DEMONSTRATION OF A LONG TERM SAMPLING APPROACH FOR CHARACTERIZING VAPOR INTRUSION

ER-201504

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ESTCP

PROJECT TEAM

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AIM OF THE STUDY

- Characterize VOCs from vapor intrusion using an innovative low flow rate controller attached to evacuated canisters.

- Validate the feasibility of using long term canister sampling (2-weeks) method indoors and comparing it to both long term diffusion tube sampling (2 weeks) and consecutive multiple day 24-hour canister sampling.

EXPOSURE LIMITS

Trichloroethylene

Exposure Limits (ppm)	8-hr TWA (ppm)	STEL (ppm)	Ceiling (ppm)	μg/m³
OSHA- PEL	100	200	300	537,400
CAL-OSHA - PEL	25			134,350
NIOSH-REL	Ca			
ACGIH - TLV	10			53,740
EPA Regions, Selected States	0.0011 to 0.0048			6-26

- ppm = parts per million, where 10 ppm = 53.74 mg/m^3 or 53,742 ug/m^3
- TWA = Time Weighted Average
- STEL = Short Term Exposure Limit
- C = Ceiling limit
- Ca = Potential occupational carcinogens

2018 OSHA Annotated Table Z-2[(a)]

SCREENING LEVELS (SLs) AND TLVs

Analyte	Carcinogenic SL TR = 1 x 10^{-6} ($\mu g/m^3$)	Carcinogenic SL TR = 1 x 10^{-4} ($\mu g/m^3$)	Non-carcinogenic SL THQ = 1 ($\mu g/m^3$)	Non-carcinogenic SL THQ = 3 ($\mu g/m^3$)	TLV-TWA ($\mu g/m^3$)
Benzene	1.6	160	130	390	1,600
TCE	3	300	8.8	26.4	54,000

Notes:
SL = screening level
TR = target cancer risk
THQ = total hazard quotient
TLV-TWA = threshold limit value based on an 8-hr time-weighted average

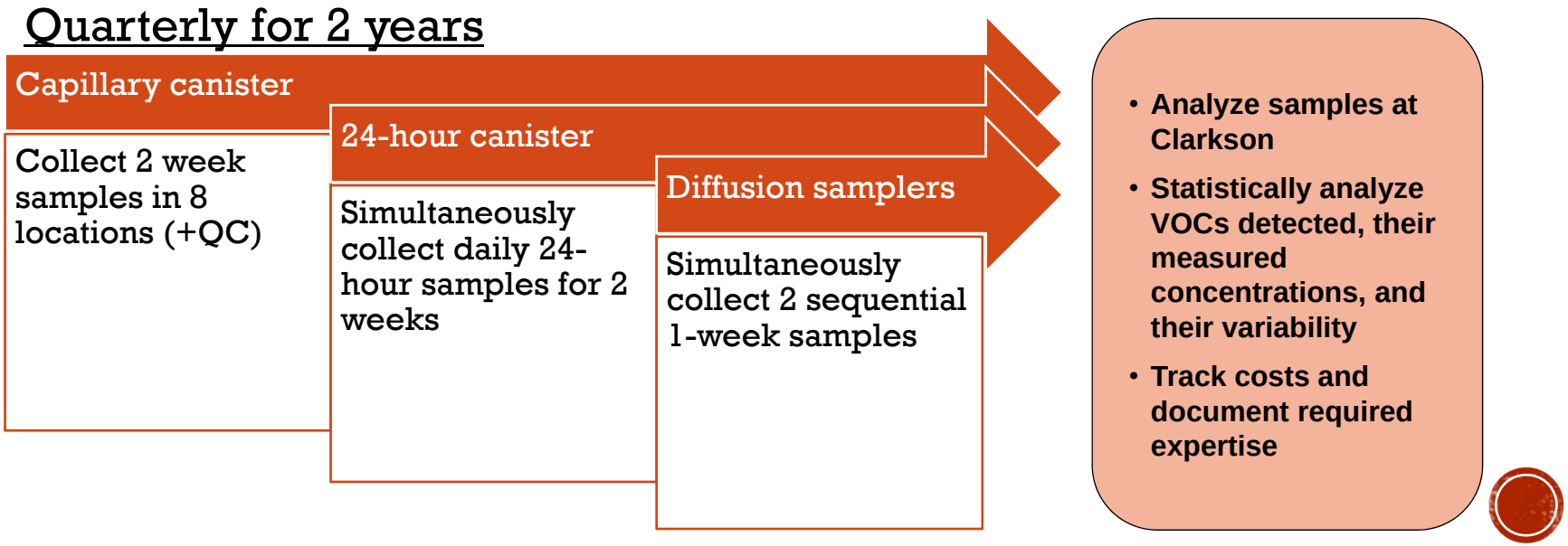
RELATIONSHIP TO A DISEASE MODEL

- Long-term average as the most effective means of predicting long-term disease.
- For many chronic toxicants, burden and damage are unlikely to be impacted by large transient or peak exposures during short periods of a work shift or for 24 hours in the case of IAQ.
- Exposures are log-normally distributed (almost always) suggesting that individual risk is related to the mean exposure over time.
- Hence, the primary aim of assessment of exposure for long-term effects should be to evaluate the mean exposure received by the individual worker or occupant over time.
- It also follows that exposures to 'peaks' will generally be less important in relation to long-term risk and, therefore should be weighted less.
- **Hence a longer term sample should provide a better estimate of long term exposure and risk.**

Rappaport (1991), and Rappaport, Selvin and Roach (1988)

PERFORMANCE OBJECTIVES

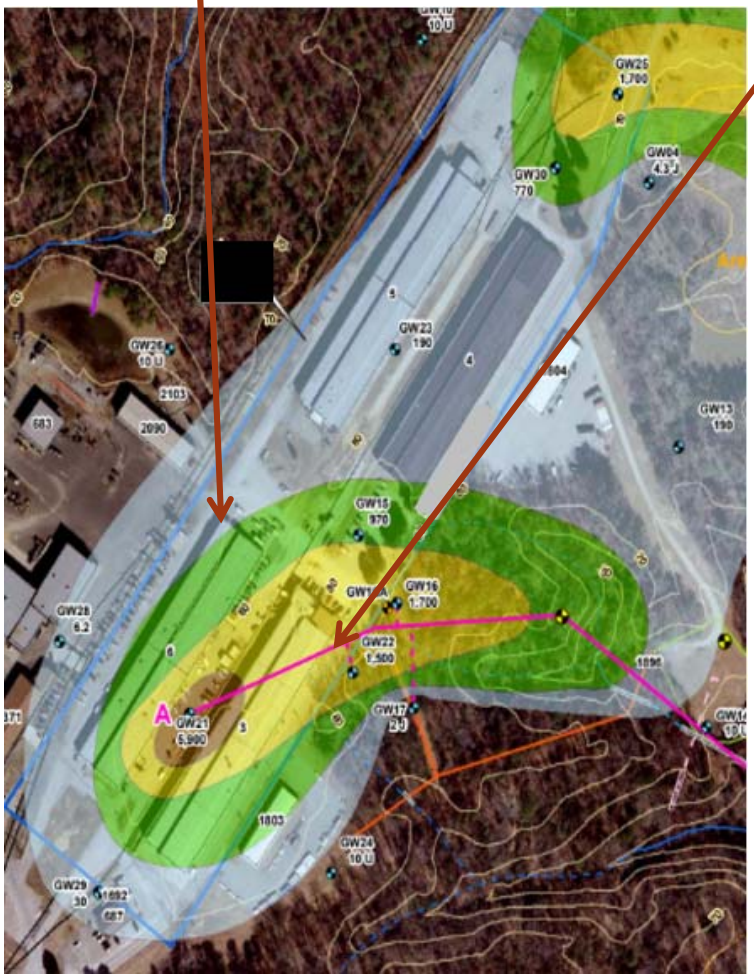
- Compare to 24-hr canister approach and diffusion sampler approach: accuracy, precision, completeness
- Cost-effectiveness
- Expertise



METHODS: SITE DESCRIPTION

Building B
- Built in 1919 on elevated concrete slab
- Max [TCE] in indoor air = 83 μg/m^3
- Large open areas, some offices, storage

Building A
- Built in 1941 on concrete slab
- Max [TCE] in indoor air = 170 μg/m^3
- Was used to support public works and utilities maintenance



Risk-based screening level = 8.8 μg/m^3 (1.64 ppb)

- Max [TCE] from 2012
- Cracks sealed → resampled
- Buildings remain above acceptable level
- Other contaminants in sub slab: Toluene, Freons, TCA, DCE

TEST DESIGN

Demonstrate and validate capillary canisters

Capillary-Canister
- 14 day samples
- 8 locations + 3QC
- 1 sample per location
- 4 seasons

TOTAL SAMPLES = 44/yr

Traditional Canister
- 24 hour samples
- 8 locations + 1QC
- 14 samples per location
- 4 seasons

TOTAL SAMPLES = 504/yr

Diffusion samplers
- 2 consec. 7 d samples
- 8 locations + 1QC
- 1 sample per location
- 2 field blanks
- 4 seasons

TOTAL SAMPLES = 88/yr

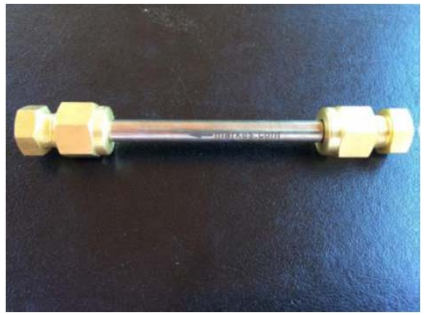
Background
- Ambient air – 2 upwind quarterly
- Sub slab – 4 buildings, collect every 3rd day, quarterly
- 4 seasons

TOTAL SAMPLES = 68/yr

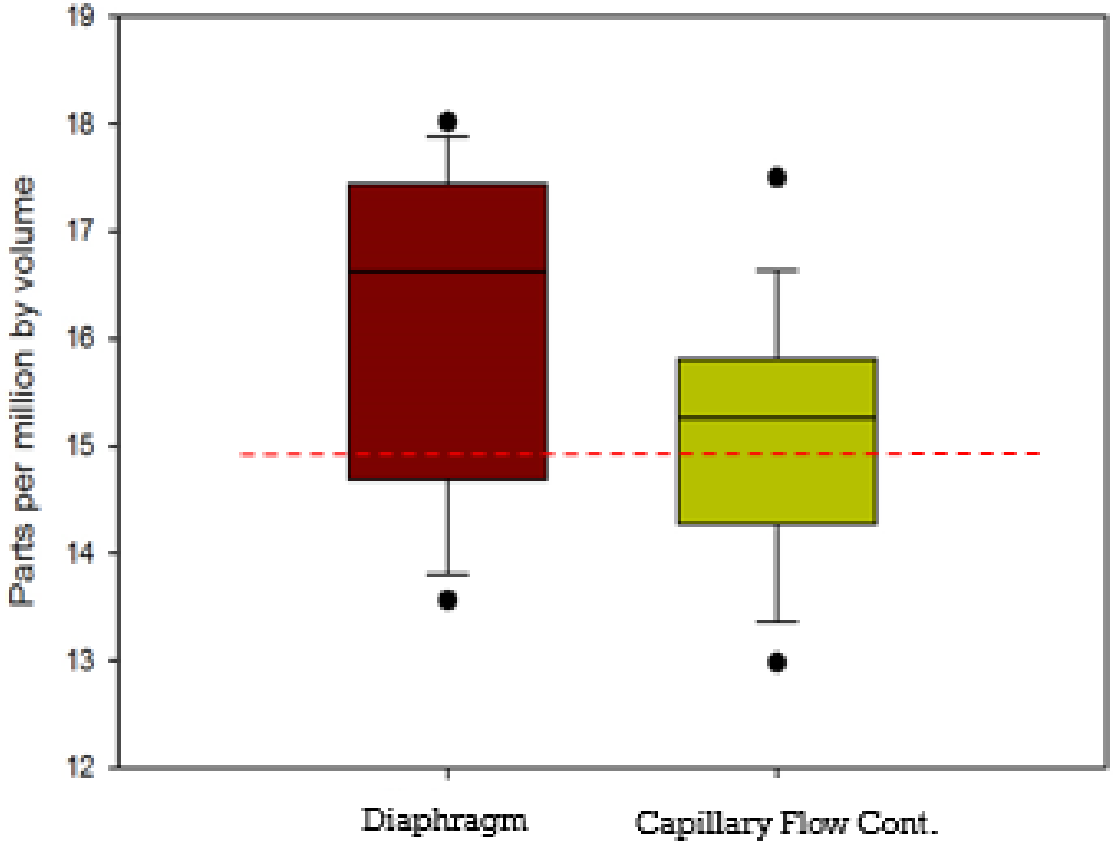
- 1 personnel on site during full sampling period each quarter
- Samples collected daily and shipped to Clarkson's CARES laboratories
- Analysis by thermo GC-MS, Markes pre-concentrator and autosampler
- TO-15 and TO-17
- Detection limit: TCE: 0.06 ppb, PCE: 0.046 ppb

TEST DESIGN:

- Two buildings with 2 locations per building
- Two-week sampling period, quarterly, 2 years
- Monitoring station at each site
- Sampling devices
  - Diaphragm –Canisters (3.4 ml/min)
  - Capillary flow controller – Canister
    - 0.32 and 0.1 mL/min
  - Sorbent tubes (2.68 mL/min)
- Other
  - Temperature
  - Relative humidity
  - Pressure
  - Direct-reading: VOCs



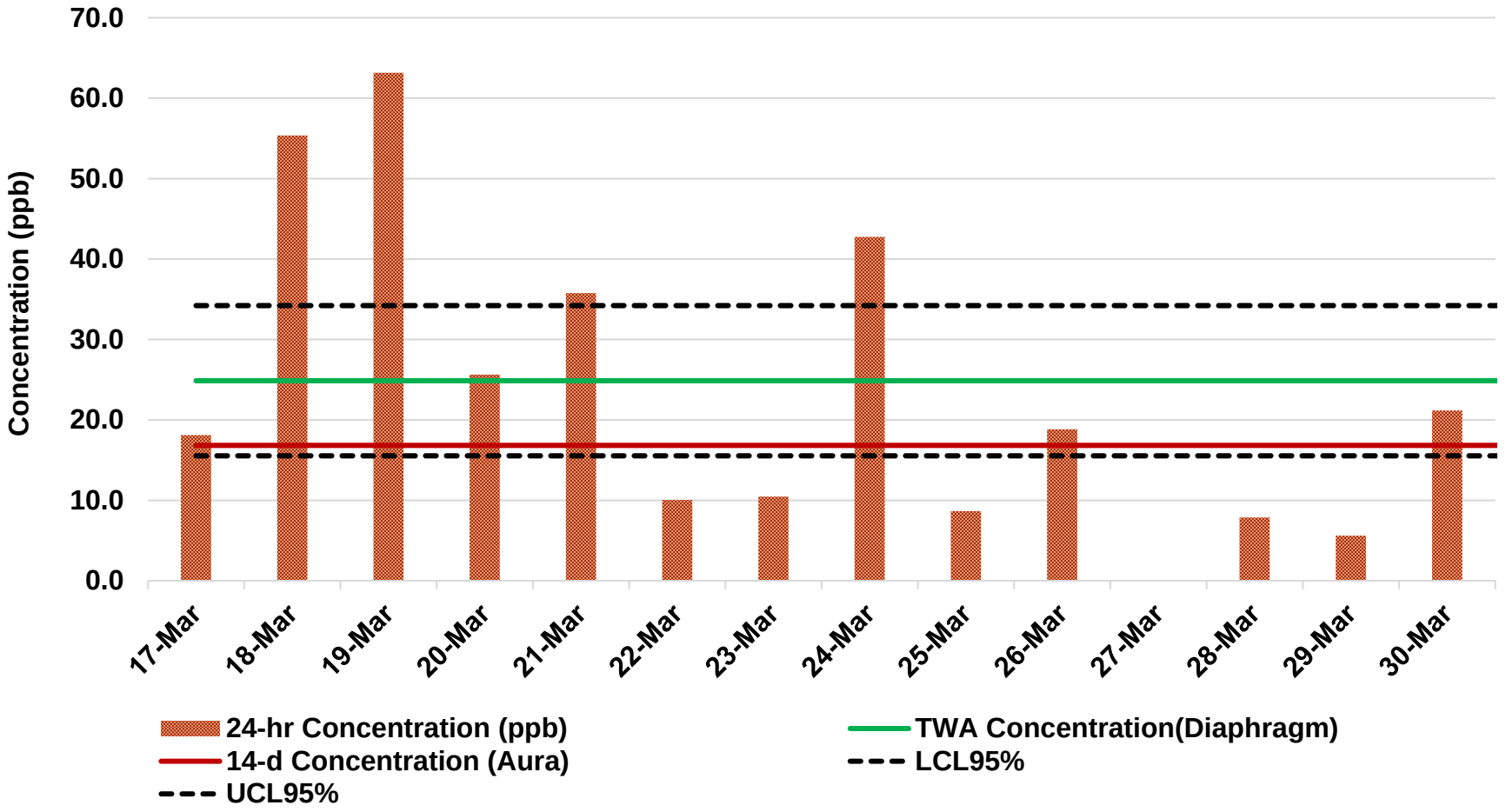
PERFORMANCE ASSESSMENT: LABORATORY



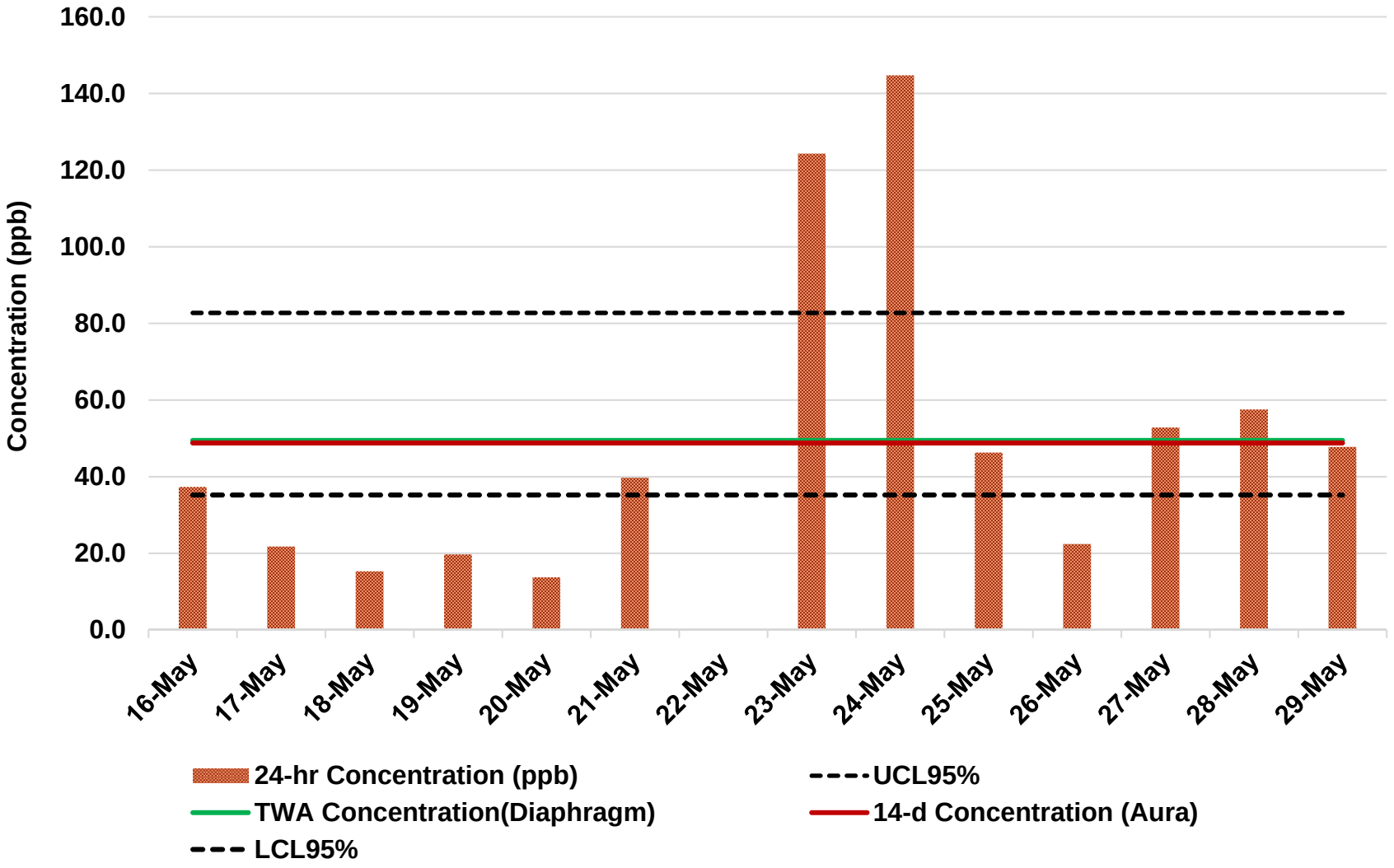
Flow Controller	stdv	% RSD
Capillary	1.1	**6.9**
Diaphragm	1.5	**9.1**

N=24 for each flow controller

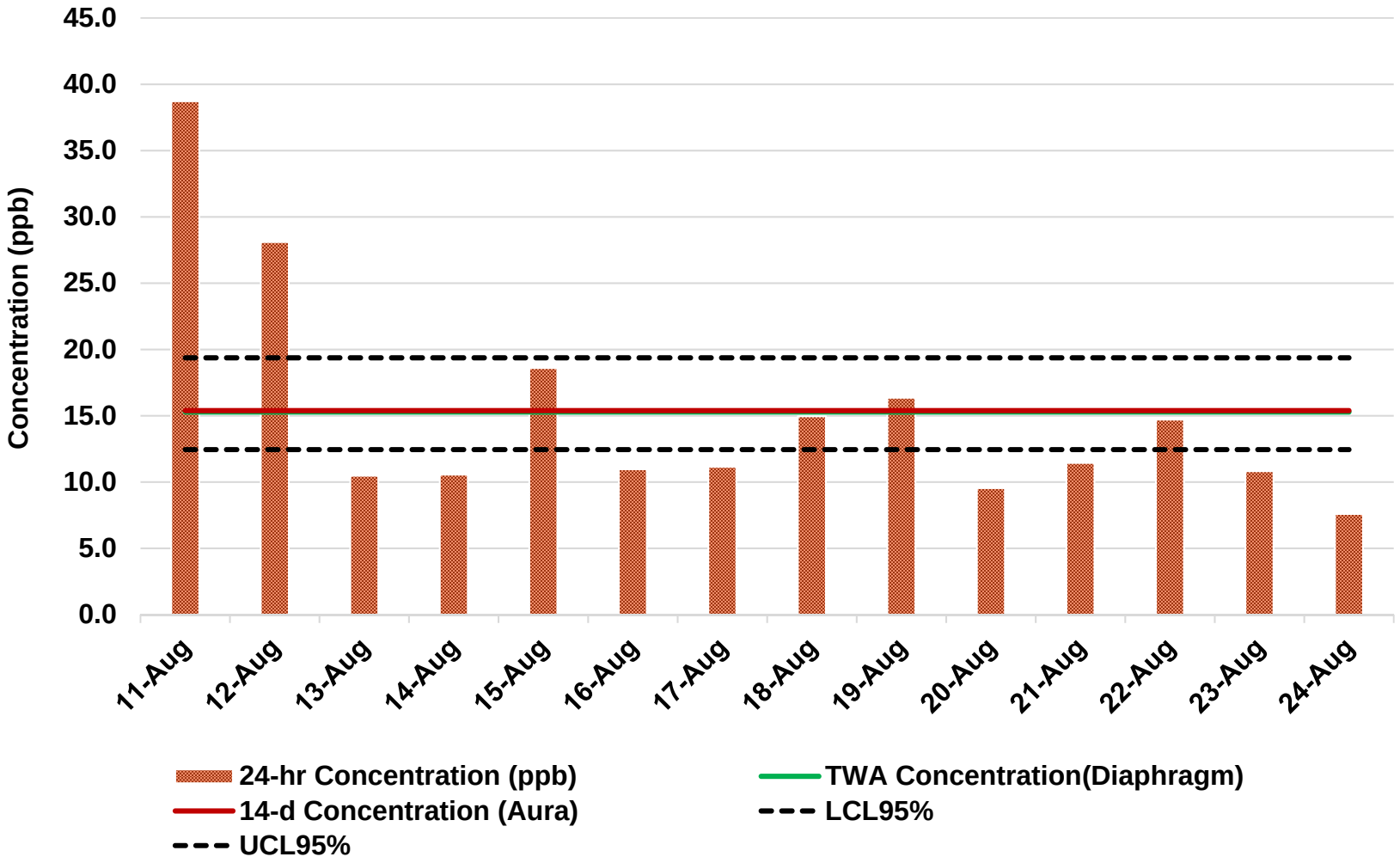
MARCH 2017 LOCATION 1 TCE CONCENTRATIONS



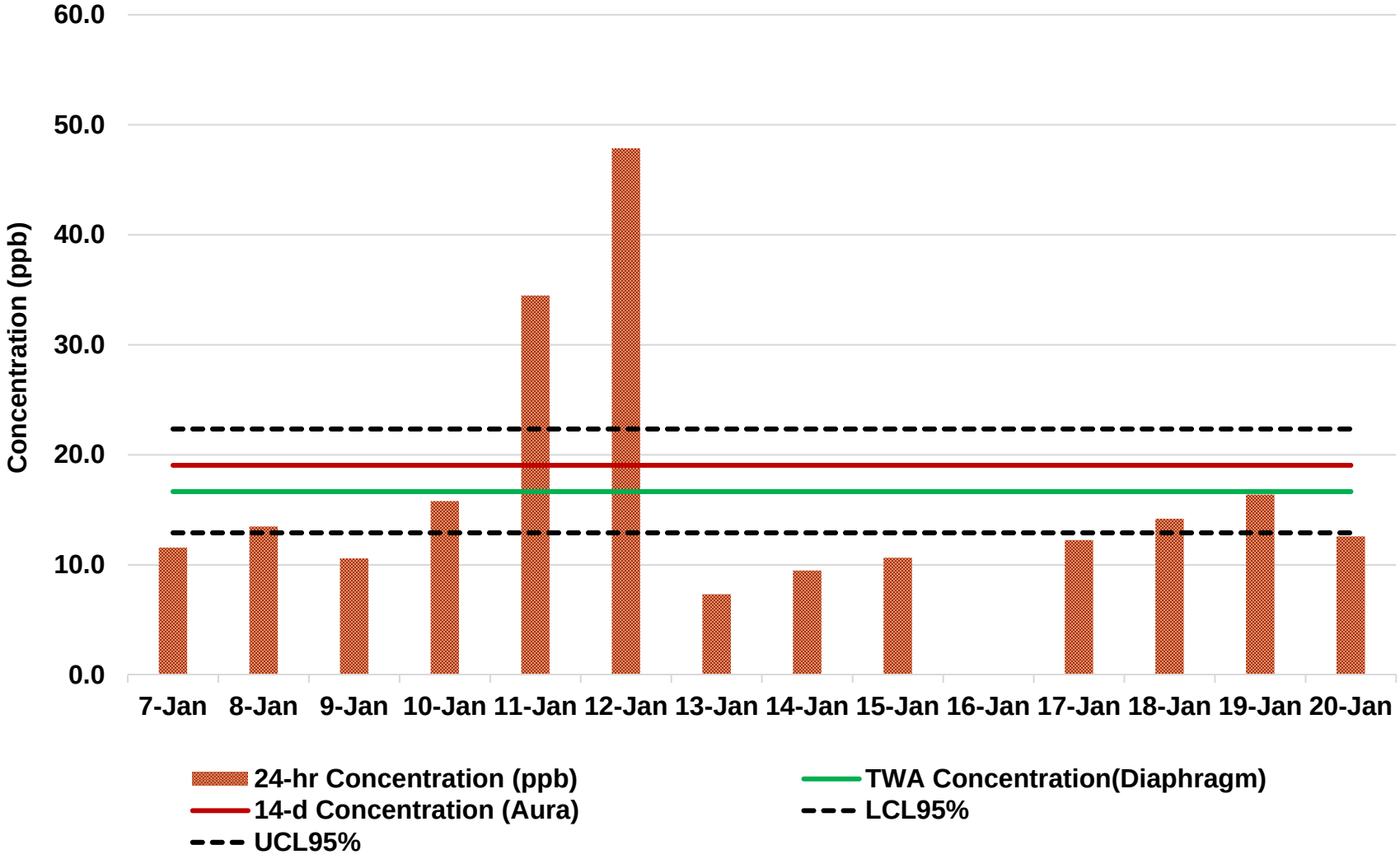
MAY 2017 LOCATION 1 TCE CONCENTRATIONS



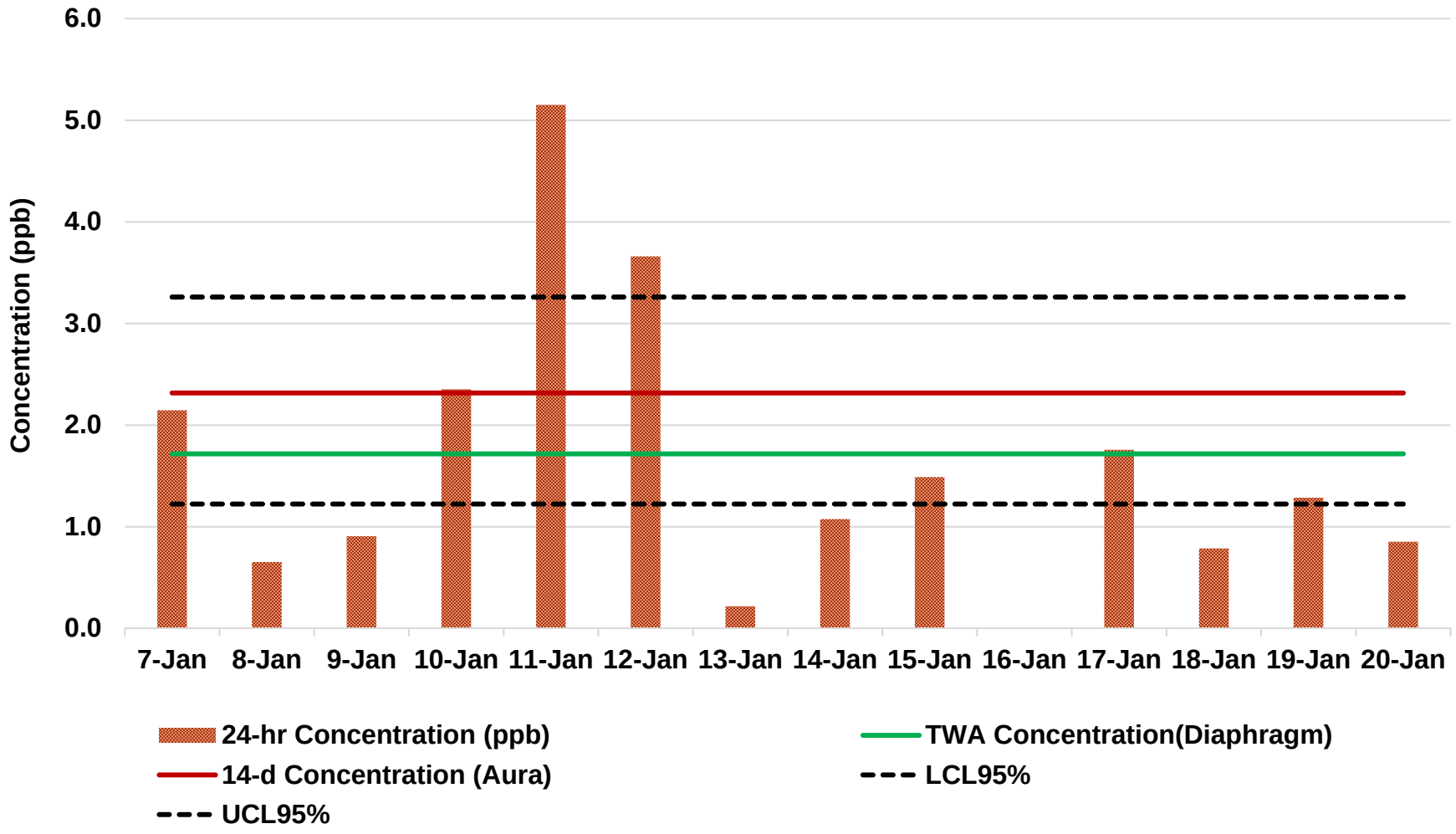
AUGUST 2017 LOCATION 1 TCE CONCENTRATIONS



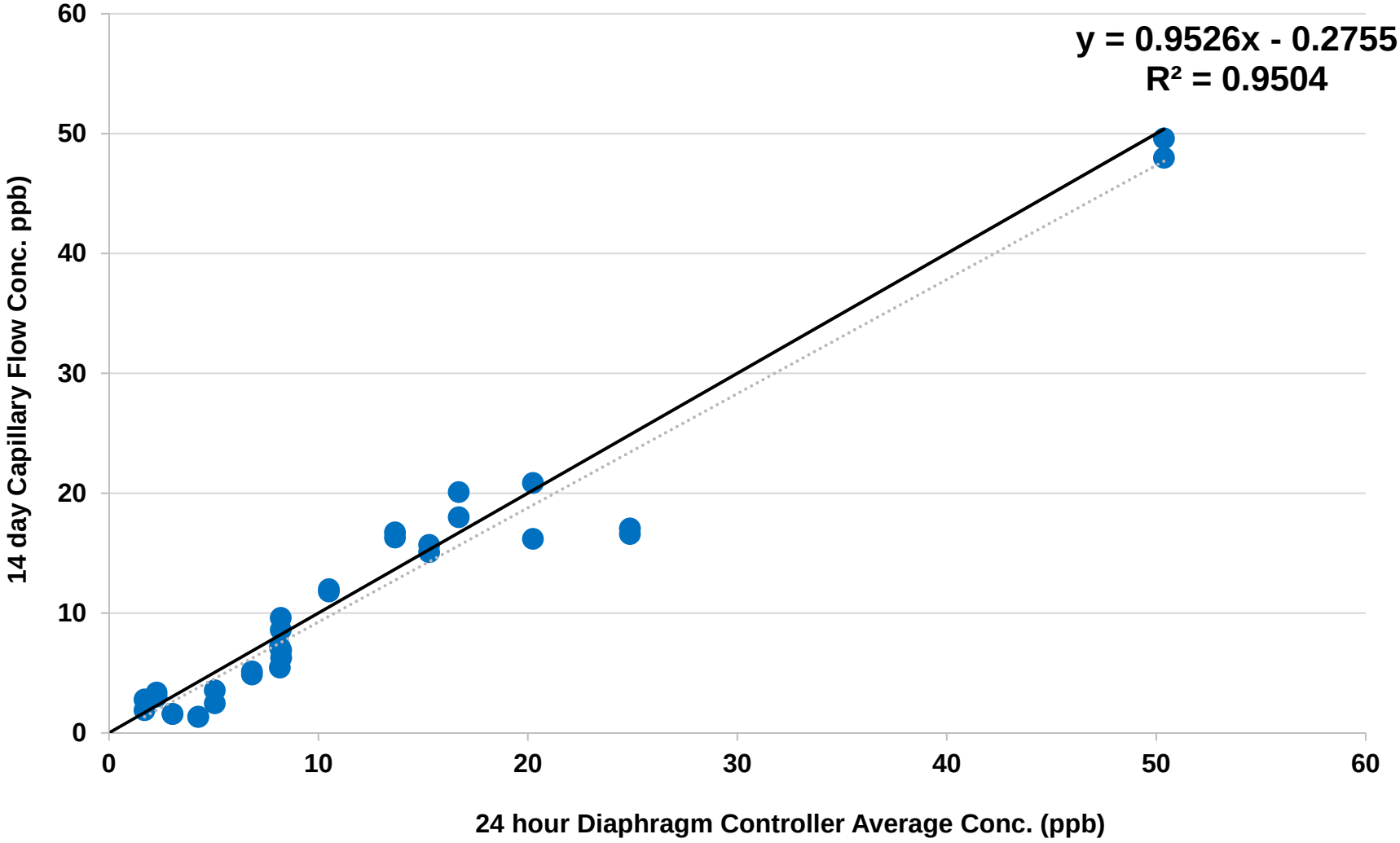
JANUARY 2018 LOCATION 1 TCE CONCENTRATIONS



JANUARY 2018 LOCATION 4 TCE CONCENTRATIONS

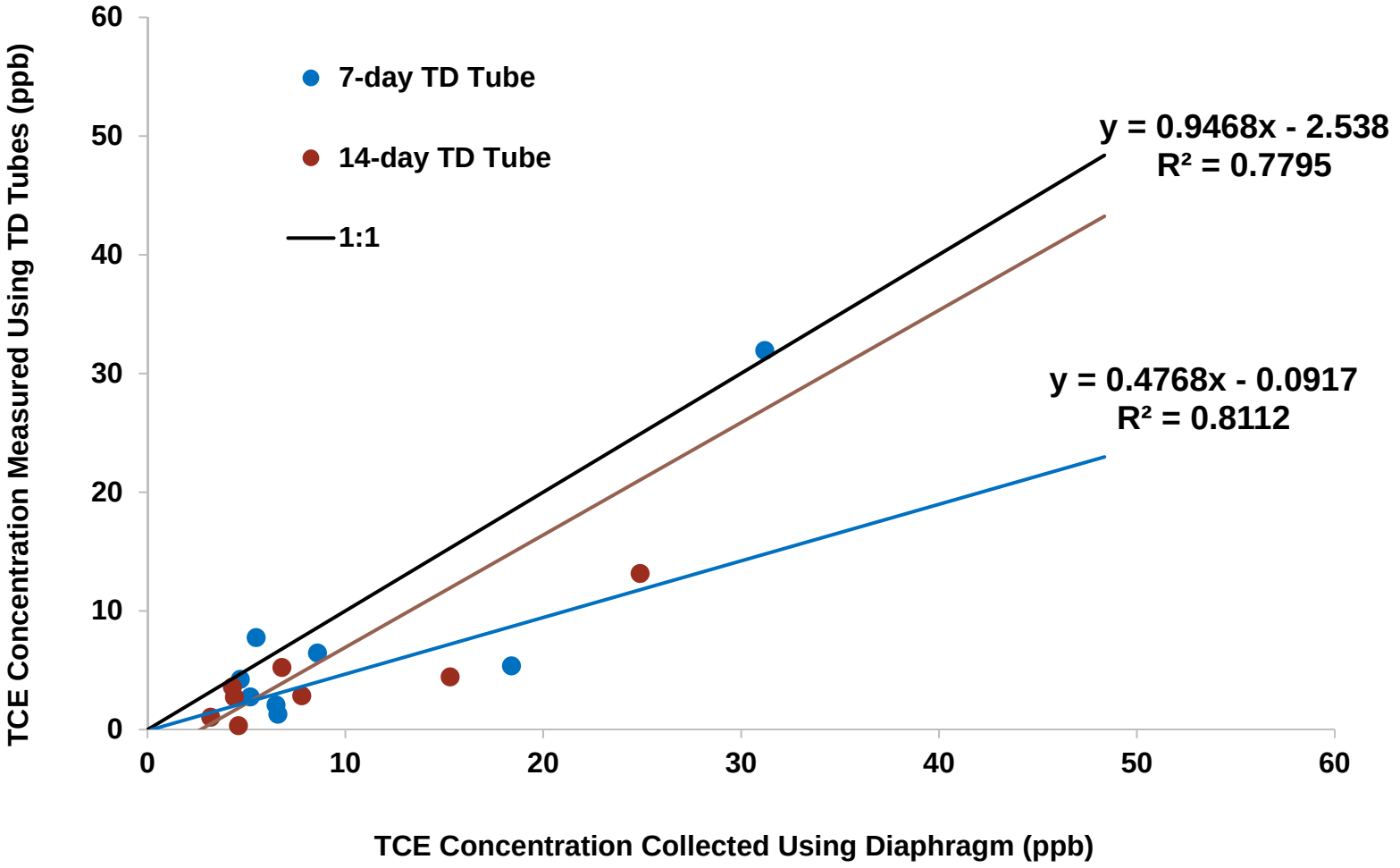


14 DAY SAMPLE VS MEAN OF THE 24 HR SAMPLES

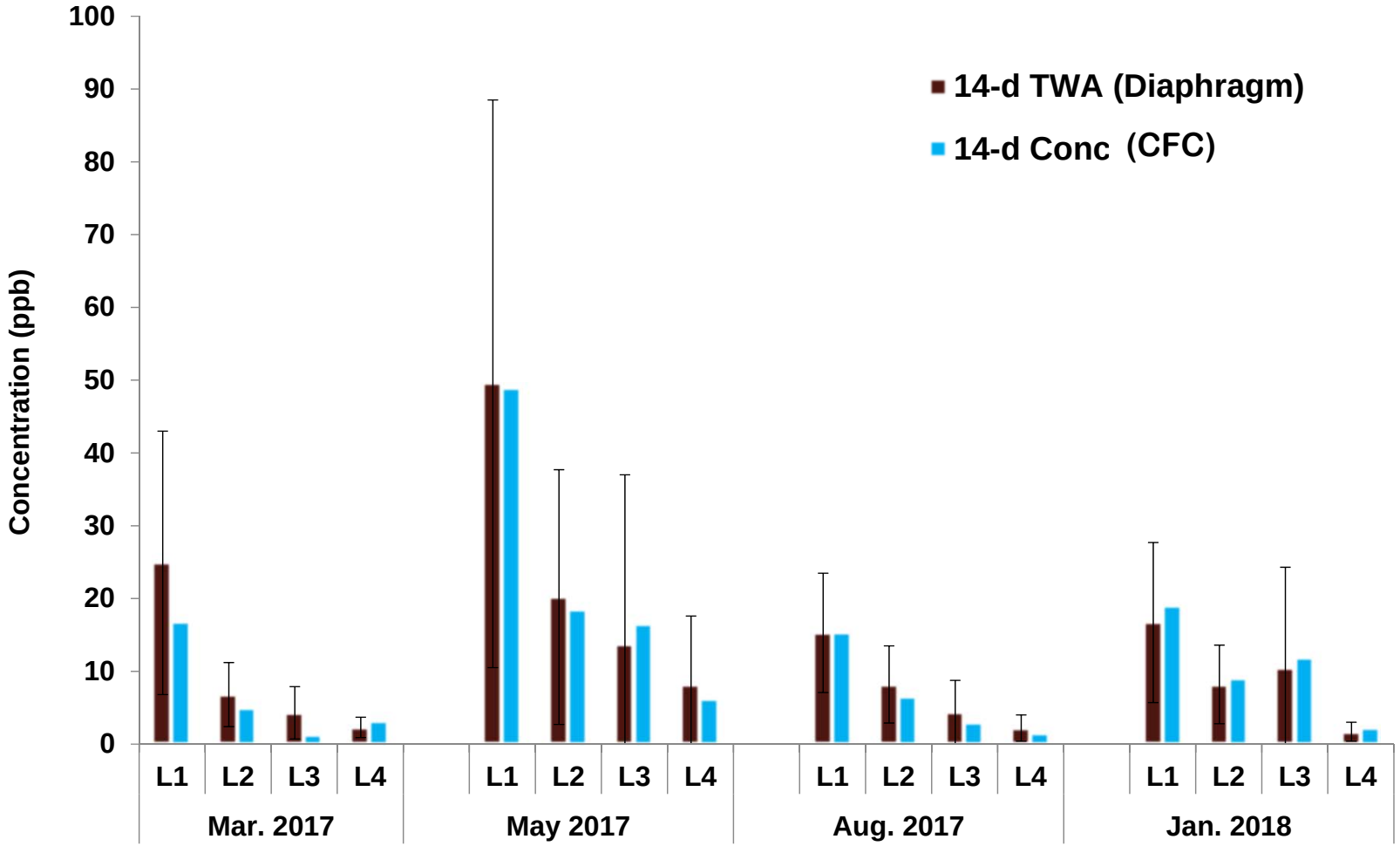


N=32

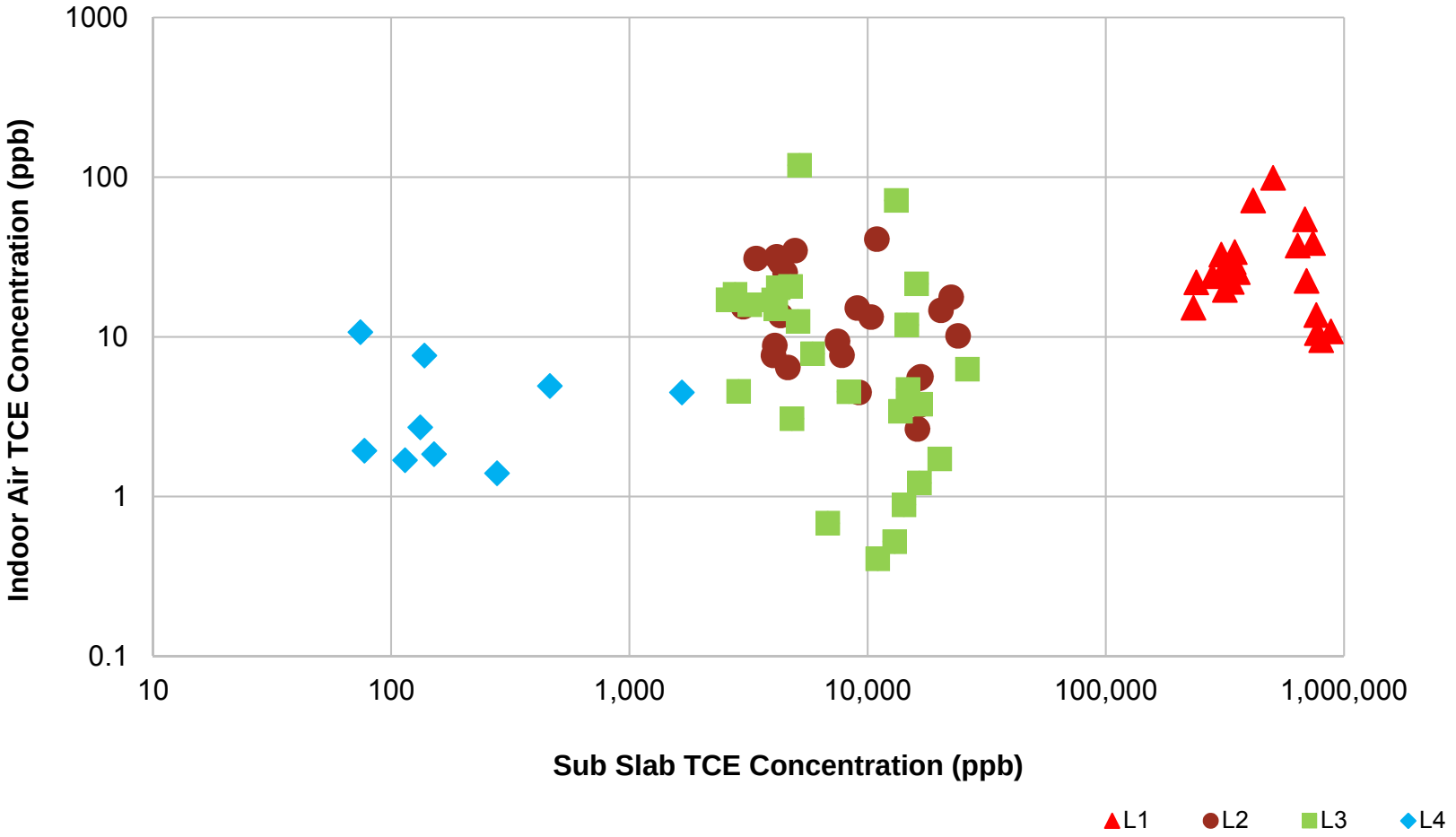
PERFORMANCE OF THE THERMAL DESORPTION TUBES VS CANISTER FOR TCE



SEASONAL COMPARISON BETWEEN DIAPHRAGM AND CAPILLARY FLOW CONTROLLERS

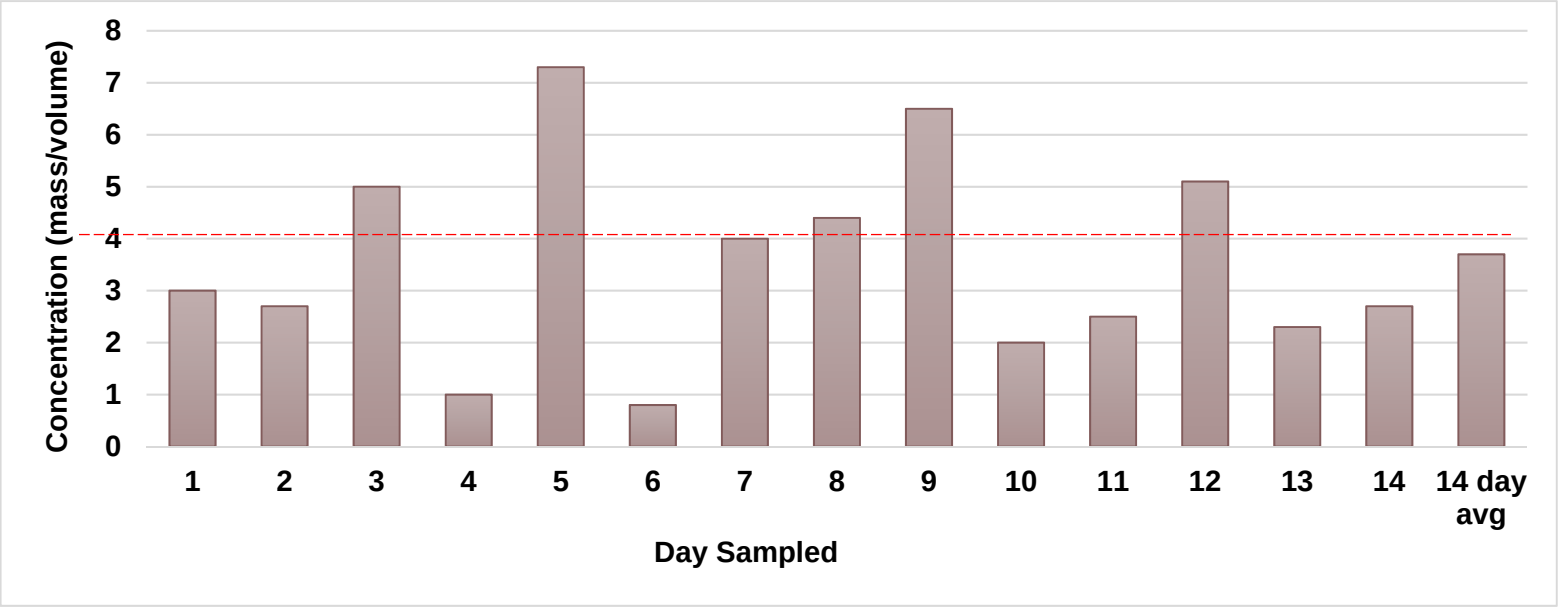


SUB-SLAB VS. INDOOR AIR (MARCH 2017-JANUARY 2018)



COST ASSESSMENT (STILL UNDER EVALUATION)

- How many samples would be needed to make the same risk-based decision with similar degree of certainty?
- What are the associated costs?
  - # samples – materials and analysis
  - Field sampling time
  - Deployment and travel costs



CONCLUSIONS

- Fifteen out of the 16 tests demonstrated that the capillary flow controller performed within 95% confidence level from diaphragm.
- No statistical difference at concentration, temperature, and humidity ranges for CPC and Diaphragm.
- The longer sampling period should be more representative of long term exposure.
- Long term sampling may provid4 better data for decision making

QUESTIONS