

# Letter Health Consultation

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Evaluation of 2014-2015 Indoor Air TCE Concentrations after Installation of  
Air Filtration Systems at the

CHEM FAB SITE  
DOYLESTOWN, BUCKS COUNTY, PENNSYLVANIA

**Prepared by**  
**Pennsylvania Department of Health**

JULY 28, 2015

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES  
Agency for Toxic Substances and Disease Registry  
Division of Community Health Investigations  
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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LETTER HEALTH CONSULTATION

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Air Filtration Systems at the

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Prepared By:

Pennsylvania Department of Health  
Division of Environmental Health  
Under a cooperative agreement with the  
Agency for Toxic Substances and Disease Registry





To: Eduardo Rovira, On Scene Coordinator, US Environmental Protection Agency (EPA) Region 3

From: Sasidevi Arunachalam, Epidemiology Program Specialist, Health Assessment Program, Division of Environmental Health Epidemiology, Pennsylvania Department of Health (PADOH)

Subject: Evaluation of 2014-2015 indoor air trichloroethylene (TCE) concentrations after installation of air filtration systems at the Chem Fab Site, follow-up and recommendations

Date: July 28, 2015

US EPA Region 3 requested that PADOH and ATSDR review recent indoor air samples collected from April 2014-April 2015 at the Chem Fab Site in Doylestown, PA to determine if the public is being harmed by exposures to indoor air in an office building at the site. Based on the review of current data, PADOH and ATSDR conclude that vapor intrusion is occurring at the Chem Fab site. The levels of TCE measured in indoor air at office locations 300 and 330 pose a public health hazard to sensitive populations (i.e., the developing fetus of a pregnant woman). Visitors and part-time workers who work less than four hours per day are not at an increased risk of adverse health effects related to TCE at office locations 300 and 330. No harmful health effects are expected at office locations 310, 314, 320, 324 and 328. However, these conclusions are based on a few limitations, such as 1) limited knowledge regarding the operation of filtration units on a regular basis; 2) limited sample size and significant variability in the values detected; and 3) exposure assumptions considered to be health protective may over or under estimate the actual risk. If the air filtration units are not used or maintained effectively, then the indoor TCE levels may rise and pose a public health hazard at all locations.

The air filtration units are not a permanent solution; therefore, PADOH and ATSDR recommend (1) take immediate action to reduce exposures to TCE at office locations 300 and 330; (2) continue operating the temporary air filtration units (everyday/all day) at the Chem Fab site to reduce TCE levels in indoor air; (3) perform routine maintenance and monitoring to ensure the temporary air filtration units are operating properly; (4) conduct more frequent air sampling until TCE levels are consistently below those of health concern; and at the same time collect information on the performance of the filtration units and weather conditions at the time of sampling, as TCE levels in indoor air may vary on those factors; (5) continue to provide ongoing health education support to building occupants, and (6) implement a permanent remedy to control exposures to TCE at all office locations.

PADOH and ATSDR will review and evaluate any future environmental data for this site as requested and distribute the findings to the community during community advisory group meetings.

### **Background and Statement of Issues**

The Chem Fab Site, located on North Broad Street in Doylestown, operated as an electroplating and metal processing facility from 1965-1994 and stored waste chemicals on the property. EPA removed 117 drums of chemicals and 8,400 gallons of liquid waste in 1994. Past and current indoor air TCE exposure are associated with the on-site contaminated surface water, surface soil, ground water, and the resulting vapor intrusion from subsurface contamination beneath structures. TCE vapor intrusion mitigation efforts were initiated at this site in October 2011 by EPA<sup>1</sup>. Previous sampling events (pre-activation of gas mitigation system) showed a maximum indoor air concentration of TCE of 225 $\mu\text{g}/\text{m}^3$ . TCE levels found in the main building posed a public health threat to employees of businesses, their patrons, or visitors prior to installation and operation of the gas mitigation system. At the recommendation of PADOH and ATSDR to reduce TCE levels in indoor air, a gas vapor mitigation system was installed. EPA resampled the air in August 2012. Follow-up sampling in August 2012 showed a decrease of TCE concentrations in indoor air at all office/commercial space locations after the activation of the gas mitigation systems. However, the maximum indoor air concentration of TCE detected in the August 2012 sampling event was still elevated (30 $\mu\text{g}/\text{m}^3$ ). Because the evaluation of the August 2012 data resulted in identifying a health concern<sup>2</sup>, temporary air filtration units were installed to further reduce the TCE levels. Follow-up sampling in January 2013 showed a decrease (5 $\mu\text{g}/\text{m}^3$ ) of TCE concentrations in indoor air at all office/commercial space locations after the installation of a temporary air filtration unit. Based on the January 2013 data, PADOH and ATSDR concluded that the current TCE levels are not expected to harm the health of office workers and visitors<sup>3</sup>. Modifications and follow up are often required to optimize the performance of venting systems<sup>4</sup>. EPA collected more indoor air samples in April 2014, January 2015, and April 2015 to determine whether TCE concentrations remained below levels of health concern following the installation of the temporary air filtration units.

### **Discussion**

*Environmental Data:* PADOH and ATSDR evaluated the available indoor air sampling information for potential exposure to TCE at the Chem Fab site. Summa canisters were placed in seven office locations: 300, 310, 314, 320, 324, 328, and 330. One ambient air summa canister was placed on the backside of 330. Table 1 below summarizes TCE concentrations detected in the indoor air samples collected in the main building on January 2013, April 2014, January 2015, and April 2015 after the installation of temporary air filtration units. Summary TCE concentrations detected before and after interim measures were installed (October 2011 to April 2015) are presented in Appendix 1, Table 1. Maximum detections of TCE and reference health effect of TCE values are presented in Appendix 1, Figure 1.

**Table 1: Maximum indoor air TCE concentration detected at each office location after installation of the temporary air filtration units (January 2013-April 2015)**

Office Location	Post-Installation of Temporary Air filtration units ( $\mu\text{g}/\text{m}^3$ )			
	January 2013	April 2014	January 2015	April 2015
300	5	20	19	7
310	4	NA	3	3
314	1	NA	4	5
320	ND	NA	11	13
324*	ND	NA	ND	9
328	ND	12	ND	11
330	ND	25	27	18
Ambient air (behind 330)	3	NA	ND	ND

NA: No samples collected from these office spaces. ND: not detected. \*Building 324 sub-slab results were 58,000 and 50,000 in January 2015 and April 2015, respectively.

The samples collected in 2014 and 2015 show indoor levels of TCE fluctuate over time and by office space location. PADOH understands that the temporary air filtration units were not operated continuously (24 hours per day/7 days per week) which may have been responsible for fluctuating levels at these locations. As stated in previous documents, PADOH/ATSDR recommends that the air filtration units remain operational (24 hours per day/7 days per week) until a more permanent remedy is implemented. Also, based on the review of January 2013-April 2015 data, PADOH and ATSDR found no apparent trend in indoor levels of TCE. Though vapor intrusion varies on an hourly, daily, and seasonal basis<sup>5</sup> active venting systems can reduce this variability<sup>4</sup>.

The 24-hour TCE indoor air concentrations found during the latest rounds of sampling for all seven indoor office locations were above ATSDR's Chronic Minimum Risk Level (cMRL), as well as the EPA's Reference Concentration (RfC) of  $2 \mu\text{g}/\text{m}^3$ .

The maximum concentration detected at each office location from April 2014 to April 2015 was used for further evaluation in this report. The maximum concentration was used to account for worst case scenario at each location. The indoor air samples were collected over a 24-hour

period. In an occupational setting, people do not work 24 hours straight. Therefore, to evaluate the potential health effects of TCE, PADOH and ATSDR calculated the adjusted exposure concentrations using a range of site-specific exposure scenarios to determine the adjusted exposure factor (see Appendix 1). Full-time workers are assumed to be at the facility for eight hours per day five days per week or ten hours per day six days per week. Part-time workers and visitors are assumed to be on-site for one hour a day for four days per week, or two or four hours per day for five days per week. All workers and visitors were assumed to take two weeks of vacation per year, so the exposure was also adjusted to 50 weeks per year. The adjusted exposure concentrations were calculated by multiplying the adjusted exposure factor by the concentration of the chemical (see Appendix 1). Table 2 below shows the adjusted exposure concentrations to TCE for the seven office locations for the exposure scenarios described above.

**Table 2: Maximum and adjusted indoor air TCE concentration detected at each office location after post-installation of the temporary air filtration units from April 2014-April 2015.**

Office Location	Maximum Unadjusted 24-hrs TCE ( $\mu\text{g}/\text{m}^3$ )	Adjusted TCE exposure concentrations in micrograms per cubic meter ( $\mu\text{g}/\text{m}^3$ ) by Exposure Duration*				
		10-hrs	8-hrs	4-hrs	2-hrs	1-hr
300	20	6.8	4.6	2.3	1.1	0.5
310	4	1.4	0.9	0.5	0.2	0.1
314	5	1.7	1.1	0.6	0.3	0.1
320	13	4.5	3.0	1.5	0.7	0.3
324	9	3.1	2.1	1.0	0.5	0.2
328	12	4.1	2.8	1.4	0.7	0.3
330	27	9.2	6.2	3.1	1.5	0.6

\* Maximum indoor air concentrations are adjusted to various time exposure duration scenarios. For example, the 24 hour maximum indoor concentration of TCE detected in office space 330 is adjusted to a 10-hour worker exposure; it assumes exposure for 10 hours, 6 days a week, 50 weeks a year. See additional calculations and exposure assumption in Appendix 1.

### Public Health Implications of TCE in Indoor Air

The most likely exposure scenario is a worker exposed for 10 hours per day. The adjusted TCE concentrations for full time workers (assuming a maximum exposure of 10-hrs, 6 days per week) are above EPA's RfC and ATSDR's cMRL for office locations at 300, 320, 324, 328 and 330, but below the RfC for the office locations 310 and 314 (Table 2). The adjusted concentrations exceeded the CREG value of  $0.24 \mu\text{g}/\text{m}^3$  at all locations. Since the adjusted TCE concentrations exceeded the CREG and the cMRL, further evaluation was performed to determine for the potential cancer risk as well as for non-cancerous health effects.

**Table 3: Estimated lifetime excess cancer risk and non-cancer hazard quotient associated with potential exposure to maximum TCE concentration adjusted for 10-hrs\* from April 2014-April 2015 data set with maximum 10-hrs of exposure time.**

Office Location	Adjusted 10-hour TCE Concentration ( $\mu\text{g}/\text{m}^3$ )*	Cancer Risk <sup>†</sup>	Hazard Quotient <sup>‡</sup> (HQ)
300	6.8	$4 \times 10^{-6}$	3.4
310	1.4	$8 \times 10^{-7}$	0.7
314	1.7	$9 \times 10^{-7}$	0.9
320	4.5	$2 \times 10^{-6}$	2.2
324	3.1	$2 \times 10^{-6}$	1.5
328	4.1	$2 \times 10^{-6}$	2.0
330	9.2	$5 \times 10^{-6}$	4.6

\*Assumes 10 hours of exposure, six days a week for 50 weeks a year

<sup>†</sup>Cancer risk calculated using EPA’s inhalation unit risk (IUR) for TCE of  $4.10\text{E}-06$  ( $\mu\text{g}/\text{m}^3$ )<sup>-1</sup> for 10 years of exposure.

<sup>‡</sup>Hazard quotient calculated using ATSDR’s chronic minimum risk level (cMRL) for TCE of  $2$  ( $\mu\text{g}/\text{m}^3$ ).

### Cancer effects evaluation

EPA has characterized TCE as “carcinogenic to humans” by all routes of exposure and has estimated an inhalation unit risk (IUR) of  $4 \times 10^{-6}$  per  $\mu\text{g}/\text{m}^3$ . US Department of Health and Human Services has classified TCE as “reasonably anticipated to be a human carcinogen”<sup>6</sup>. The International Agency for Research on Cancer (IARC) has classified TCE as “probably carcinogenic to humans” (Group 2A). Using the adjusted 10-hour indoor air concentrations of TCE in Table 3, EPA’s IUR, and equations shown in Appendix 1, ATSDR and PADOH estimated excess cancer risk.

PA Department of Environmental Protection’s acceptable excess life time risk level is one in one hundred thousand ( $1 \times 10^{-5}$ ). All of the uncertainties and conservative exposure assumptions associated with the dose calculations are included in the risk estimation as well as the uncertainty in deriving the IUR<sup>7</sup>. Using the adjusted 10-hour indoor air concentrations of TCE for all the office locations, the estimated cancer risk ranged from  $4 \times 10^{-6}$  to  $9 \times 10^{-7}$  based on 10-year exposure duration. Based on our evaluation, the adjusted TCE exposure concentrations measured during the April 2014—April 2015 sampling event pose no apparent increased cancer risk to the workers or visitors in all office locations at Chem Fab site.

### Non-cancer health effects evaluation

Adverse noncancerous effects associated with TCE exposure by inhalation include hepatic, renal, neurological, immunological, reproductive, and developmental effects<sup>8</sup>. PADOH and ATSDR evaluated the potential for non-cancerous adverse health effects that may result from exposure to adjusted TCE concentrations that were above ATSDR cMRL (see Table 3 and example calculations in Appendix 1). Hazard quotients (HQs) are the ratios of exposure estimates to noncancer health guideline values, such as cMRLs. If the HQ is less than 1.0, it is unlikely that

significant toxic effects would occur because the adjusted concentration is below the cMRL. This means that no further evaluation is necessary. If the HQ is greater than 1.0, then further evaluation is necessary, because the adjusted concentration exceeds the cMRL. If a HQ for a contaminant exceeds 1.0, the levels are then compared to levels in the scientific literature and a professional judgment is made.

The adjusted indoor air levels ( $1.4 \mu\text{g}/\text{m}^3$  and  $1.7 \mu\text{g}/\text{m}^3$ ) for 10-hours of exposure to TCE in offices 310 and 314, respectively, resulted in HQs less than 1.0 and it is unlikely that significant toxic effects would occur after exposure to these levels. However, the adjusted indoor air levels ( $6.8 \mu\text{g}/\text{m}^3$ ,  $4.5 \mu\text{g}/\text{m}^3$ ,  $3.1 \mu\text{g}/\text{m}^3$ ,  $4.1 \mu\text{g}/\text{m}^3$ , and  $9.2 \mu\text{g}/\text{m}^3$ ) for 10-hours of exposure to TCE at office locations 300, 320, 324, 328, and 330, respectively, resulted in HQs greater than one and warrant further evaluation.

In EPA's TCE Integrated Risk Information System (IRIS) toxicological profile, the most sensitive observed adverse effects, which were used as the primary basis for the RfC, were those affecting the immune system and the developing fetus. The RfC of  $2 \mu\text{g}/\text{m}^3$  is based on route-to-route extrapolated results from oral studies for the critical effects of heart malformations (rats) and immunotoxicity (mice). Kidney toxicity is considered supportive of the critical effect, but it was not used as a principal basis for the RfC. Based on the animal study data as reviewed in the IRIS toxicological profile, EPA predicts that:

- A small risk of fetal heart malformations exists for pregnant women exposed to TCE levels approaching or exceeding  $21 \mu\text{g}/\text{m}^3$ ;
- A small risk of decreased thymus weight exists for humans exposed to TCE levels approaching or exceeding  $190 \mu\text{g}/\text{m}^3$ ; and
- A small risk of kidney impacts, including toxic nephropathy and increased kidney weights exists for humans exposed to TCE levels approaching or exceeding  $30 \mu\text{g}/\text{m}^3$ .

An epidemiological study concluded that pregnant women residing in areas where soil vapor intrusion of TCE and other volatile contaminants into indoor air occurred was associated with cardiac defects<sup>9</sup>. Although this study did not evaluate a dose-response relationship, indoor air measurements were not tested, and other contaminants (tetrachloroethylene or PCE) were present, it supports fetal cardiac effects as an appropriate toxicological endpoint in humans, the use of animal studies for the RfC, and the route extrapolation from oral to inhalation. The major milestones for cardiac heart development in humans occur over a three week period in the first trimester of pregnancy. Exposures to TCE during this critical period may increase the risk of heart malformations in the developing fetus. In addition, studies have shown kidney toxicity in TCE-exposed workers<sup>9</sup>. ATSDR has adopted the EPA RfC value as the cMRL for TCE inhalation exposures.

Based on our evaluation of the available literature, indoor air TCE concentrations slightly above the cMRL at offices 320, 324 and 328 are not expected to result in adverse health effects. However, the indoor air concentrations of TCE in office locations 300 (6.8  $\mu\text{g}/\text{m}^3$ ) and 330 (9.2  $\mu\text{g}/\text{m}^3$ ) are approaching levels of health concern. Even though these concentrations are below the EPA's modeled concentrations of 21  $\mu\text{g}/\text{m}^3$  and 30  $\mu\text{g}/\text{m}^3$  where fetal cardiac malformations were observed in pregnant rats and kidney effects in rats, they are approaching these human equivalent concentrations that may be associated with developmental effects. Hence, if a pregnant woman is exposed to the TCE levels found in office spaces 300 and 330 for 8-10 hours per day, 5-6 days per week, her fetus may be at an increased risk of heart malformations.

### **Conclusions**

Based on the April 2014-2015 data and comparison of adjusted values with available literature, PADOH and ATSDR reached following conclusions:

1. Vapor intrusion is occurring at the Chem Fab site. The levels of TCE measured in indoor air at locations 300 and 330 are a public health hazard to sensitive populations (i.e., the developing fetus of a pregnant woman). This conclusion for office location 330 assumes building occupants are exposed to TCE for 8-10 hours per day, 5-6 days per week. The conclusion for office location 300 assumes building occupants are exposed to TCE for 10 hours per day, 6 days per week.
2. Visitors and part-time workers who work less than four hours per day are not likely to experience any adverse health effects to TCE at office locations 300 and 330.
3. No harmful health effects are expected at office locations 310, 314, 320, 324, and 328.
4. If the air filtration units are not used or maintained effectively, indoor TCE levels may increase and pose a public health hazard at all office locations.

## Recommendations

Based on reported indoor TCE levels, PADOH and ATSDR have the following recommendations:

- Take immediate action to reduce exposures to TCE at office locations 300 and 330.
- Continue operating the temporary air filtration units (everyday/all day) at the Chem Fab site to reduce TCE levels in indoor air,
- Perform routine maintenance and monitoring to ensure the temporary air filtration units are operating properly,
- Conduct more frequent air sampling until TCE levels are consistently below those of health concern; and collect information on the performance of the filtration units and weather conditions at the time of sampling, as TCE levels in indoor air may vary on those factors,
- Continue to provide ongoing health education support to building occupants, and
- Implement a permanent remedy to control exposures to TCE at all office locations.

If you have any questions, please contact me at 717-547-3310, or by e-mail at [sarunachal@pa.gov](mailto:sarunachal@pa.gov).

Sincerely,



Sasidevi Arunachalam, MS PHS  
Epidemiology Program Specialist  
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## References

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## **Appendix 1 Calculations**

### **Exposure Calculations**

$$EC = (CA \times ET \times EF \times ED)/AT$$

Where:

EC ( $\mu\text{g}/\text{m}^3$ ) = exposure concentration;

CA ( $\mu\text{g}/\text{m}^3$ ) = contaminant concentration in air;

ET (hours/day) = exposure time;

EF (days/year) = exposure frequency;

ED (years) = exposure duration; and

AT (ED in years x 365 days/year x 24 hours/day) = averaging time

Note: If the duration of the exposure period is less than one year, the units in the above equation can be changed to the following: EF (days/week); ED (weeks/exposure period); and AT (hours/exposure period).

### **Adjusted Exposure Factor for industrial workers and visitors:**

10 hours of exposure per day, 6 days per week, 50 weeks per year:

$$10 \text{ hours} \times 6 \text{ days} \times 50 \text{ weeks} / 24 \text{ hours} \times 7 \text{ days} \times 52 \text{ weeks} = 0.34$$

8 hours of exposure per day, 5 days per week, 50 weeks per year:

$$8 \text{ hours} \times 5 \text{ days} \times 50 \text{ weeks} / 24 \text{ hours} \times 7 \text{ days} \times 52 \text{ weeks} = 0.23$$

4 hours of exposure per day, 5 days per week, 50 weeks per year:

$$4 \text{ hours} \times 5 \text{ days} \times 50 \text{ weeks} / 24 \text{ hours} \times 7 \text{ days} \times 52 \text{ weeks} = 0.114$$

2 hours of exposure per day, 5 days per week, 50 weeks per year:

$$2 \text{ hours} \times 5 \text{ days} \times 50 \text{ weeks} / 24 \text{ hours} \times 7 \text{ days} \times 52 \text{ weeks} = 0.057$$

1 hour of exposure per day, 4 days per week, 50 weeks per year:

$$1 \text{ hour} \times 4 \text{ days} \times 50 \text{ weeks} / 24 \text{ hours} \times 7 \text{ days} \times 52 \text{ weeks} = 0.023$$

### **Example of Adjusted Exposure Concentration for maximum measured air concentration of $27\mu\text{g}/\text{m}^3$ from April 2014 – April 2015 sampling event**

Adjusted Exposure Concentration = Adjusted Exposure Factor x CA

For 10 hours:  $0.34 \times 27\mu\text{g}/\text{m}^3 = 9.2\mu\text{g}/\text{m}^3$

For 8 hours:  $0.23 \times 27\mu\text{g}/\text{m}^3 = 6.2\mu\text{g}/\text{m}^3$

For 4 hours:  $0.114 \times 27\mu\text{g}/\text{m}^3 = 3.1\mu\text{g}/\text{m}^3$

For 2 hours:  $0.057 \times 27\mu\text{g}/\text{m}^3 = 1.5\mu\text{g}/\text{m}^3$

For 1 hour:  $0.023 \times 27\mu\text{g}/\text{m}^3 = 0.6\mu\text{g}/\text{m}^3$

### Estimation for Estimating Excess Cancer Risk

$$CR = EC \times IUR \times EY/78 \text{ years}$$

**Example cancer risk calculation for 10 years of exposure for maximum measured air concentration of 27  $\mu\text{g}/\text{m}^3$  (9.2  $\mu\text{g}/\text{m}^3$  adjusted) for April 2014 –April 2015 sampling event**

$$CR = 0.000004 (\mu\text{g}/\text{m}^3)^{-1} \times 9.2\mu\text{g}/\text{m}^3 \times 10 \text{ years} / 78 \text{ years} = 5 \times 10^{-6}$$

Where:

CR = Cancer Risk

IUR  $(\mu\text{g}/\text{m}^3)^{-1}$  = Inhalation Unit Risk = 0.000004

EC  $(\mu\text{g}/\text{m}^3)$  = adjusted exposure concentration = 9.2

EY (years) = exposure years = 10

### Noncancer Hazard Calculation

$$\text{Hazard Quotient} = EC / \text{cMRL} = 6.1\mu\text{g}/\text{m}^3 / 2\mu\text{g}/\text{m}^3 = 3.0$$

Where:

EC  $(\mu\text{g}/\text{m}^3)$  = adjusted exposure concentration

cMRL  $(\mu\text{g}/\text{m}^3)$  = ATSDR chronic MRL = 2

**Appendix 1, Table 1: Summary of TCE air results ( $\mu\text{g}/\text{m}^3$ ) from the offices at Chem Fab NPL site from October 2011-April 2015.**

Office Location	Pre-Activation of Gas Mitigation System		Post- Activation of Gas Mitigation System	Post-Installation of Temporary Air filtration units			
	Oct. 2011	Jan. 2012	Aug. 2012	Jan. 2013	Apr. 2014	Jan. 2015	Apr. 2015
300	81	78	6	5	20	19	7
310	53	22	5	4	NA	3	3
314	225	6	5	1	NA	4	5
320	26	18	15	ND	NA	11	13
324*	18	NA	15	ND	NA	ND	9
328	29	27	17	ND	12	ND	11
330	45	44	30	ND	25	27	18
Ambient air (behind 330)	NA	NA	NA	3	NA	ND	ND

NA: No samples collected from these office spaces. ND: not detected. \*Building 324 sub-slab results were 58,000 and 50,000 in January 2015 and April 2015, respectively.

**Figure 1:** Indoor air concentrations of TCE at commercial buildings and reference health effect values

