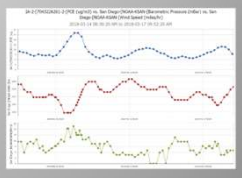
Resolving Vapor Intrusion Challenges via Automated Continuous Real-Time Monitoring

Mass DEP
Waste Site Cleanup
Advisory Committee



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HARTMAN
ENVIRONMENTAL GEOSCIENCE

Presented to the Massachusetts Waste Site Cleanup Advisory Cleanup Committee on November 14, 2018 in Boston, MA.

Lecture notes are at the bottom of each slide so that if played out as a hard-copy, the presentation can be a useful reference document.

Presentation Summary

- Brief System Description
- IA Temporal Variation
- Applications of Monitoring

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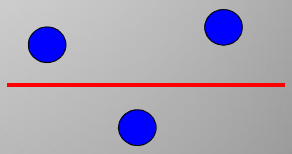
The following topics will be covered very quickly in this 30 minute presentation.

Longer presentations are available which cover the material more slowly and completely.

The Fundamental Problem with VI Assessments & Remedies

With These:

You Get:



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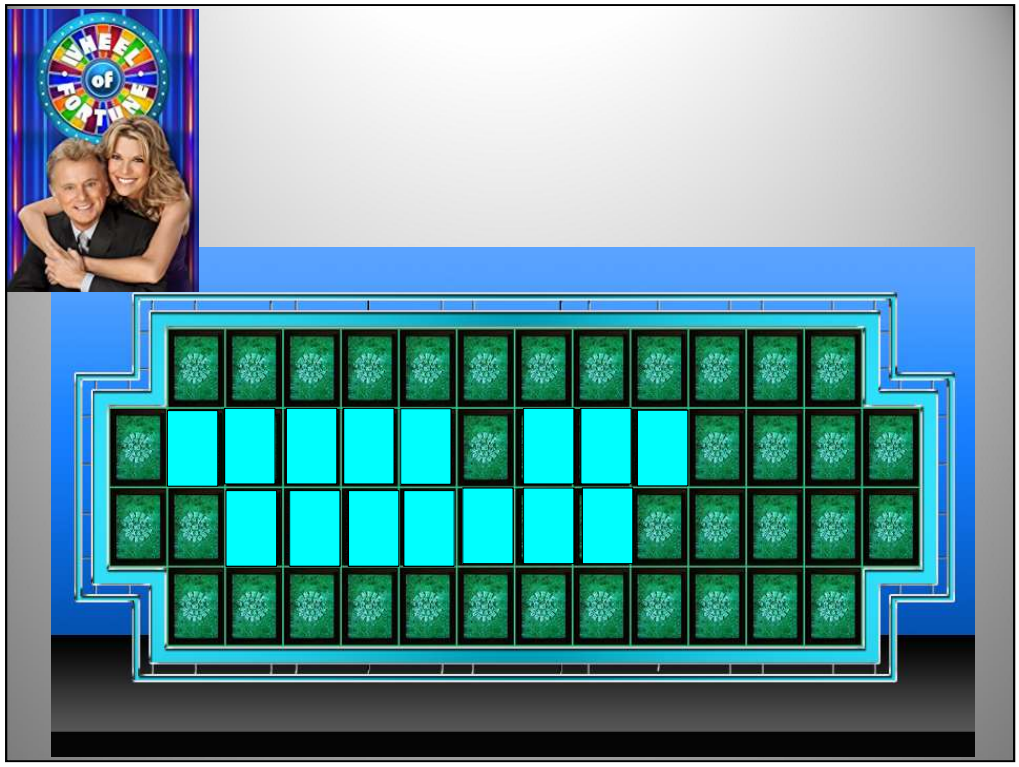
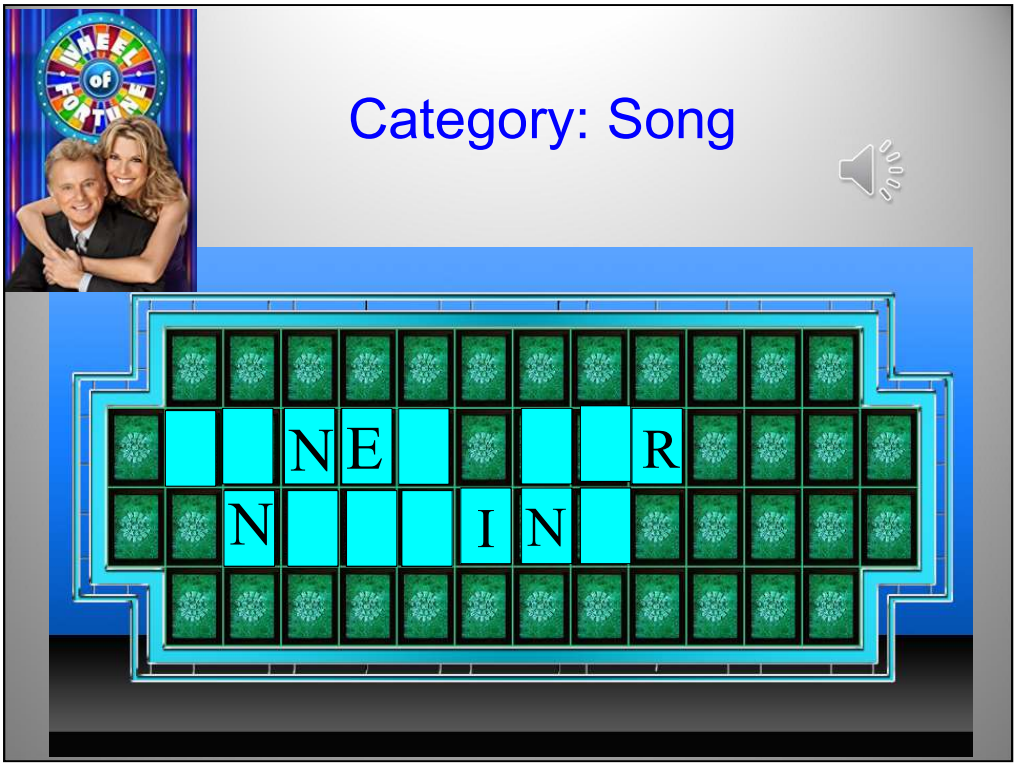
With canisters or passive collectors, you only get a few data-points with no temporal pattern.

With only a few data points, it is extremely difficult to reach a conclusion. So, more sampling rounds are needed ultimately requiring more time & expense.



Trying to solve indoor detections with only a few data points is like, well, the bonus round in Wheel of Fortune. Very difficult to figure out the puzzle.



Let’s see how you do.

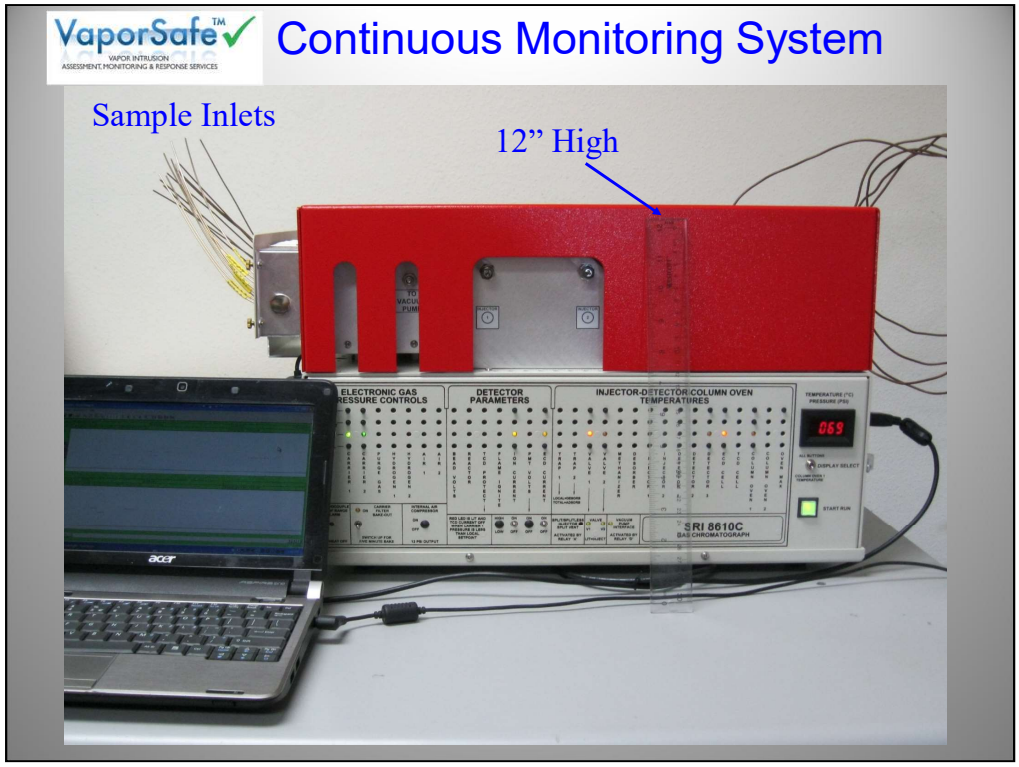
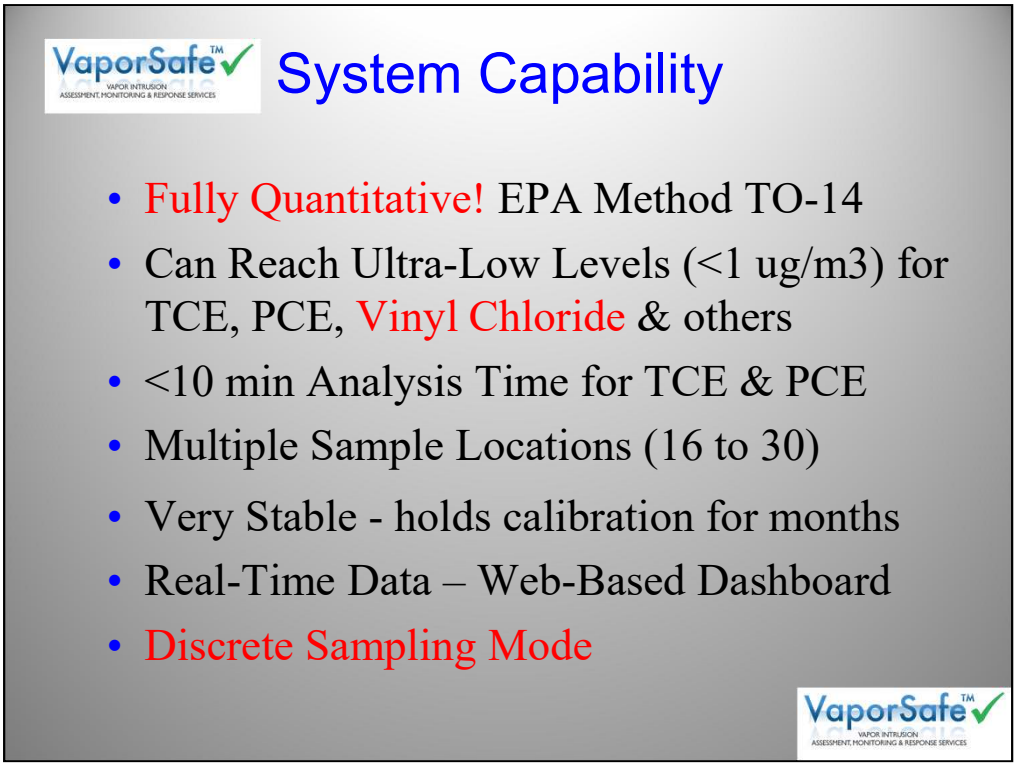


Photo of the Vaporsafe monitoring system. The instrument is about the size of a microwave and can fly around as checked baggage for less than $100.

The 16 stainless steel tubes in the upper left are connected to small diameter (1/8” or ¼”) tubing which then run to the monitoring locations.



VaporSafe monitoring system capabilities.

Fully quantitative (not screening level data), measures the most critical compounds, can do that in 10 minutes and can monitor 16 or more locations. The data are sent to the web after every analysis to a server with a user-friendly interface enabling the client access to the data in real-time.

The system can also be put in discrete sample mode enabling the user to look for VOC entry points or to collect confirmation samples if an unexpected compound is detected.

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Data

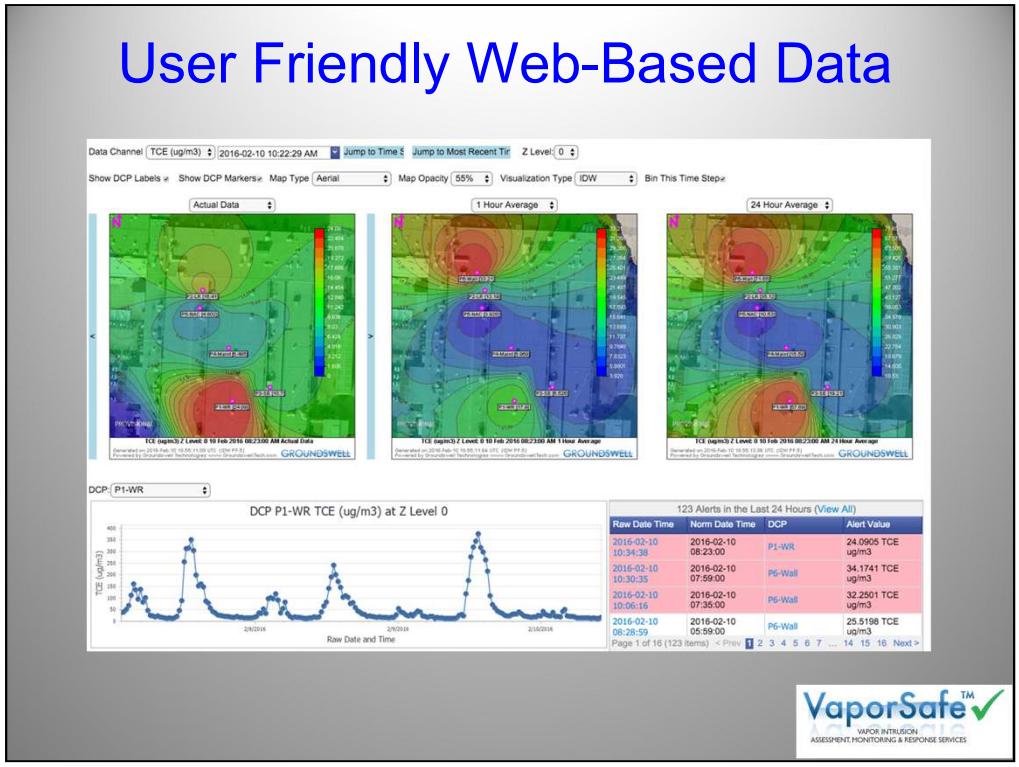
- Concentrations
- Pressure Differential
- Barometric, Temp., Wind Speed, etc.
- Daily Summary Reports (by e-mail)
- Trigger Relays
- User Friendly Dashboard
  - VOC Conc vs Time
  - Contour/Isopleth Images
  - Moving Averages
  - Plots in Seconds

VaporSafe data reporting/management capabilities. In addition to concentration data, the system also can log differential (cross-slab) pressure, meteorological parameters such as barometric pressure, temperature and wind speed. Each day, a daily summary of the data is e-mailed to authorized personnel.

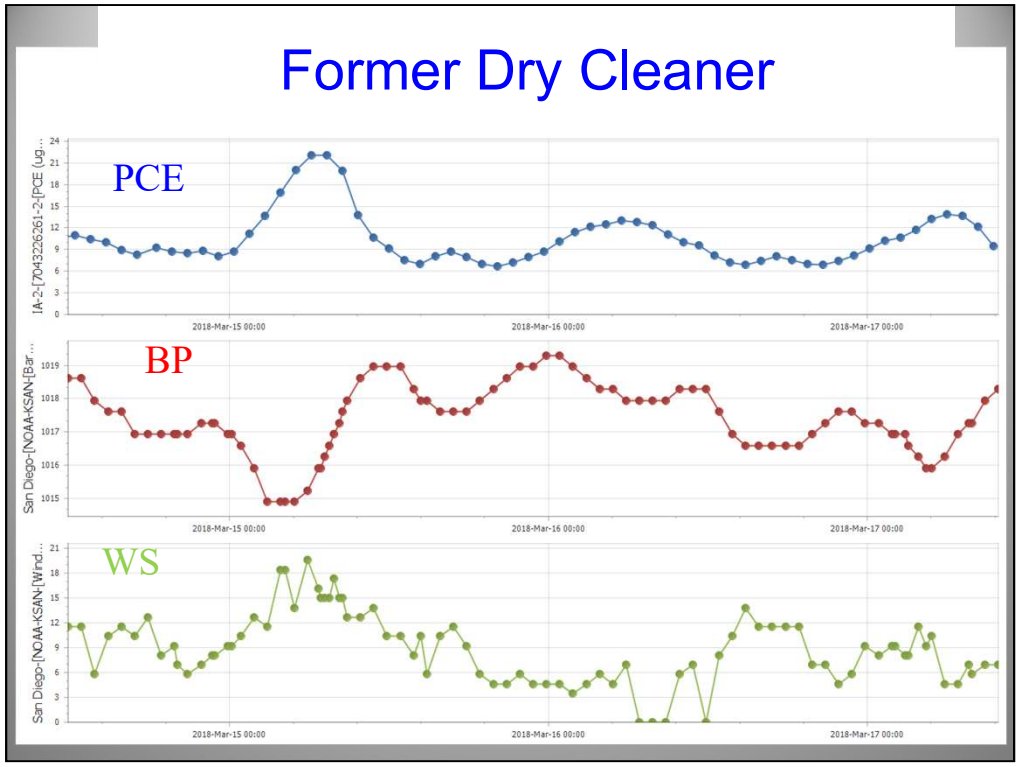
The system can trigger relays which can perform such functions as turn on/off fans and filtration units, open louvers, or modify HVAC systems.

A user-friendly web-based interface enables authorized users immediate inspection and analysis of the data.

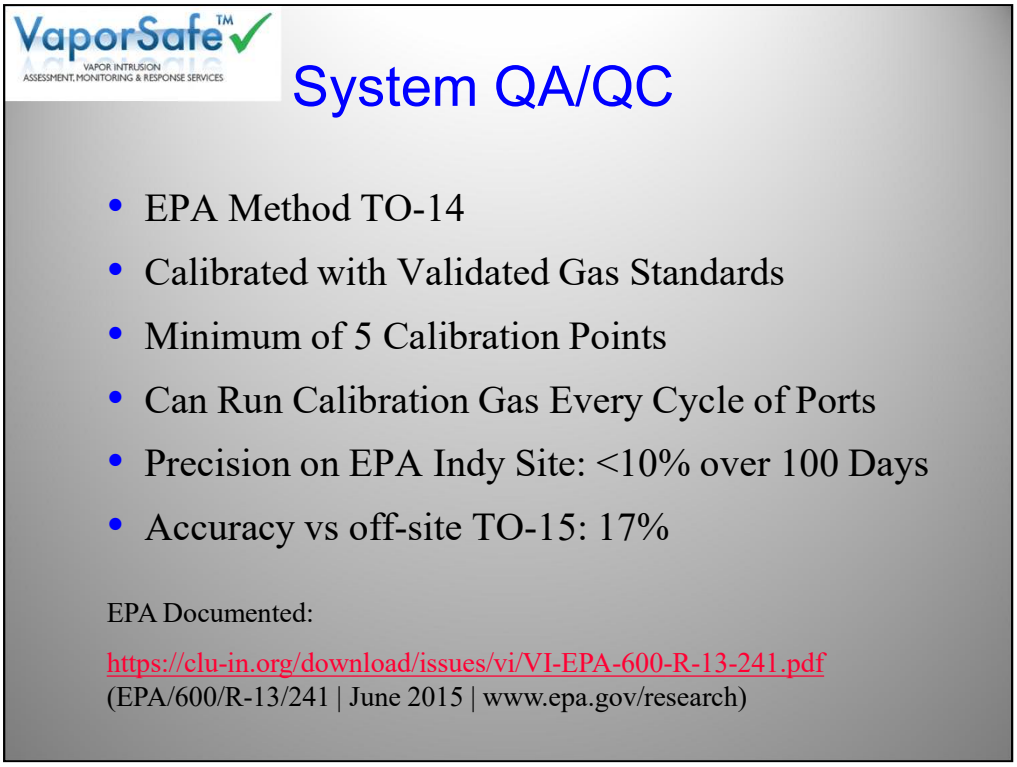
User Friendly Web-Based Data



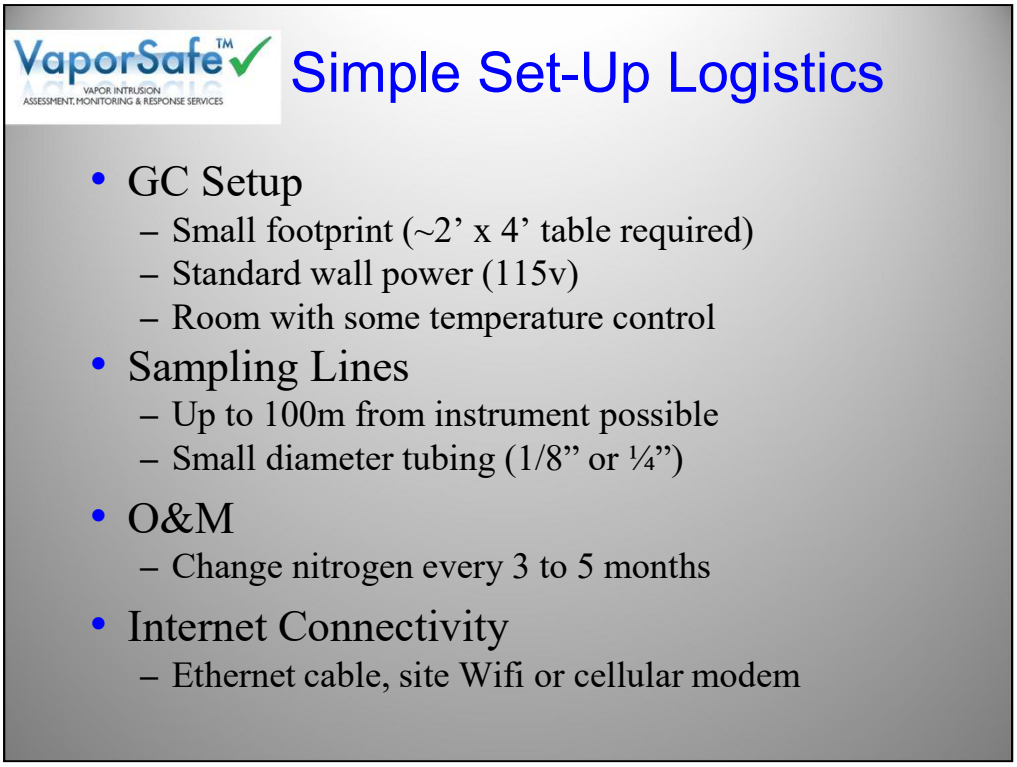
A picture of the user-friendly interface. Contour plots, plots of concentration versus time, stacked plots, and auto-alerts are all available from the dashboard. Plots can be easily exported into a jpeg file or into a ppt for rapid display to interested parties. Data can be easily downloaded in cvs or xls formats.



Stacked parameter plots like this one are generated on the dashboard in seconds. The plots can then be imported into Powerpoint with a few keystrokes enabling the data to be presented to interested parties rapidly.



Quality assurance and quality control of the system. The analytical method is EPA TO-14 and the system calibration follows the method protocols. If desired, a cylinder of calibration gas can be connected to one of the 16 ports and analyzed every cycle of ports. Precision & accuracy of the system from 100 days of operation at the EPA Indianapolis test site were within 10% and 17%, respectively.

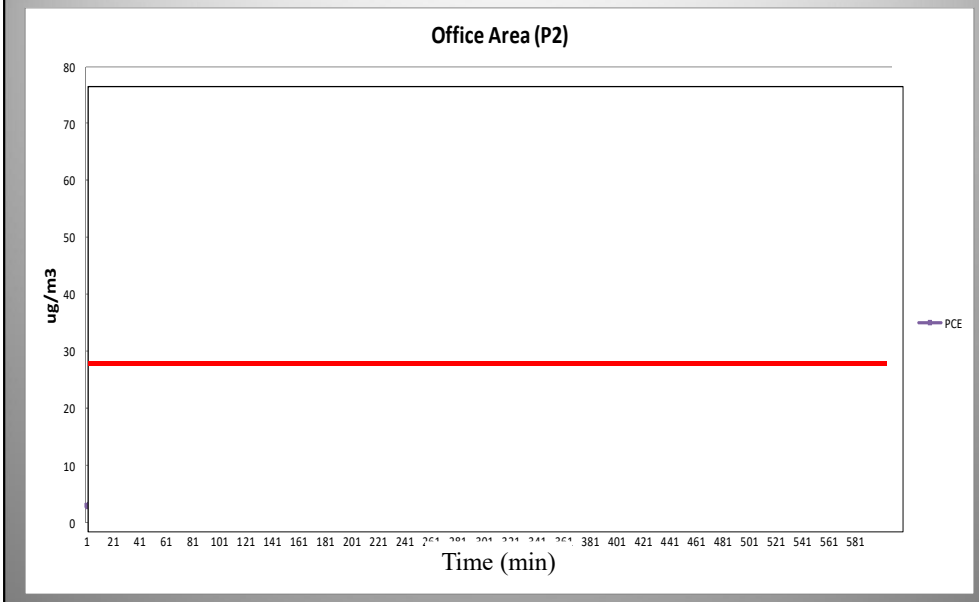


Set-up is very simple. Standard wall power, a cylinder of pure nitrogen, a small table and internet connection are all that is required.

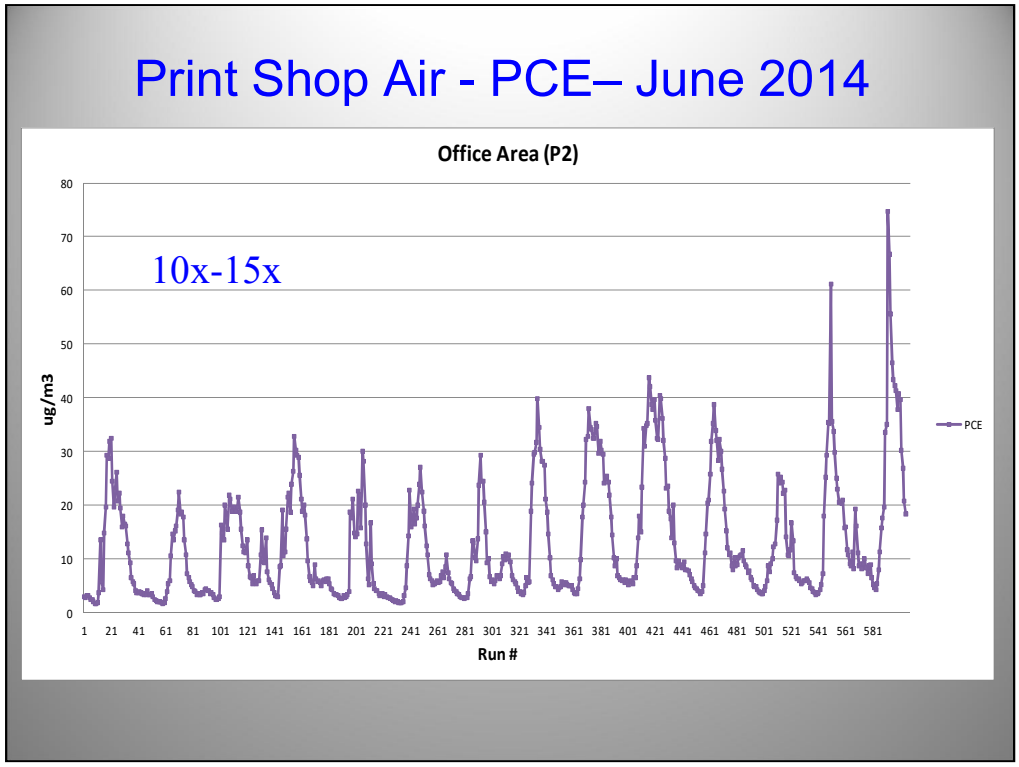
There is very little O&M required.

Sampling tubing can be run as far away as 100 meters.

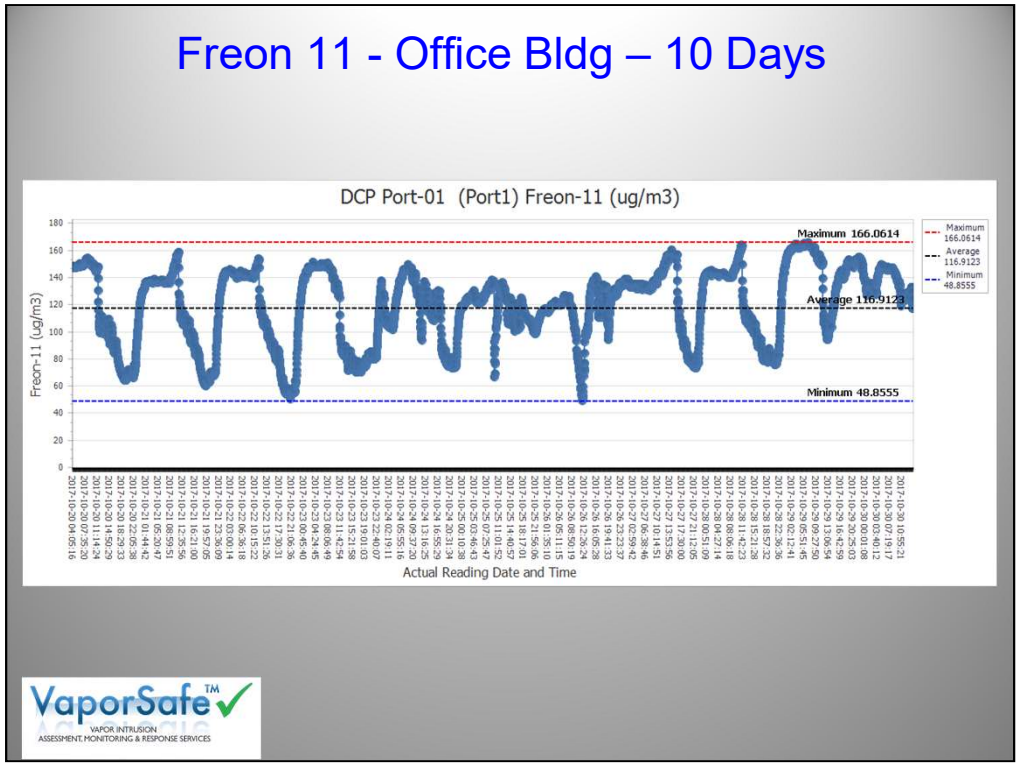
IA Values Are Not Like This



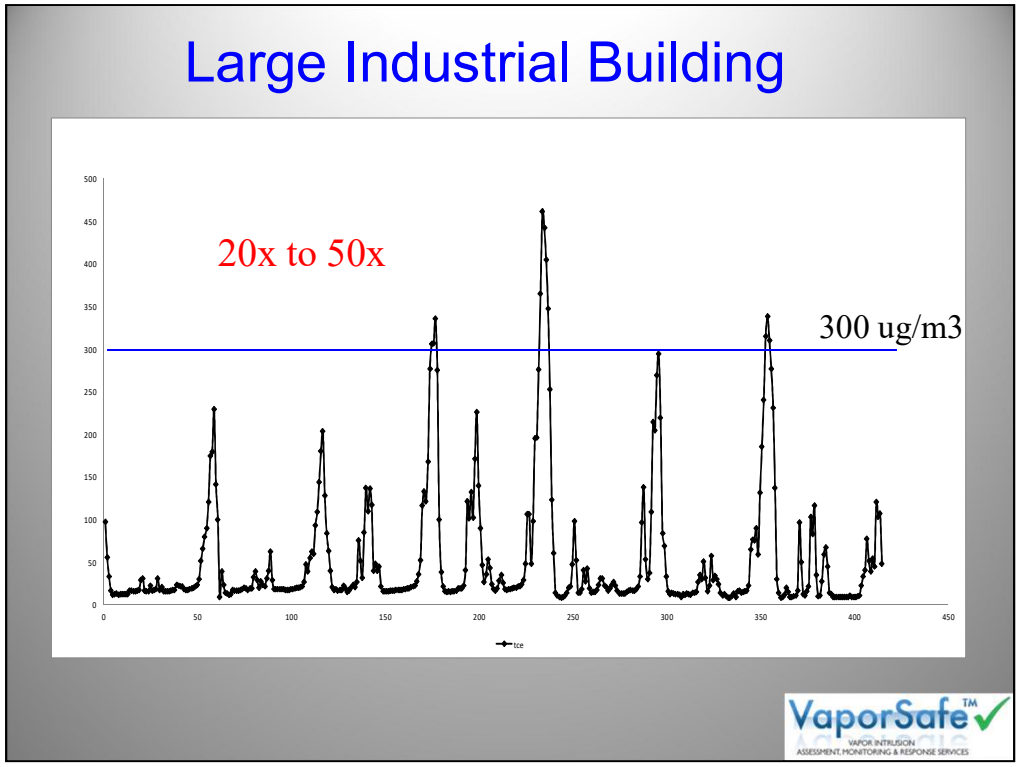
Indoor air VOC concentrations are not static.



Fourteen days of PCE concentrations inside an active Print Shop: every night values increased, but were low during the day.



Freon-11 in indoor air over 10 days in the office building. The pattern was consistent from day to day and was a result of the HVAC system.



Six days of continuous monitoring of TCE at a very large commercial warehouse in San Diego. The huge increases occur at about the same time every day. What is causing this to happen?

Determining Exposures to VOCs

How High?

How Often?

For How Long?

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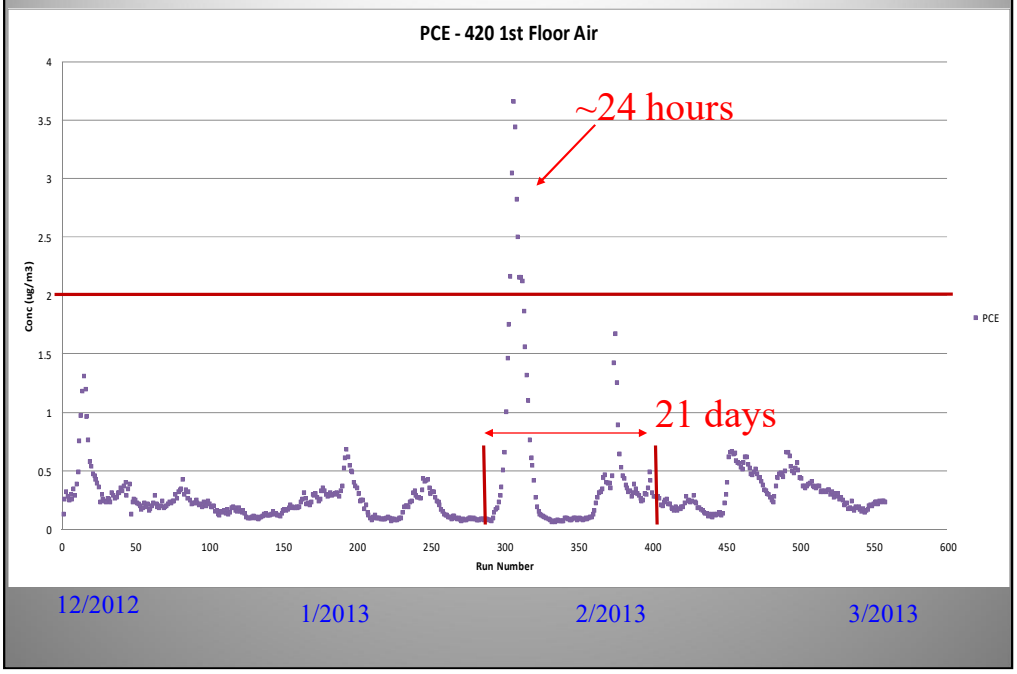
The current hottest topic throughout the VI. world: Short term TCE exposure.

High resolution data (~150 analyses/day) enables determination of how often indoor air values exceed allowable levels and for how long.

Monitoring Indoor Air VOCs



If this was TCE, the short-term exposure level would be 2 ug/m3 over 21 days. There was only 1 occurrence over 2 ug/m3 and only for about a 24 hour period. There were no exceedances for a 21 day period.

Is this a concern? It depends upon the exposure time considered to be a threat to fetuses.

Finding VOC Entry Points

- Discrete Sample Mode: 40-50 samples/day
- Continuous Mode: 16 locations at a time

Minimizes False Negatives

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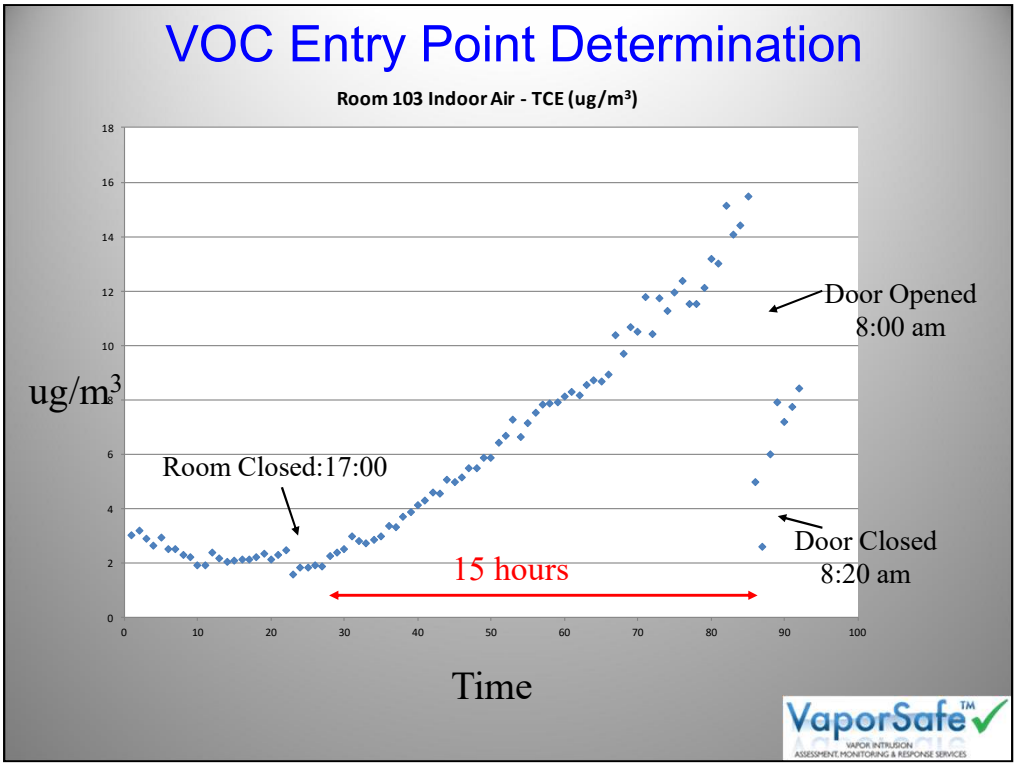
A huge benefit of the system is the ability to locate VOC entry points in a building. This can be done in either discrete sample mode or in automated monitoring mode .

In discrete mode, samples are collected in gas-tight syringes and manually injected into the instrument. Generally, 40 to 50 samples can be collected and analyzed in an 8-hour day. This enables substantial coverage of sites with multiple buildings or of building that have many rooms (schools, apartment buildings, large commercial/industrial buildings).

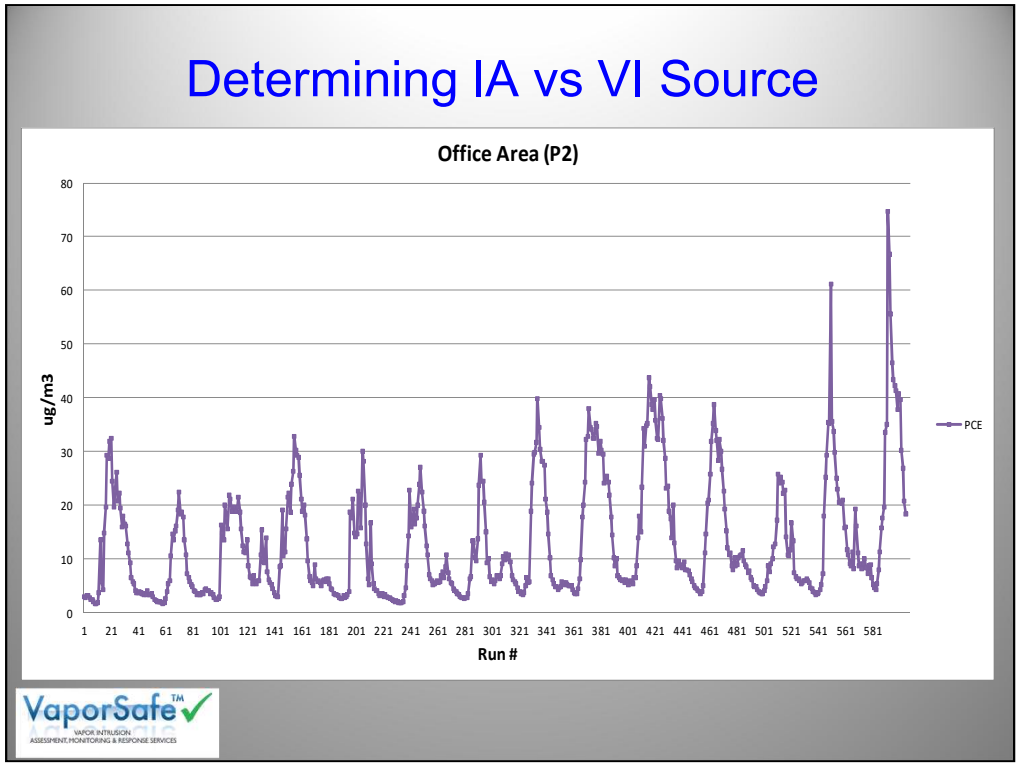
In automated monitoring mode, up to 16 locations can be analyzed at one time. This enables data to be collected over a period of time to detect entry points that might fluctuate over time.

At many sites, discrete samples are collected during the day and then the system is put in monitoring mode overnight at locations based upon the discrete data.

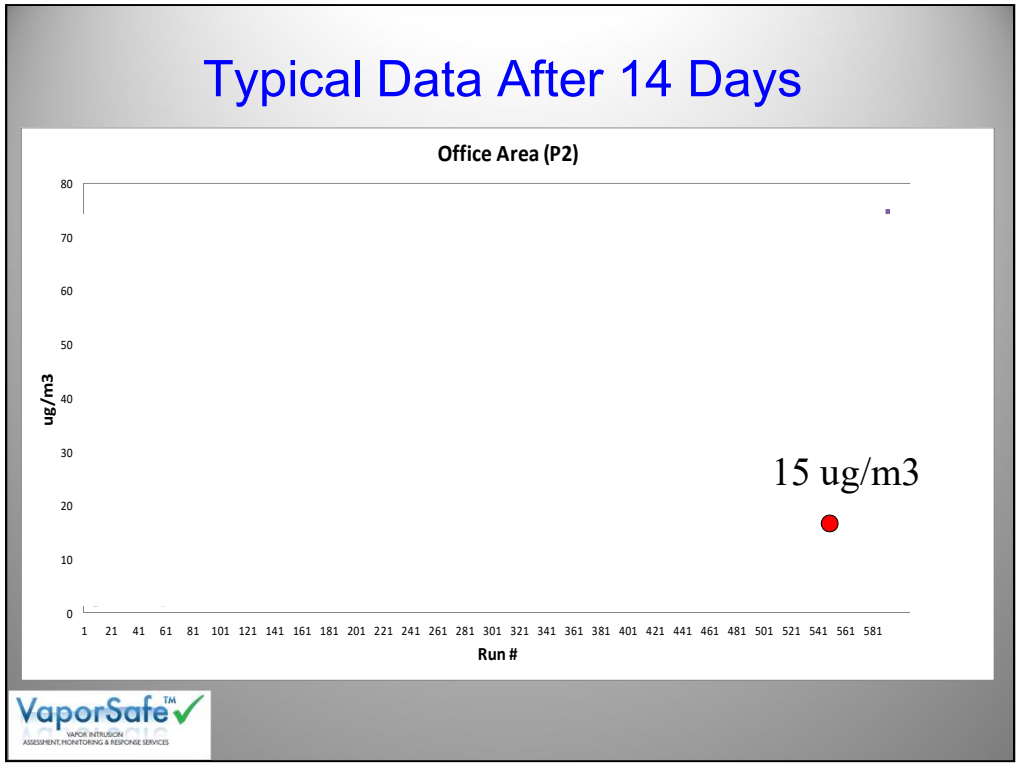


Here's an example of locating VOC entry points in one overnight sampling period. This plot shows indoor air TCE concentrations in a small room after the room was closed up for 15 hours. The continuous increase in TCE indoor air values documented that the room was the entry point for the TCE and the total mass entering the room (mass flux) could be calculated. At 8 am the next morning, the doors to the room were opened and an immediate drop was detected. The doors were closed again at 8:20 and concentrations immediately began to increase again.

Imagine doing this at 16 locations in a building. You could readily see which locations showed increases and to what magnitude.

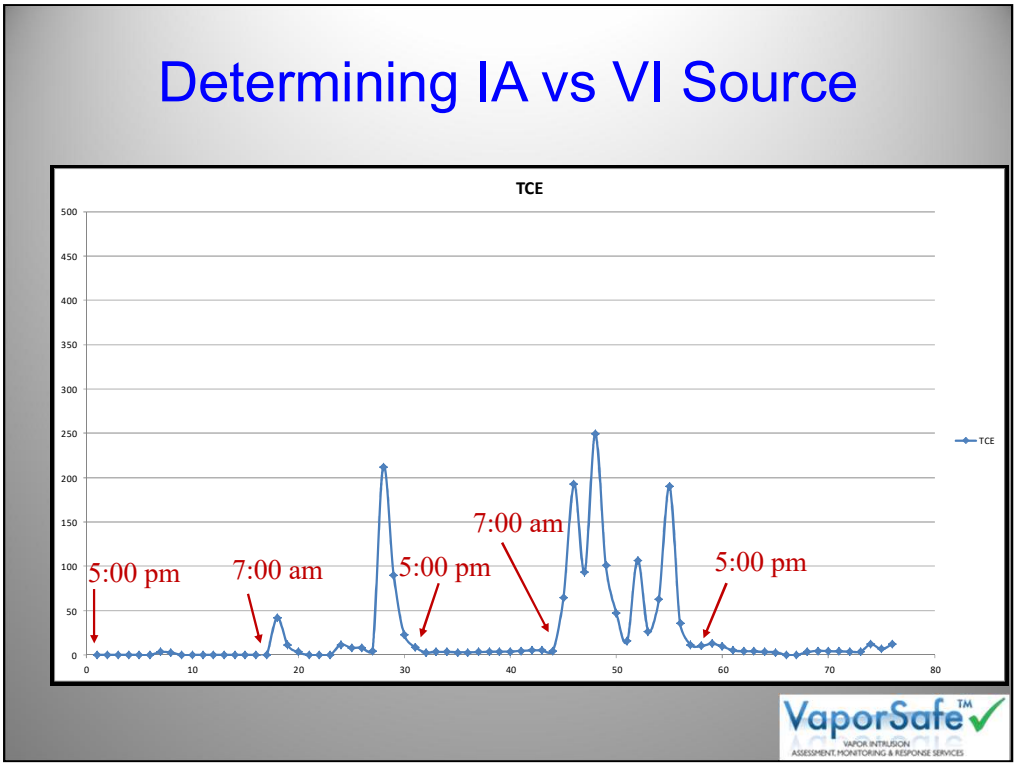


Fourteen days of PCE concentrations inside an active Print Shop: every night values increased, but were low during the day. If the PCE was from printing materials, the concentrations would have gone up during the work day. But the reverse was seen, indicating a subsurface source. The daily pattern was determined to be due to the HVAC system (during the day creating a positive pressure and lower at night reducing the inside pressure). The continuous monitoring also demonstrated that values were below allowable levels during the period when people were working.



The dot in red shows the result if you had deployed a time-averaged sample for 14-days. The single value would have been biased high & indicated a problem. A false positive.

But equally important: a single data point does not show you a pattern so that cause-and-effect can be recognized.



TCE indoor air concentrations in a furniture manufacturing facility. Concentrations were low at night, but then increased during the work day. If vapor intrusion was the source, values should have increased at night when the facility was closed up. The opposite was observed. It had to be coming from an inside source. What was the TCE source? On-site discrete sampling with the system found the hidden source.

Assessing Effectiveness of Remedies

- Can Try Various Remedies & See Effects
  - HVAC modifications
  - Fans on/off
  - Air filtration units
  - Sealing sumps & cracks
  - Optimizing vapor recovery systems

Can put VI Issue to Rest in Days Rather than Months or Years!!

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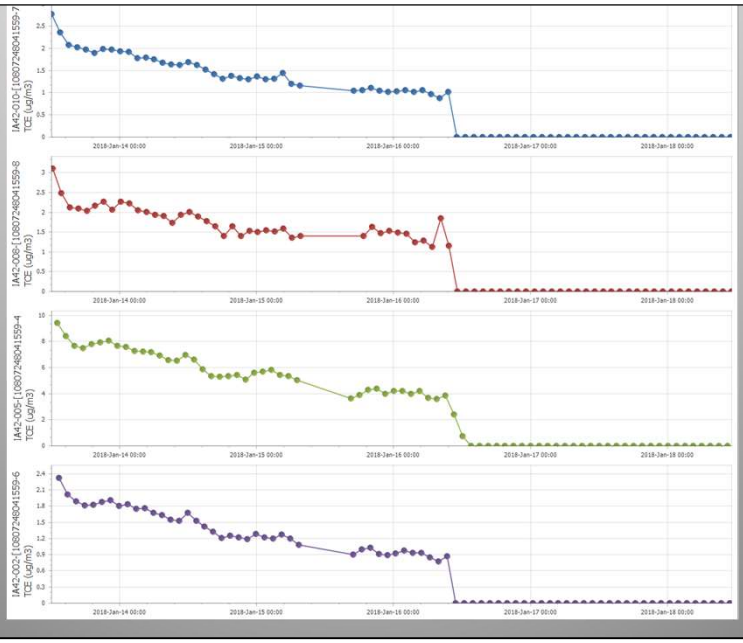
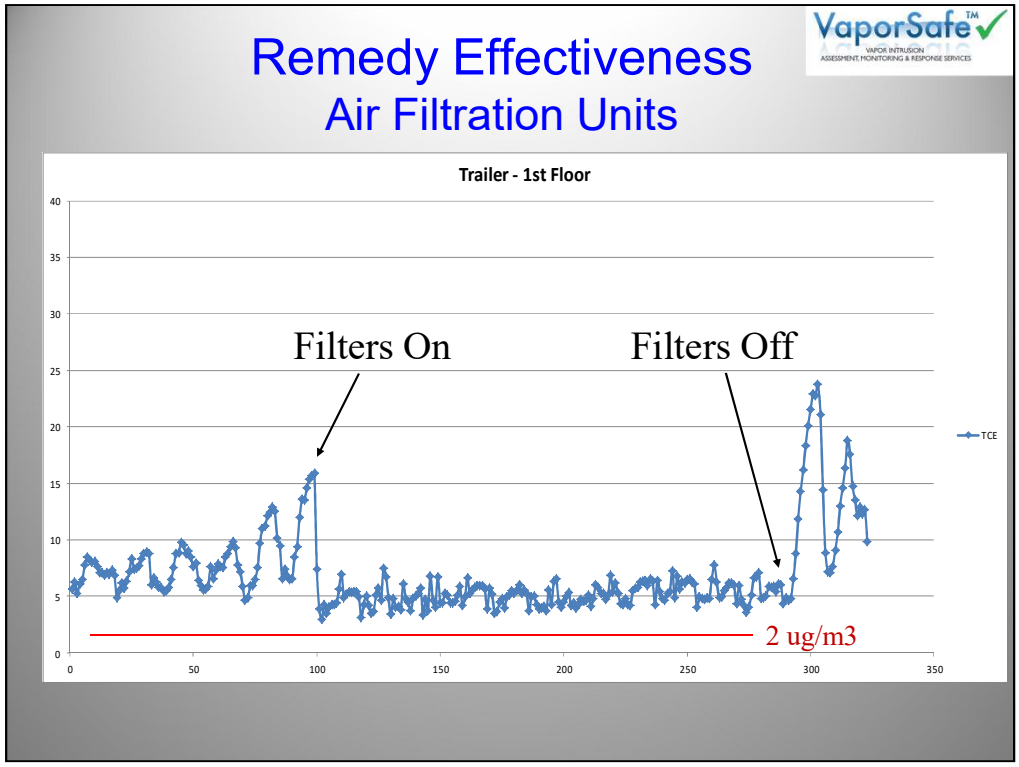
Monitoring data allow real-time evaluation of the effectiveness of a remedy. Adjustments to HVACs, vapor recovery systems, indoor air filtration units, exhaust fans can be made and the results seen in real-time.

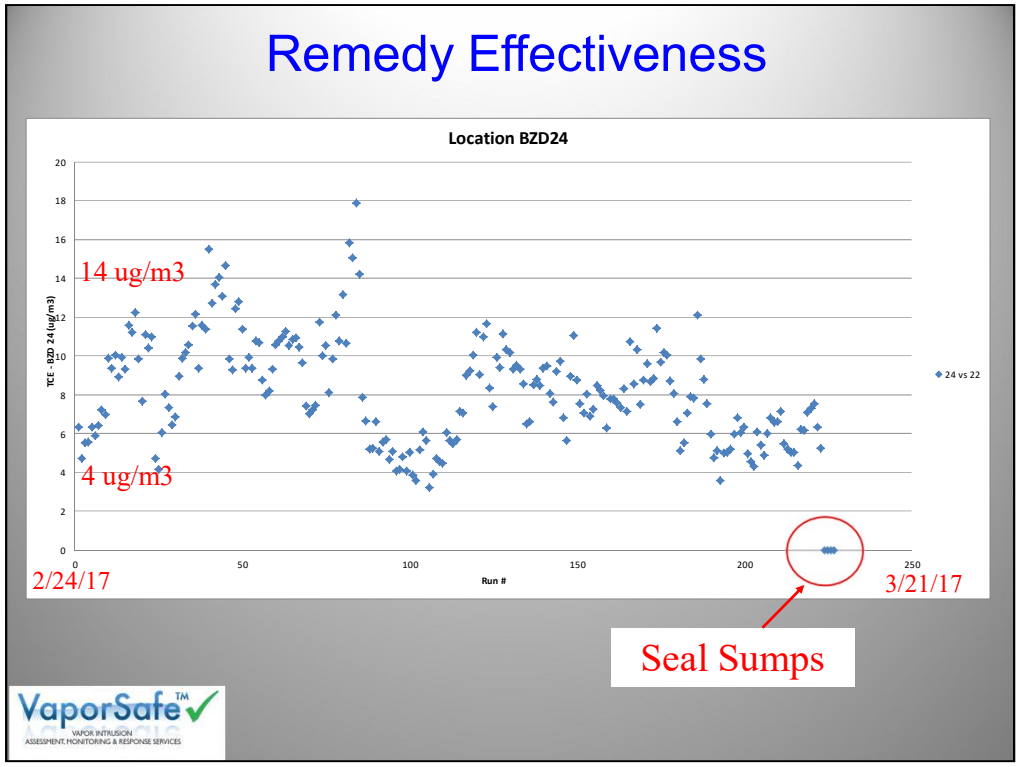
Proving the Effectiveness of a Remedy SSD System



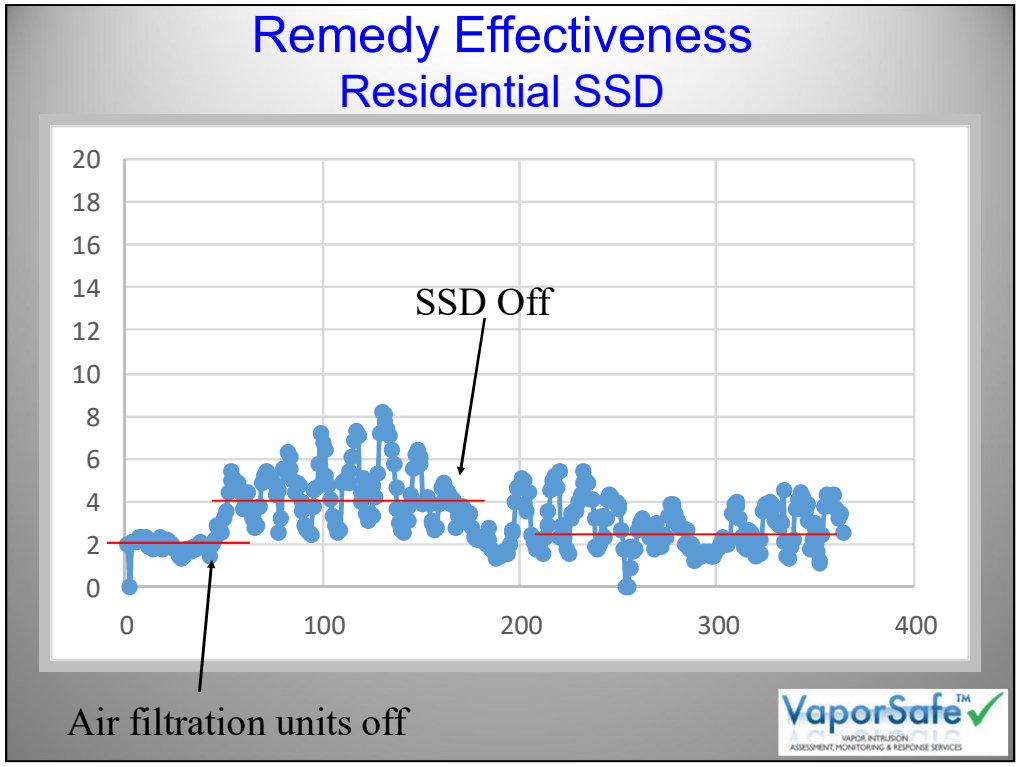
TCE indoor air concentrations at 4 locations in an operating facility. Note instant drop in indoor air TCE concentrations when the mitigation system was started-up and to levels that were far below allowable levels. The consistent low TCE values over the next 3 days was proof of the effectiveness of the system over the footprint of the building.



Indoor air concentrations of TCE in a double-wide trailer with a skirt underneath the trailer floor. Two indoor air filtration units were installed as a remedy to high TCE values (5 to 15 ug/m3). The filters decreased the indoor air TCE concentrations, but not below allowable levels. Another remedy had to be selected.



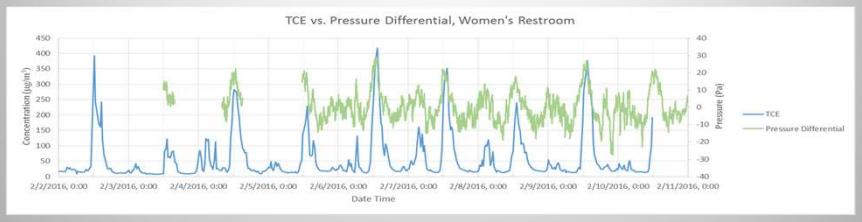
TCE concentrations in a basement at an industrial facility. Values ranged from 4 ug/m3 to 14 ug/m over the 1-month sampling period. But when two floor sumps were sealed up, values dropped to zero within a couple of hours. The monitoring data documented that this remedy would be effective and plans were made to seal the sumps permanently.



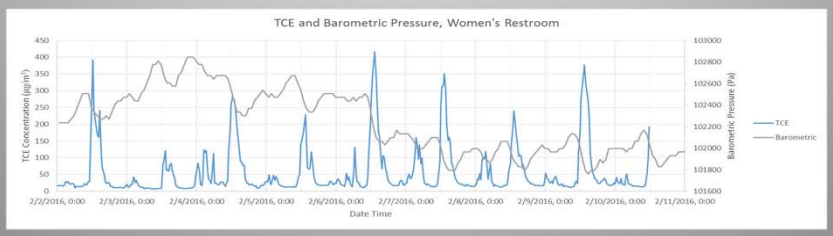
TCE indoor air concentrations in a home. The home was equipped with both a sub-slab depressurization system (SSD) and an indoor air filtration unit. The indoor air values were still at levels of concern. After a few days of monitoring, the air filtration units were turned off. Values increased and showed a sinusoidal pattern. After another 10 days, the SSD was turned off after 2 weeks (run #180) and the indoor air concentrations DECREASED!!

One conclusion from these data is that actual VOC concentration data are necessary to be sure that a mitigation system is operating effectively. The manometer on the SSD system indicated the system was pulling a vacuum, but clearly was not reducing the TCE levels low enough.

Determining Cause & Effect



Correlation with Differential Pressure

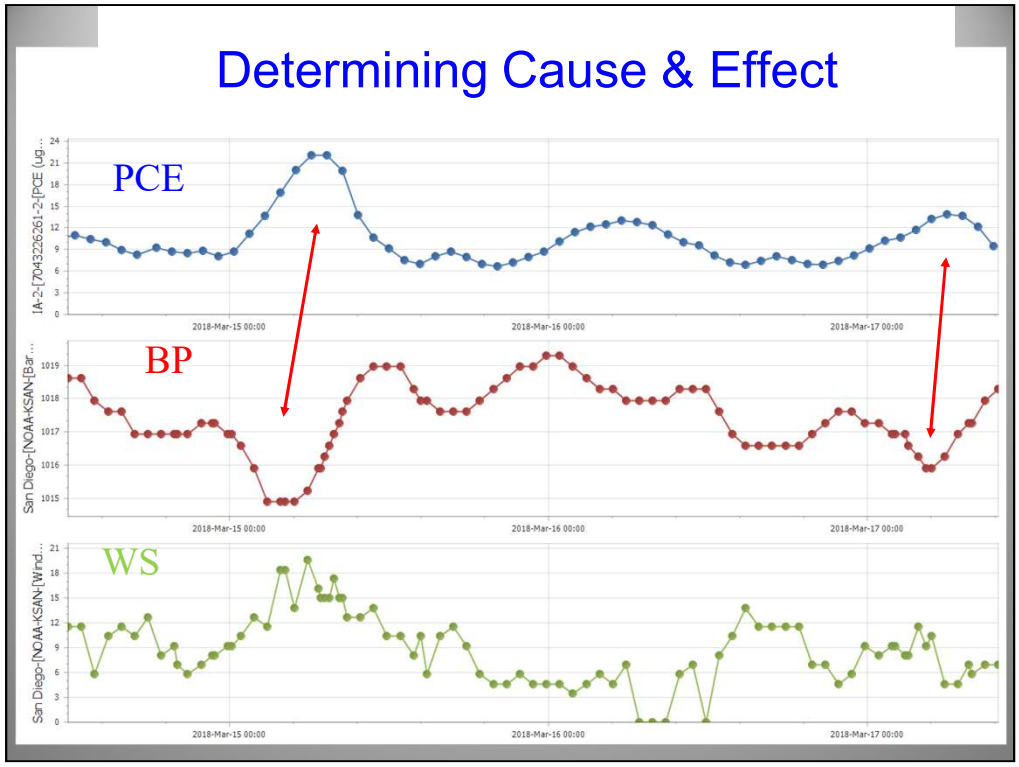


Correlation with Barometric Pressure Change

Comparison of the indoor TCE values to sub-foundation pressure shows a direct correlation between indoor air concentrations to positive pressure under the slab.

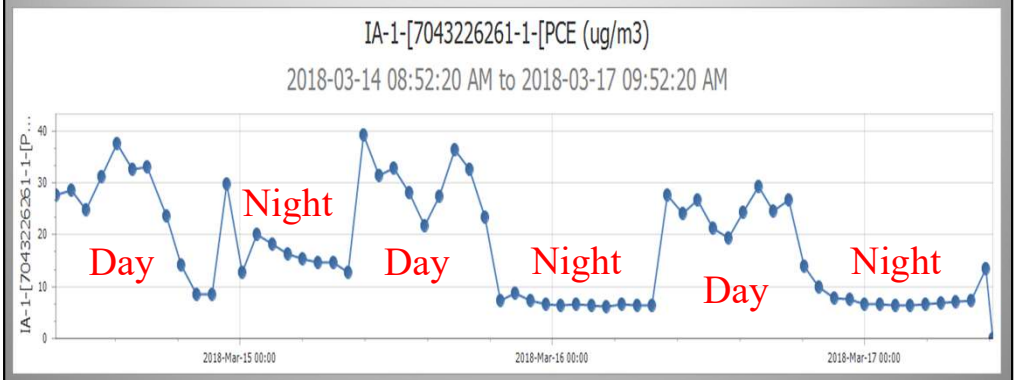
Comparison of the indoor TCE values to barometric pressure shows an increase in TCE concentrations when there is a drop in barometric pressure (probably due to ocean temperature effects).

Dropping barometric pressure causes the sub-foundation to be over-pressurized versus the overlying room,. If there are conduits through the slab, such as cracks, floor drains or sumps, vapors can be pushed into the room through these conduits.

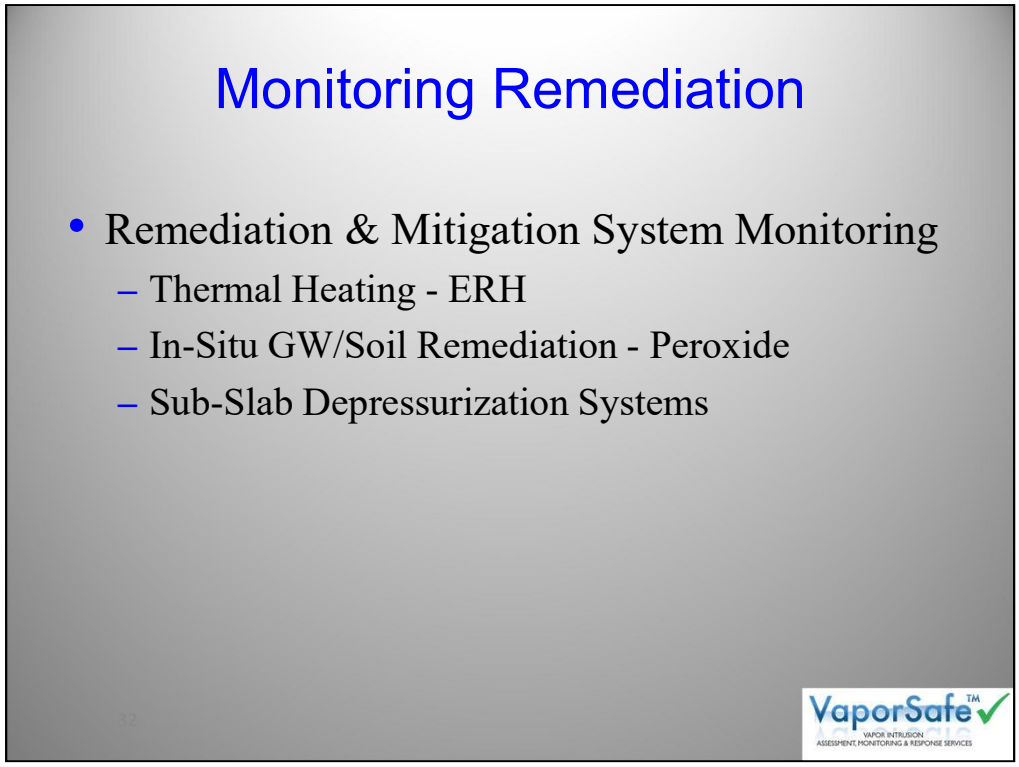


PCE indoor air concentrations in an office building which was formerly a dry cleaner. Definite correlations exist between the indoor air PCE values and dropping barometric pressure. The office building contained a janitor closet with a floor drain which was concluded to be the PCE entry pathway.

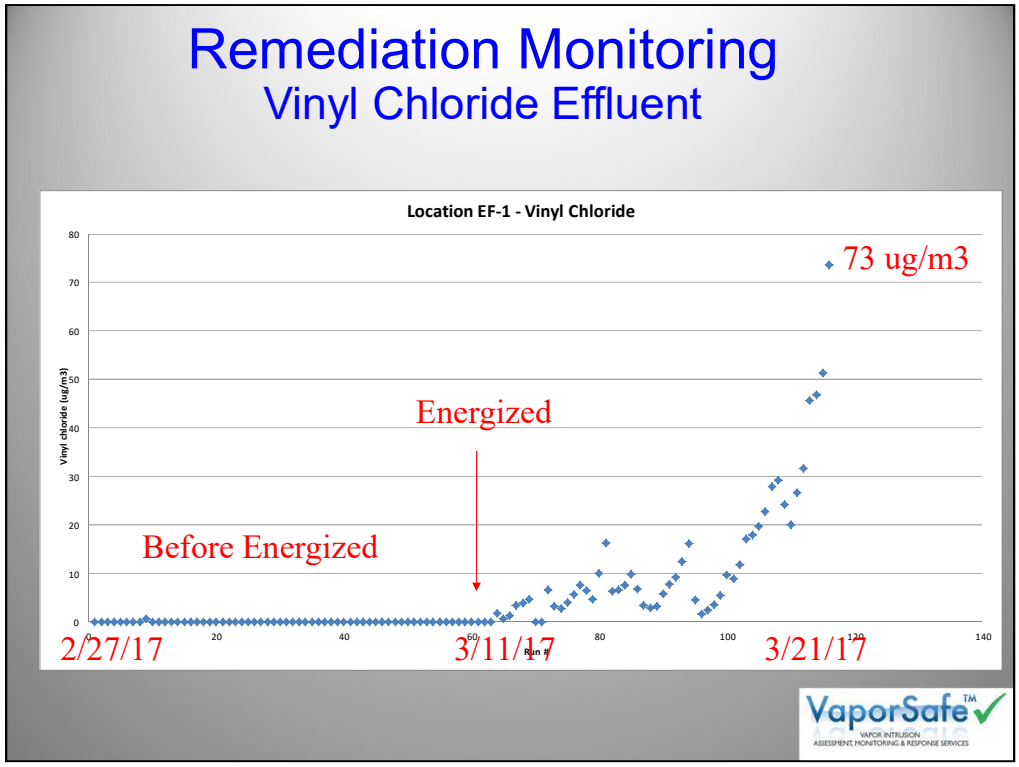
Former Dry Cleaner - Bathroom



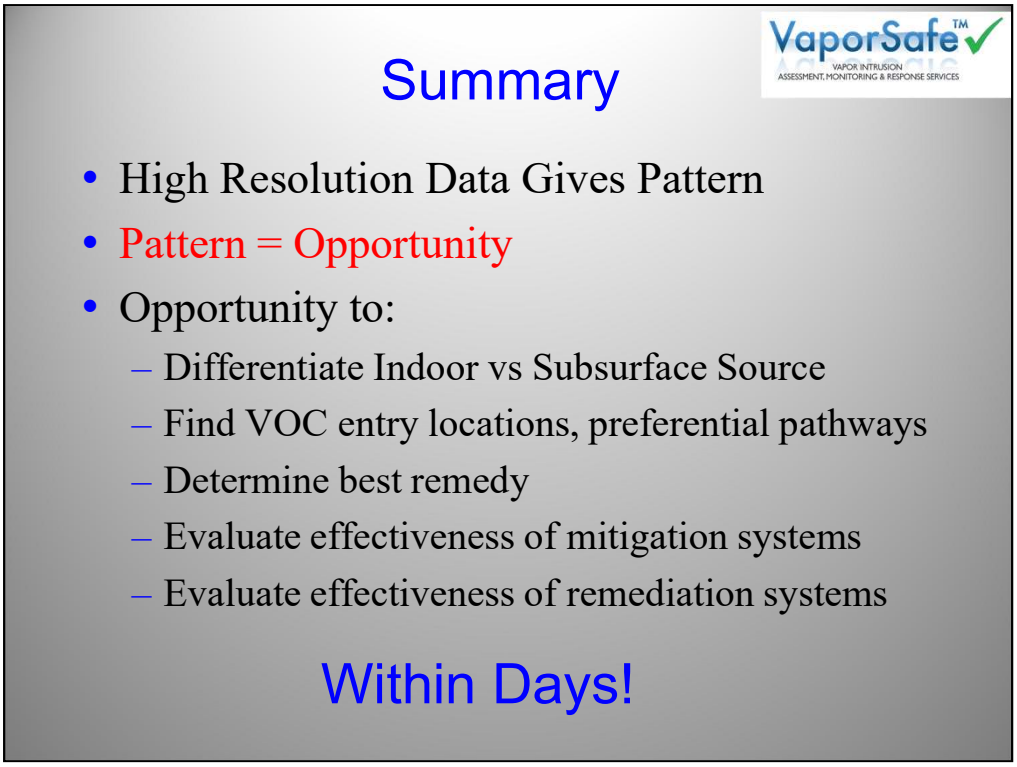
PCE indoor air concentrations in the same office building, but in the bathroom. High, variable levels during the day, but lower, stable values at night. What could be causing this pattern?



Vaporsafe can provide data from many locations around a site to demonstrate the effectiveness of remediation systems and building mitigation systems.



Vinyl Chloride in the effluent from a permanganate scrubber located immediately adjacent to a large thermal remediation project. The vinyl chloride concentrations started increasing almost immediately once the electrodes were energized. Vaporsafe data enabled rapid recognition of this situation and enabled the consultant to take immediate corrective action.



Summary of lessons learned from monitoring projects since March 2015. Continuous high frequency monitoring can be implemented during many phases of a vapor intrusion project life-span: initial evaluation, determining whether mitigation is required, and if so, to help optimize the remedy. The key to all of this is having enough data to recognize the pattern. Once you have the pattern, you have an opportunity to figure out the cause of the pattern and to find remedies for it.

All this can be done with one mobilization. And often within a few days.

The Obvious Questions:

- What Does it Cost?
  - ✓ $1000 - $2000/day (~$10/analysis)
  - ✓ 10 canisters: $5000
- Do Agencies Accept?
  - ✓ EPA Regions 1, 9, 10
  - ✓ MA, CA, NH, IN, AZ, OH, Navy
  - ✓ Upcoming: EPA-R5, NC, USACE
- How do Results Compare to TO-15?
  - ✓ No complaints to date

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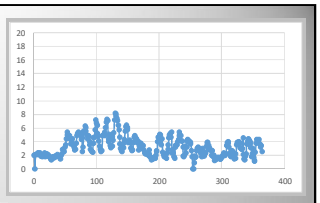

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