptable (10^{-4}) (12).

Chemical Specific Toxicity

PCE

PCE is a manufactured compound widely used for dry-cleaning fabrics and as a metal degreaser. It is also used as an intermediate in the manufacturing of other products. It is a nonflammable liquid at room temperature, evaporates easily into the air, and has a sharp, sweet odor. Most people can smell PCE in air at about 1 ppm ($\sim 6,800 \mu\text{g}/\text{m}^3$). These people may become accustomed to the odor and stop smelling it due to a phenomenon called olfactory fatigue (13).

Numerous occupational studies have shown that chronic exposures to high levels of PCE in air (higher than levels detected at Randy's) can affect the liver, the kidneys, the neurological system, and other body systems. The chronic MRL for PCE is based on neurological effects observed during a 10-year occupational study. Prolonged reaction times were reported in women exposed during work to PCE at a median concentration of 15,000 ppb for an average of 10 years (14).

A number of human studies (primarily epidemiology studies of dry cleaning workers) suggest the possibility of increased cancer incidences from exposure to PCE, particularly esophageal and bladder cancers. It has not, however, been shown to definitively cause cancer in humans. Other cancers suspected of being associated with exposures to high levels of PCE (much higher than levels measured in Randy's) include intestinal, pancreatic, lung, kidney, skin, colon, and lymphatic/hematopoietic cancer. Following inhalation exposure to high levels of PCE, mononuclear cell leukemia was observed in rats and hepatic tumors were observed in mice. However, because mononuclear cell leukemia and hepatic tumors are common in rats and mice, respectively, the relevance of these tumors to humans is not clear.

EPA's Integrated Risk Information System (IRIS) does not provide an inhalation cancer slope factor for PCE, but an estimate of 0.002 mg/kg/day (unit risk = 5.8×10^{-7} per $\mu\text{g}/\text{m}^3$) was provided by the Superfund Technical Support Center(15). The California Environmental Protection Agency uses a slope factor of 0.02 mg/kg/day (unit risk = 5.9×10^{-6}). The Washington State Department of Ecology recently recommended using this value for cancer-based cleanups for PCE under the state's Model Toxics Control Act (MTCA) (16). These differing values further add to the uncertainty of cancer risk assessment of this chemical. For this reason, this health consultation provides low-end and high-end risk cancer risk estimates for exposure to PCE, which are based on these differing slope factors.

TCE

TCE is primarily used as a metal degreaser, particularly in the automotive and metals industries. It is also found in some household products, such as typewriter correction fluid, paint removers, adhesives, and spot removers. At room temperature, it is a colorless liquid with a sweet, chloroform-like odor. Most people can smell TCE in air at about 28 ppm ($\sim 150,000 \mu\text{g}/\text{m}^3$) (17).

EPA's National Center for Environmental Assessment is currently finishing a revised human health risk assessment on TCE. This assessment will present EPA's most current evaluation of the potential health risks from exposure to TCE. The mechanistic information suggests some risk factors may make some populations more sensitive, and that TCE could affect children and adults differently. TCE exposure is associated with a number of health effects, including neurotoxicity, immunotoxicity, developmental, liver, kidney, and endocrine effects. The RfC for TCE is based on critical effects on the central nervous system, liver, and endocrine system.

Recent and extensive review of available data has led EPA to characterize TCE as "highly likely to produce cancer in humans." These findings are consistent with those of the International Agency on Research of Cancer and the National Toxicology Program (18). This classification is based on sufficient evidence in animals and limited evidence in humans. The strongest evidence that TCE can cause cancer in humans comes from occupational studies that have found increases in lung, liver, and kidney cancers in workers exposed over several years (18).

In experimental rodent studies, high doses of TCE administered to mice resulted in tumors of the lungs, liver, and testes. Other possible cancers associated with exposure to high levels of TCE include cancer of the bladder, stomach, prostate, kidney, and pulmonary system.

EPA's *Trichloroethylene Health Risk Assessment: Synthesis and Characterization* proposed a cancer slope factor that ranges from 0.02 (derived from an epidemiological study with inhalation as the route of exposure) to 0.4 (derived from a residential drinking water exposure) (18). For this reason, this health consultation includes both a low-end and a high-end cancer risk estimate for exposure to TCE, using these differing slope factors.

Multiple Chemical Exposure

Almost every occurrence of environmental exposure includes multiple contaminants to consider. The potential exists for these chemicals to interact in the body and increase or decrease the potential for adverse health effects. The vast number of chemicals in the environment makes it impossible to measure all of the possible interactions between these chemicals.

The risks for groups of chemicals that have similar noncancer toxic effects, such as PCE and TCE, which cause liver toxicity, can be added. This is done by summing the hazard quotients associated with exposure to PCE and TCE to produce a hazard index. A hazard index that is greater than 1 indicates that an exposure is occurring at levels of potential concern. The more the hazard index exceeds 1, the more likely an exposure is to result in adverse noncancer health effects.

Because cancer risk is a measure of probability, cancer risks related to individual chemicals are summed to produce a total cancer risk. These risks are reported in Appendix B, Table B4.

Child Health Considerations

ATSDR recognizes that the unique vulnerabilities of infants and children deserve special emphasis with regard to exposures to environmental contaminants. Infants, young children, and the unborn may be at greater risk than adults from exposure to particular contaminants. Exposure during key periods of growth and development may lead to malformation of organs

(teratogenesis), disruption of organ function, and even premature death. In certain instances, maternal exposure, via the placenta, could adversely affect the unborn child.

After birth, children may receive greater exposures to environmental contaminants than adults. Children are often more likely to be exposed to contaminants from playing outdoors, eating food that has come into contact with hazardous substances, or breathing soil and dust. Pound-for-pound of body weight, children drink more water, eat more food, and breathe more air than do adults. For example, in the United States, children in the first 6 months of life drink 7 times more water per pound as the average adult. The implication for environmental health is that, by virtue of children's lower body weight, given the same exposures, they can receive significantly higher relative contaminant doses than adults.

Because exposures to infants and young children at the former Randy's Nutrition Center location are expected to be infrequent (i.e., much less than the 8 hours/day, 5 days/week assumptions used for this health consultation), the health risks to children are minimal.

Conclusions

1. A ***past public health hazard*** existed for workers at Randy's Nutrition Center exposed to dry cleaning solvents from Pacific Cleaners.
 - Workers were exposed to levels of PCE more than 10 times higher than ATSDR's minimal risk level (MRL), and TCE at levels 2 times greater than EPA's reference concentration (RfC).
 - High-end estimates of cancer risk were over an order of magnitude (10 times) greater than what is considered acceptable by EPA.
 - Levels of PCE and TCE in indoor air at Randy's were similar or increased from 2002 to 2004 indicating that the source of these contaminants in air was still uncontrolled.
 - Randy's Nutrition Center moved to another location due to health concerns.
 - Pacific Cleaners purchased a new dry cleaning machine that uses an alternative solvent (DF-2000™).
2. An ***indeterminate public health hazard*** currently exists for workers at the business adjacent to Pacific Cleaners.
 - Although Pacific Cleaners is currently using a new dry cleaning machine with an alternative solvent (DF-2000™), it has not been verified that the machine does not leak, and the toxicity of DF-2000™ is uncertain.

Recommendations

1. A follow-up inspection should be conducted at Pacific Cleaners to ensure that VOCs are not being released from their new machine in quantities that affect their neighbors.

Public Health Action Plan

Actions Taken

1. DOH has sampled indoor air at Randy's Nutrition Center on two separate occasions to determine the levels of dry cleaning solvents in indoor air.
2. Health consultations that interpret air sampling data have been prepared for air sampling events that occurred in 2002 and 2004.
3. Pacific Cleaners has replaced its old dry cleaning machine with a new one that uses an alternative solvent.

Actions Planned

1. DOH will provide copies of this health consultation to Thurston County Health Department, Olympic Region Clean Air Agency (ORCAA), Pacific Cleaners, and the current occupants of the business adjacent to Pacific Cleaners.
2. DOH will contact ORCAA and ask them to conduct an inspection to ensure that the current dry cleaning machine does not leak.

Preparer of Report

Gary Palcisko
Washington State Department of Health
Office of Environmental Health Assessments
Site Assessment Section

Designated Reviewer

Wayne Clifford, Manager
Site Assessment Section
Office of Environmental Health Assessments
Washington State Department of Health

ATSDR Technical Project Officer

Alan Parham
Division of Health Assessment and Consultation
Agency for Toxic Substances and Disease Registry

Appendix A: Contaminant Screening

Levels of chemicals detected in indoor air at Randy's Nutrition Center were compared to health-based comparison values. If a contaminant was found at levels below a comparison value, then it was not evaluated further.

Table A1. Contaminants Detected at Randy's Compared to Health-Based Screening Values

Chemical	Max Concentration ($\mu\text{g}/\text{m}^3$)	Noncancer Health Comparison Value ($\mu\text{g}/\text{m}^3$)	Cancer Health Comparison Value ($\mu\text{g}/\text{m}^3$)	Contaminant of Concern?
Trichloroethylene	376	40*	0.5†	Yes
Tetrachloroethylene	11,528	271‡	3.3§	Yes

* U.S. Environmental Protection Agency (EPA) reference concentration (RfC)

† Washington's Model Toxics Control Act (MTCA) Method B

‡ Agency for Toxic Substances and Disease Registry (ATSDR) chronic minimal risk level (MRL)

§ EPA Region 9 preliminary remediation goal (PRG)

Appendix B: Exposure Dose Calculations and Assumptions

Noncancer health effects were evaluated simply by comparing the measured air concentration to the adjusted minimal risk level (MRL) or reference dose (RfD). An adjustment was needed to reflect an intermittent exposure of workers who spends 8 hours per day, 5 day per week, and 50 weeks per year at their place of employment versus a continuous exposure. The following equation shows the adjustment of the tetrachloroethylene (PCE) MRL and trichloroethylene (TCE) RfC.

$$\text{PCE MRL (adjusted)} = \frac{271 \mu\text{g}/\text{m}^3 \times 52 \text{ weeks} \times 24 \text{ hours} \times 7 \text{ days}}{50 \text{ weeks} \times 8 \text{ hours} \times 5 \text{ days}} = 1,183 \mu\text{g}/\text{m}^3$$

$$\text{TCE RfC (adjusted)} = \frac{40 \mu\text{g}/\text{m}^3 \times 52 \text{ weeks} \times 24 \text{ hours} \times 7 \text{ days}}{50 \text{ weeks} \times 8 \text{ hours} \times 5 \text{ days}} = 175 \mu\text{g}/\text{m}^3$$

The factor by which a measured air concentration exceeds an MRL or reference concentration (RfC) is called a hazard quotient [*hazard quotient* = air concentration ($\mu\text{g}/\text{m}^3$) / RfC or MRL ($\mu\text{g}/\text{m}^3$)]. Exceeding a hazard quotient of 1 does not mean that a person is going to get sick because numerous safety factors are used while deriving RfCs or MRLs. However, the more the hazard quotient exceeds 1, the more likely adverse noncancer health effect will occur as a result of an exposure.

Cancer risk is evaluated by first calculating an average daily dose over a person's lifetime, and then multiplying the dose by a cancer slope factor to produce the probability, or risk of cancer. These equations and exposure assumptions are shown below and in Table B1:

$$\text{Dose}_{(\text{cancer (mg/kg/day)})} = \frac{C \times CF_1 \times IR \times EF \times ED}{BW \times AT_{\text{cancer}}}$$

$$\text{Risk} = \text{Dose}_{(\text{cancer (mg/kg/day)})} \times \text{CSF}$$

Table B1. Exposure Assumptions

Parameter	Value	Unit	Comments
Concentration (C)	Variable	µg/kg	Maximum detected value
Conversion Factor ₁ (CF ₁)	0.001	mg/µg	Converts contaminant concentration from micrograms (µg) to milligrams (mg)
Inhalation Rate (IR)	5	m ³	Volume of air inhaled during 8 hour work day.*
Exposure Frequency (EF)	250	days/year	Assumes weekends off and 2 weeks vacation per year
Exposure Duration (ED)	25	years	Number of years working at one place of employment
Body Weight (BW)—adult	70	kg	Adult mean body weight
Averaging Time _{cancer} (AT)	25,550	days	70 years
Minimal Risk Level (MRL) or Reference Concentration (RfC)	Contaminant - specific	µg/m ³	Source: Agency for Toxic Substances and Disease Registry; U.S. Environmental Protection Agency (EPA)
Cancer Slope Factor (CSF)	Contaminant - specific	mg/kg/day ⁻¹	Source: EPA

* Inhalation rate adapted from long-term adult male inhalation rate of 15 m³/day as presented in the U.S. Environmental Protection Agency's *Exposure Factors Handbook* (19). Inhalation rate was divided by a factor of 3 to account for an 8-hour work day as opposed to a 24-hour breathing rate.

Table B2. Noncancer Hazard Associated with Exposure to Tetrachloroethylene (PCE) and Trichloroethylene (TCE) at Randy’s Nutrition Center Adjacent to Pacific Cleaners, Olympia, Washington

Location	Chemical	Concentration ($\mu\text{g}/\text{m}^3$)	Adjusted RfC or MRL ($\mu\text{g}/\text{m}^3$)	Hazard Quotient
Randy’s Backroom	PCE	11,528	1183	9.7
	TCE	376	175	2.1
Hazard Index*				11.8
Randy’s Compounding Area	PCE	7,459	1183	6.3
	TCE	285	175	1.6
Hazard Index*				7.9

* Hazard index is the sum of hazard quotients. This accounts for additive effects of PCE and TCE, which are both toxic to similar organs/systems.

Table B3. Cancer Risk Associated With Exposure to Tetrachloroethylene (PCE) and Trichloroethylene (TCE) at Randy’s Nutrition Center Adjacent to Pacific Cleaners, Olympia, Washington

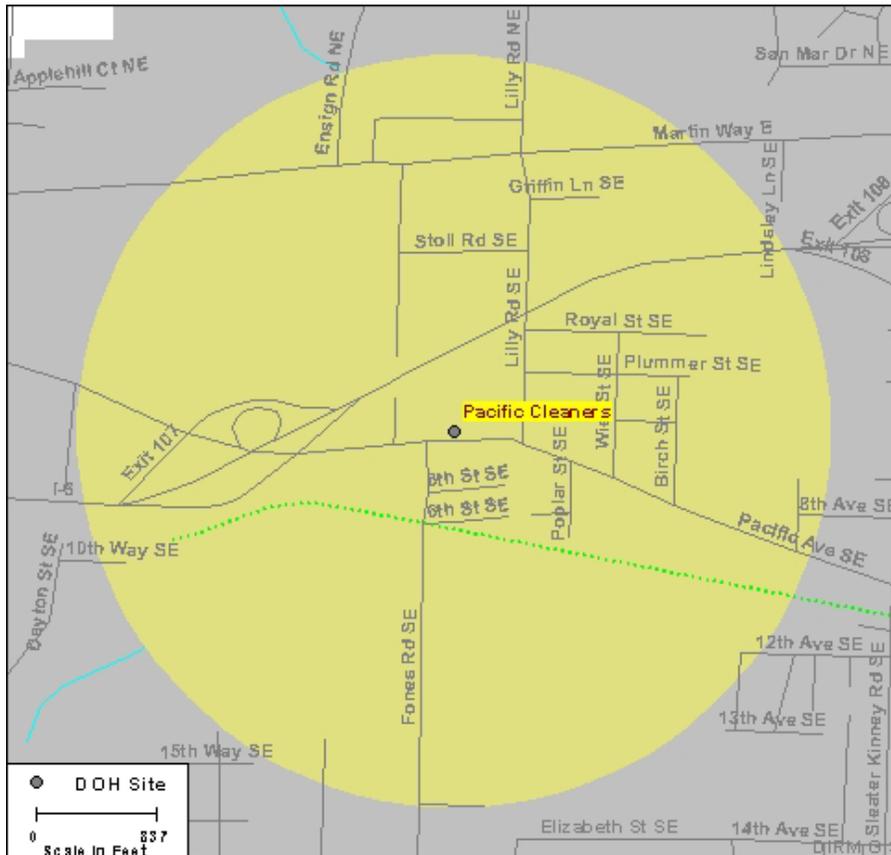
Location	Chemical	Concentration (µg/m ³)	Average Daily Dose (cancer) (mg/kg/day)	Low-end Cancer Slope Factor (mg/kg/day)*	High-end Cancer Slope Factor (mg/kg/day)*	Low-end Cancer Risk	High-end Cancer Risk
Randy’s Backroom	PCE	11,528	1.8 x 10 ⁻¹	0.002	0.02	3.7 x 10 ⁻⁴	3.7 x 10 ⁻³
	TCE	376	6.0 x 10 ⁻³	0.02	0.4	1.2 x 10 ⁻⁴	2.4 x 10 ⁻³
Total Cancer Risk						4.9 x 10⁻⁴	6.1 x 10⁻³
Randy’s Compounding Area	PCE	7,459	1.2 x 10 ⁻¹	0.002	0.02	2.4 x 10 ⁻⁴	2.4 x 10 ⁻³
	TCE	285	4.5 x 10 ⁻³	0.02	0.4	9.0 x 10 ⁻⁵	1.8 x 10 ⁻³
Total Cancer Risk						3.3 x 10⁻⁴	4.2 x 10⁻³

*TCE cancer slope factor, as presented in the U.S. Environmental Protection Agency’s *TCE Health Risk Assessment: Synthesis and Characterization* (18) is a range between 0.02 (derived from an epidemiological study with inhalation as the route of exposure) to 0.4 (derived from a residential drinking water exposure). PCE cancer slope factor ranges from 0.002 (provided by Superfund Technical Support center) to 0.02, as used by the California Environmental Protection Agency and Washington State Department of Ecology.

Figure 1. Pacific Cleaners Site Location and Demographics. Olympia, Thurston County, Washington.



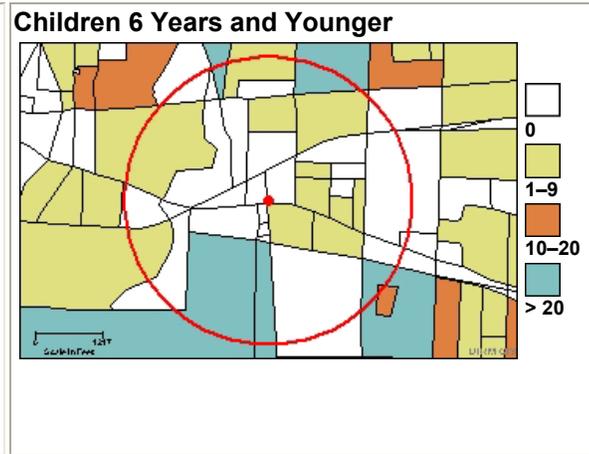
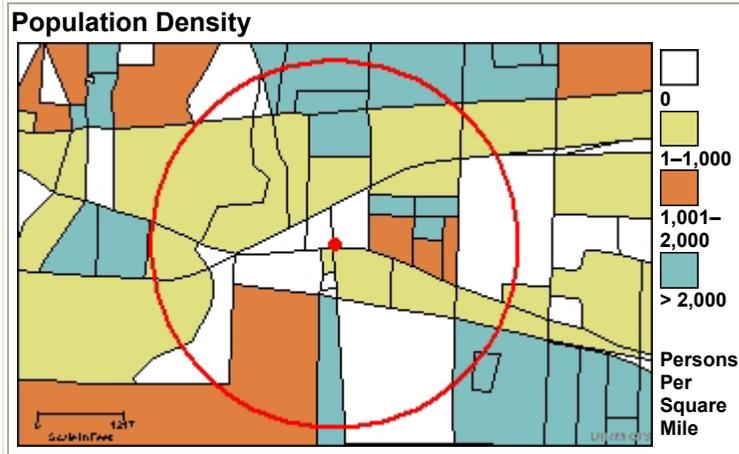
PACIFIC CLEANERS



Demographic Statistics Within 1/2 Mile of the Site*

Total Population	1,286
White	1,056
Black	40
American Indian, Eskimo, Aleut	28
Asian or Pacific Islander	69
Other Race	32
Hispanic Origin	89
Children Aged 6 Years and Younger	105
Adults Aged 65 Years and Older	310
Females Aged 15–44 Years	260
Total Aged over 18 Years	1,063
Total Aged under 18 Years	223
Total Housing Units	700

* Calculated using the area proportion technique. Source: 2000 U.S. CENSUS



Certification

This Health Consultation was prepared by the Washington State Department of Health under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the health consultation were begun.

Alan Parham
Technical Project Officer,
CAT, SPAB, DHAC
ATSDR

The Division of Health Assessment and Consultation, ATSDR, has reviewed this public health consultation and concurs with the findings.

Roberta Erlwein
Team Leader,
CAT, SPAB, DHAC
ATSDR

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