Health Consultation

Evaluation of follow-up Indoor Air Samples
Roy's Barbershop and Farmer's Insurance adjacent to the Eastside Laundry-Cleaners Site
Olympia, Thurston County, Washington

September 18, 2007

Prepared by

The Washington State Department of Health
Under a Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

DOH 334-149 September 2007

Foreword

The Washington State Department of Health (DOH) has 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 and 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, and should not necessarily be relied upon if site conditions or land use changes in the future.

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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 *comparison value* used to select contaminants of potential health concern and is based on the *cancer slope factor* (CSF).
Cancer Slope Factor	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	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 exposure**], of intermediate duration, or long-term [**chronic exposure**].
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 [see **reference dose**].
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

The purpose of this health consultation is to evaluate health risks from exposure to tetrachloroethylene (PCE) at Roy's Barbershop and Farmer's Insurance located adjacent to an active drycleaner (Eastside Laundry-Cleaners). The Washington State Department of Health prepared this health consultation in response to concerns raised by the owners of a small business (Farmer's Insurance) and the Thurston County Public Health and Social Services Department (TCHD) regarding potential exposure to PCE and TCE in indoor air. 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. DOH prepares health consultations under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR).

Background and Statement of Issues

Eastside Laundry-Cleaners (Eastside) is located at 122 Turner Street NE in Olympia, Washington (Figure 1). It is located at one end of a building that houses four businesses, Eastside, Roy's Barbershop, Farmer's Insurance, and a laundry "drop shop"[a] (Figure 2). At Eastside, laundry is cleaned using PCE as a solvent within a machine located in a back room. Once laundry is removed from the dry-cleaning machine, it is taken to the "drop shop" at the opposite end of the strip mall for pressing and hanging.

Low concentrations of PCE were first discovered in subsurface soil near the Eastside facility during investigations in March 2000.[1] Subsequent investigations conducted in the same area during April and August 2001 revealed low levels of PCE and petroleum hydrocarbons in the soil, and PCE in the groundwater.[2,3] The source of soil and groundwater contamination is believed to be historic releases from the Eastside facility while under different ownership.

The owners of Farmer's Insurance expressed concerns about the potential for exposure to dry-cleaning chemicals in indoor air from subsurface and aboveground sources at Eastside Laundry. To address these concerns, DOH and TCHD conducted indoor air sampling at Eastside Laundry and two adjacent businesses (Farmer's Insurance and Roy's) in the winter of 2002. This sampling event revealed PCE levels in indoor air at Eastside, Roy's, and Farmer's Insurance, and TCE levels in indoor air at Eastside above background levels and respective health comparison values.[4] DOH evaluated the sampling data for both cancer and noncancer health effects in a health consultation dated July 19, 2002 and concluded that that PCE and TCE levels found at Eastside and PCE levels at Roy's Barbershop were of concern for noncancer and cancer health effects.[5]

It was not clear what caused the presence of PCE and TCE in indoor air at Eastside and adjacent businesses, but recommendations were made in the 2002 health consultation to improve ventilation and housekeeping (keep solvent containers covered, remove and dispose of waste products). Follow-up air sampling was also recommended to determine if these actions improved conditions within Eastside and adjacent businesses. Air sampling was conducted in January 2004, and included samples from work areas in addition to backroom samples in order to

[a] "Drop shop" is a drycleaning business where drycleaning does not occur on-site. Clothing requiring cleaning are dropped off by customers at this location and laundered elsewhere (in this case at Eastside Cleaners)

characterize exposures where employees spend the bulk of their time. Samples were collected from Eastside, Roy's, Farmer's Insurance and the "drop shop" using SiloCan 6-L, stainless steel canisters with a passive flow regulator and analyzed for Volatile Organic Compounds (VOCs) using EPA method TO-15.

Discussion

The following discussion focuses on the evaluation of dry-cleaning solvents in indoor air at Roy's Barbershop and Farmer's Insurance. Although samples were taken at Eastside and the "drop shop", results are not presented nor discussed because occupational exposures at dry-cleaning businesses are beyond the scope of this document.

Air concentrations of samples taken from Roy's Barbershop and Farmer's Insurance were screened using ATSDR and U.S. Environmental Protection Agency (EPA) health-based criteria, or comparison values (Appendix A). Appendix A, Table A1 presents chemical concentrations detected in indoor air at Roy's Barbershop and Farmer's Insurance in relation to health-based comparisons values. 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 levels in indoor air at Roy's, and Farmer's Insurance exceeded both chronic and acute non-cancer comparison values and cancer comparison values and were evaluated for both cancer and noncancer health effects. PCE levels from both 2002 and 2004 sampling events are presented in Table 1. PCE levels overall show an increase from 2002 to 2004 indicating sources of PCE in indoor air have not been controlled.

During the 2004 sampling event, additional samples were taken in the workroom of Farmer's Insurance to characterize exposure at locations within the buildings where workers spend the most time. The results show little difference between levels taken in the backroom versus the main workroom at this business.

Background Levels

The wide use of natural and synthetic chemicals is common, and as a result, ambient and indoor air normally contains low levels of these chemicals. Therefore, background levels PCE are examined to determine if levels found at Roy's Barbershop and Farmer's Insurance are typical of urban indoor air. Table 1 shows that both businesses have levels of PCE above typical background levels. Because PCE is not used in either business, this indicates that vapors generated at Eastside migrate to neighboring businesses.

Table 1. Results of air samples taken 2002 and 2004 from Roy's Barbershop and Farmer's Insurance, Olympia, Washington[6]

Location	Chemical	Winter 2002 Concentration ($\mu g/m^3$)	January 2004 Concentration ($\mu g/m^3$)	Background Concentration (indoor median ($\mu g/m^3$)[7]
Roy's PCE		1268	2300	5
Farmer's PCE		419	510 (back room) 460 (work area)	

a – chemical was not detected at or above reported practical quantitation limit

Sources of PCE

How PCE moves from Eastside to neighboring businesses is still uncertain. ORCAA and TCHD inspected Eastside on September 7, 2004, documenting improved record- keeping and housekeeping. Eastside typically uses a small amount of PCE on an annual basis (37 gallons in 2003), and waste materials were all placed in suitable containers. Although some odors were evident inside Eastside, no leaks were detected at the dry-cleaning machine.

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 (~6,800 $\mu g/m^3$). These people may become accustomed to the odor and cease smelling it due to a phenomenon called olfactory fatigue.[8]

Numerous occupational studies have shown that chronic exposures to high levels of PCE in air (higher than levels detected at Roy's Barbershop or Farmer's Insurance) can affect the liver, kidneys, and neurological system, among others. The chronic MRL for PCE is based on neurological effects observed during a 10-year occupational study. Women occupationally exposed to PCE at a median concentration of 15 ppm (~102,000 $\mu g/m^3$) for an average of 10 years had prolonged reaction times to a battery of simple reaction tests compared to women that were not.[9] To put things in perspective, workers at Roy's Barbershop and Farmer's Insurance are exposed to PCE levels of 0.3 and 0.08 ppm respectively. The acute MRL for PCE (1000 $\mu g/m^3$) is based on a no observed adverse effect level (NOAEL) in a study of human subjects exposed to 10 ppm (~68,000 $\mu g/m^3$) four hours per day for four days.

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, but it has not 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 at Roy's Barbershop or Farmer's Insurance) 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 both 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 = $5.8x10^{-7}$ per $\mu g/m^3$) was provided by the Superfund Technical Support Center.[10] California EPA uses a slope factor of 0.02 mg/kg/day (Unit risk = $5.9x10^{-6}$), and Ecology recently recommended using this value for cancer - based cleanups for tetrachloroethylene under the Model Toxics Control Act (MTCA).[11] These differing values further add to the uncertainty of cancer risk assessment of this chemical. For this reason, this health consultation estimates both a low-end and high-end risk cancer risk estimate from exposure to PCE based on these differing slope factors.

Evaluating Non-cancer Health Effects

To evaluate possible noncancer effects from exposure to PCE in indoor air, measured levels were compared to ATSDR's chronic minimal risk level (MRL). The MRL is a concentrations in air below which noncancer health effects are not expected.

MRLs are set well below toxic effect levels in order to provide an added measure of safety. The higher the chemical concentration is above the MRL, the closer it will be to an actual toxic effect level.

Because 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.

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-hour-per-day) exposure.

Noncancer risk comparisons for PCE are provided in Appendix B, Table B3. These comparisons assume that worker's at Farmer's Insurance and Roy's Barbershop are exposed to PCE for eight hours per day at levels that do not vary. The highest exposure to PCE occurs at Roy's Barbershop where indoor air levels are roughly two times greater than the adjusted chronic MRL. Although workers at Roy's Barbershop are exposed to PCE at a level above a health benchmark, the likelihood that this exposure will lead to adverse health effects is very low. Estimated exposure at Roy's Barbershop is still well below actual toxic effect levels. PCE exposure at Farmer's Insurance was below the adjusted chronic MRL and not expected to result in adverse noncancer health effects. PCE exposure at both businesses is not likely to result in acute health effects as levels are lower than the adjusted acute MRL.

Evaluating Cancer Risk

Some chemicals have the ability to cause cancer. Cancer risk is estimated by calculating a dose that a person would receive assuming they breathed PCE at levels measured in each of the businesses, and multiplying it 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 assumes 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.[12]

In this document, cancer risks are reported using scientific notation to quantify the increased cancer risk of an exposed person, or the number of excess cancers that might result in an exposed population. For example, a cancer risk of 1×10^{-6} means that if 1,000,000 people were exposed, one excess cancer might occur, or a person's chance of getting cancer in their life increases by 0.0001%. DOH considers cancer risk to be not significant when the estimate results in less than one cancer per one million exposed over a lifetime (1×10^{-6}). 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.

A range of cancer risks was calculated for exposures occurring at Roy's Barbershop and Farmer's Insurance reflecting low and high estimates of cancer slope factors for PCE (see Table B4). Cancer risk is highest at Roy's Barbershop [range from low-end estimate (7.3×10^{-5}) to high-end estimate (7.3×10^{-4})] The high-end cancer risk estimate at Roy's Barbershop is above what EPA considers acceptable (target risk ranges from 10^{-6} to 10^{-4}).[13] Cancer risk at Farmer's Insurance ranged from 1.6×10^{-5} to 1.6×10^{-4}.

Child Health Considerations

ATSDR's 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 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, ingesting food that has come into contact with hazardous substances, or breathing soil and dust. Pound for pound body weight, children drink more water, eat more food, and breathe more air than adults. For example, in the United States, children in the first six months of life drink seven 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.

Since exposures to infants and young children at Roy's Barbershop and Farmer's Insurance 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 Public Health Hazard exists for workers at Roy's Barbershop exposed to PCE.
    - Although levels of PCE are below occupational standards, Roy's Barbershop does not use dry-cleaning solvents in it's shop, therefore, workers at Roy's Barbershop are being exposed to levels of PCE at levels resulting in unnecessary and unacceptable exposure (2 times higher than the chronic MRL adjusted for occupational exposures).
    - High-end estimate of cancer risk is seven times greater than what is considered acceptable by EPA. (Low-end cancer risk estimate is within the range acceptable by EPA)
2. No Apparent Public Health Hazard exists for workers at Farmer's Insurance exposed to dry-cleaning solvents.
    - Although levels of PCE at Farmer's Insurance are above background levels, they are not at levels likely to result in non-cancer health effects.
    - High-end estimate of cancer risk associated with exposure to PCE at Farmer's Insurance is slightly above levels considered acceptable by EPA, and low-end risks are well below this level of risk.

Recommendations

- Eastside Cleaners should work with ORCAA and TCHD to identify and eliminate the release of dry-cleaning solvent that evaporates into indoor air.

- Eastside Cleaners should continue to service their dry-cleaning machine on a routine basis. Eastside should also consider replacing their existing machine with an alternative that uses less toxic solvents.

- Workers at Roy's Barbershop and Farmer's Insurance should ventilate workspaces to reduce exposure to dry-cleaning solvents.
  - Opening doors and windows (weather permitting) may provide adequate ventilation and or/air exchange.

Public Health Action Plan

Actions taken

- DOH has sampled indoor air at Roy's Barbershop and Farmer's Insurance on two separate occasions to determine the levels of dry-cleaning solvents in indoor air.
- Health consultations that interpret air sampling data from two different events have been prepared.
- DOH has contacted the Olympic Region Clean Air Agency (ORCAA) and the Thurston County Public Health and Social Services Department (TCHD) to make them aware of the conditions at Eastside and adjacent businesses.
- ORCAA and TCHD conducted an inspection of Eastside on September 7, 2004.
- DOH and TCHD verbally informed occupants of Roy's Barbershop that PCE from Eastside impacts their workspace.

Actions Planned

- DOH will provide copies of this health consultation to workers at Roy's Barbershop and Farmer's Insurance
- DOH will contact the Olympic Region Clean Air Agency to determine methods for reducing levels of dry-cleaning solvents in indoor air at Eastside and adjacent businesses.
- ORCAA has developed a calendar that helps owners and operators of dry-cleaners keep up with maintenance scheduling and record keeping. These calendars will be distributed to Eastside and other dry-cleaners in the region
- TCHD will revisit Eastside with a more sensitive instrument to determine the presence or absence of leaks in the dry-cleaning machine.
- DOH will continue to inform operators at Eastside and adjacent businesses about ventilation of workspaces to minimize exposure to fugitive dry-cleaning solvents.

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Appendix A: Contaminant Screening

Levels of chemicals detected in indoor air at Roy's Barbershop and Farmer's Insurance 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 Roy's Barbershop and Farmer's Insurance compared to health-based screening values.

Chemical	Max Concentration (µg/m3)	Noncancer Health Comparison Value (µg/m3)	Cancer Health Comparison Value (µg/m3)	Contaminant of Concern?
Tetrachloroethylene	2300	300 [c] 1000 [d]	3.3 [a] Yes	
Toluene 17		300 [c] NA		No
Chloroform 0.	6	3.1 [a] NA		No
1,1,1-Trichloroethane	1.2 2,	300 [a] NA		No
Acetone 27	0	370 [a] NA		No
2-Butanone (MEK)	9.5	1000 [a] NA		No

a- EPA Region 9 PRG
b- EPA RfC
c- ATSDR chronic MRL
d- ATSDR acute MRL

Appendix B: Exposure dose calculations and assumptions

Noncancer health effects were evaluated simply by comparing the measured air concentration to the adjusted MRL. An adjustment was needed to reflect an intermittent exposure of a worker that 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 this adjustment.

$$\text{PCE chronic MRL (adjusted)} = \frac{300\ \mu g/m^3 \times 52\ \text{weeks} \times 24\ \text{hours} \times 7\ \text{days}}{50\ \text{weeks} \times 8\ \text{hours} \times 5\ \text{days}} = 1310\ \mu g/m^3$$

$$\text{PCE acute MRL (adjusted)} = \frac{1000\ \mu g/m^3 \times 52\ \text{weeks} \times 24\ \text{hours} \times 7\ \text{days}}{50\ \text{weeks} \times 8\ \text{hours} \times 5\ \text{days}} = 4370\ \mu g/m^3$$

The factor by which a measured air concentration exceeds an MRL is called a hazard quotient [Hazard Quotient = air concentration ($\mu g/m^3$) / MRL ($\mu g/m^3$)]. Exceeding a hazard quotient of one does not mean that a person is going to get sick because numerous safety factors are used while deriving MRLs, but the more the hazard quotient exceeds one, 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:

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

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

Table B1. Exposure Assumptions

Parameter	Value	Unit	Comments
Concentration (C)	Variable	ug/kg	Maximum detected value.
Conversion Factor$_1$ (CF_1)	0.001	mg/ug	Converts contaminant concentration from micrograms (ug) to milligrams (mg)
Inhalation Rate (IR)	5	m^3	Volume of air inhaled during 8 hour workday.[a]
Exposure Frequency (EF)	250	days/year	Assumes weekends off and two 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)	25550	days	70 years
Minimal Risk Level (MRL) or Reference Concentration (RfC)	Contaminant-specific	$\mu g/m^3$	Source: ATSDR, EPA
Cancer Slope Factor (CSF)	Contaminant-specific	mg/kg-day^{-1}	Source: EPA, CalEPA, Ecology

a- Inhalation rate adapted from long-term adult male inhalation rate of 15 m^3/day as presented in EPA's Exposure Factors Handbook.[14] Inhalation rate was divided by a factor of 3 to account for and 8-hour work day as opposed to a 24 hour breathing rate.

Table B2. Noncancer hazard associated with exposure to PCE and TCE and Eastside Laundry-Cleaners and adjacent businesses, Olympia, Washington.

Business	Location	PCE Concentration) (µg/m3)	Adjusted MRL (µg/m3)	Hazard Quotient
Roy's	Work area	2300	1310 (chronic) 4370 (acute)	1.8 (chronic) 0.5 (acute)
Farmer's	Backroom	510		0.4 (chronic) 0.1 (acute)
	Work area	460		0.4 (chronic) 0.1 (acute)

Table B3. Cancer risk associated with exposure to PCE and TCE at Eastside Cleaners and adjacent businesses. Olympia, Thurston County, Washington

Business	Location	PCE Concentration ($\mu g/m^3$)	Average Daily Dose (cancer) (mg/kg/day)	Low-end Cancer Slope Factor (kg-day/mg) a	High-end Cancer Slope Factor (kg-day/mg) a	Low-end Cancer Risk	High-end Cancer Risk
Roy's	Work area	2300	3.6×10^{-2}	0.002	0.02	7.3×10^{-5}	7.3×10^{-4}
Farmer's	Backroom	510	8.1×10^{-3}	0.002	0.02	1.6×10^{-5}	1.6×10^{-4}
	Work area	460	7.9×10^{-3}	0.002	0.02	1.5×10^{-5}	1.5×10^{-4}

a- PCE cancer slope factor ranges from 0.002 (provided by Superfund Technical Support center) to 0.02 as used by Cal EPA and Washington State Department of Ecology.

Figure 1. Eastside Laundry-Cleaners site location and demographics. Olympia, Thurston County, Washington.

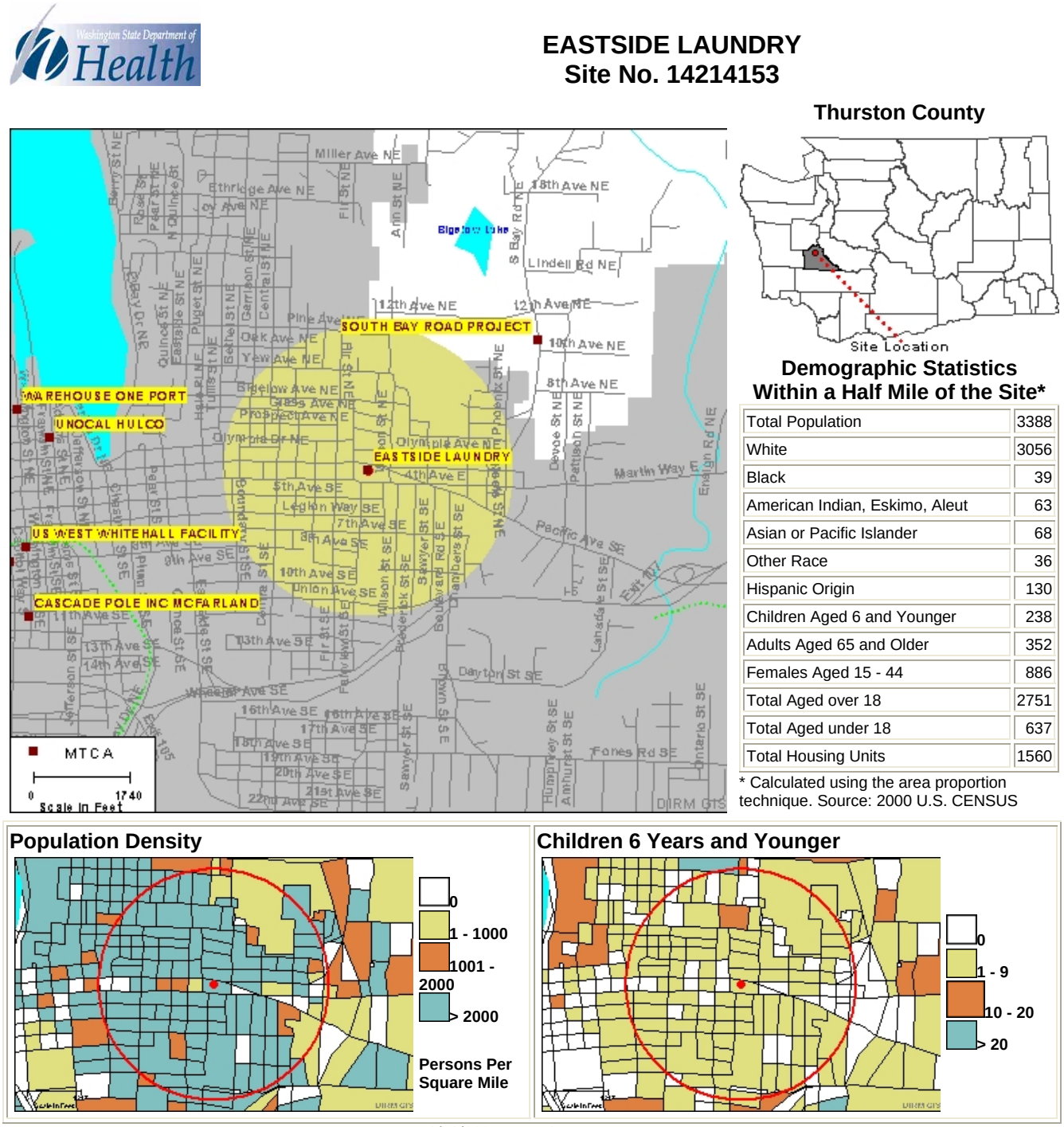
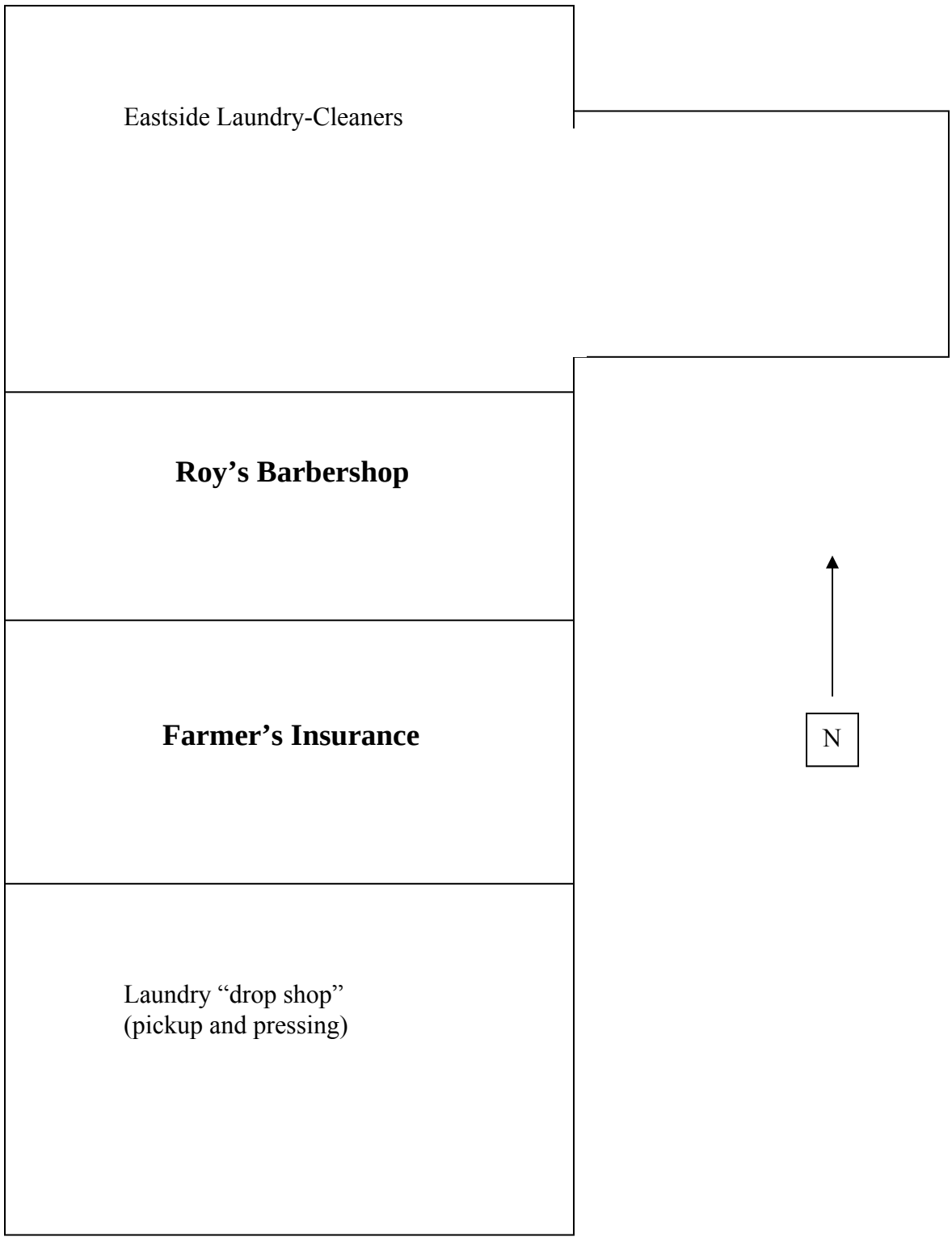


Figure 2. Layout of building that houses Eastside Laundry-Cleaners and adjacent businesses. Olympia, Thurston County, Washington.



Certification

The Washington State Department of Health prepared this Roy's Barbershop and Farmer' Insurance Health Consultation under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It was completed in accordance with approved methodology and procedures existing at the time the health consultation was initiated. Editorial review was completed by the Cooperative Agreement partner

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

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