



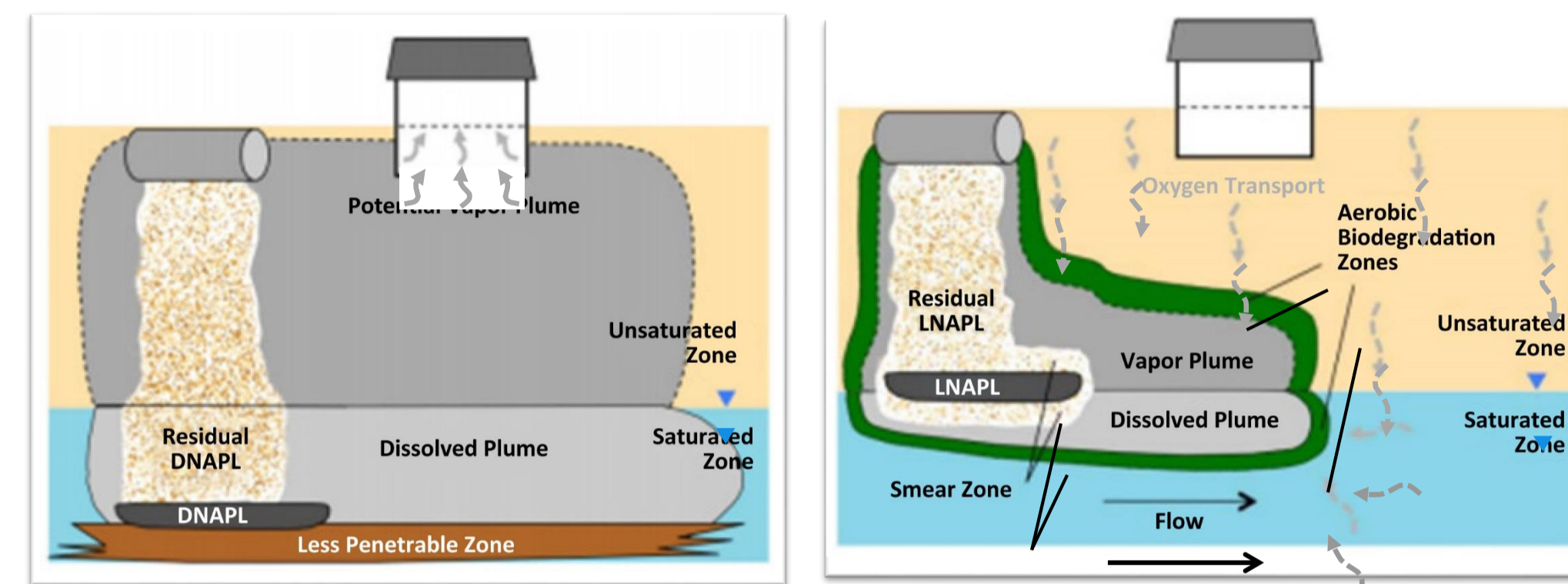
### Purpose/Utility of Research

A series of articles appeared in the Denver Post in 2000 that questioned the evaluation of the subsurface-to-indoor air pathway at contaminated sites. One aspect of site assessment that was questioned was the use of models without use of site-specific inputs, allowance for biodegradation, and calibration to indoor air measurements. Indoor air measurements are often confounded by indoor sources and sinks of vapors, ambient air contamination, barometric variability, and responsible party/owner reluctance to allow testing.

The purpose of the research was to develop a model for petroleum vapor intrusion (PVI) to provide a line-of-evidence consistent with EPA's Technical Guide for Addressing Petroleum Vapor Intrusion at Leaking Underground Storage Tank Sites (EPA 510-R-15-001). Such a model was seen as contributing to the decision to measure indoor air or sub-slab soil gas.

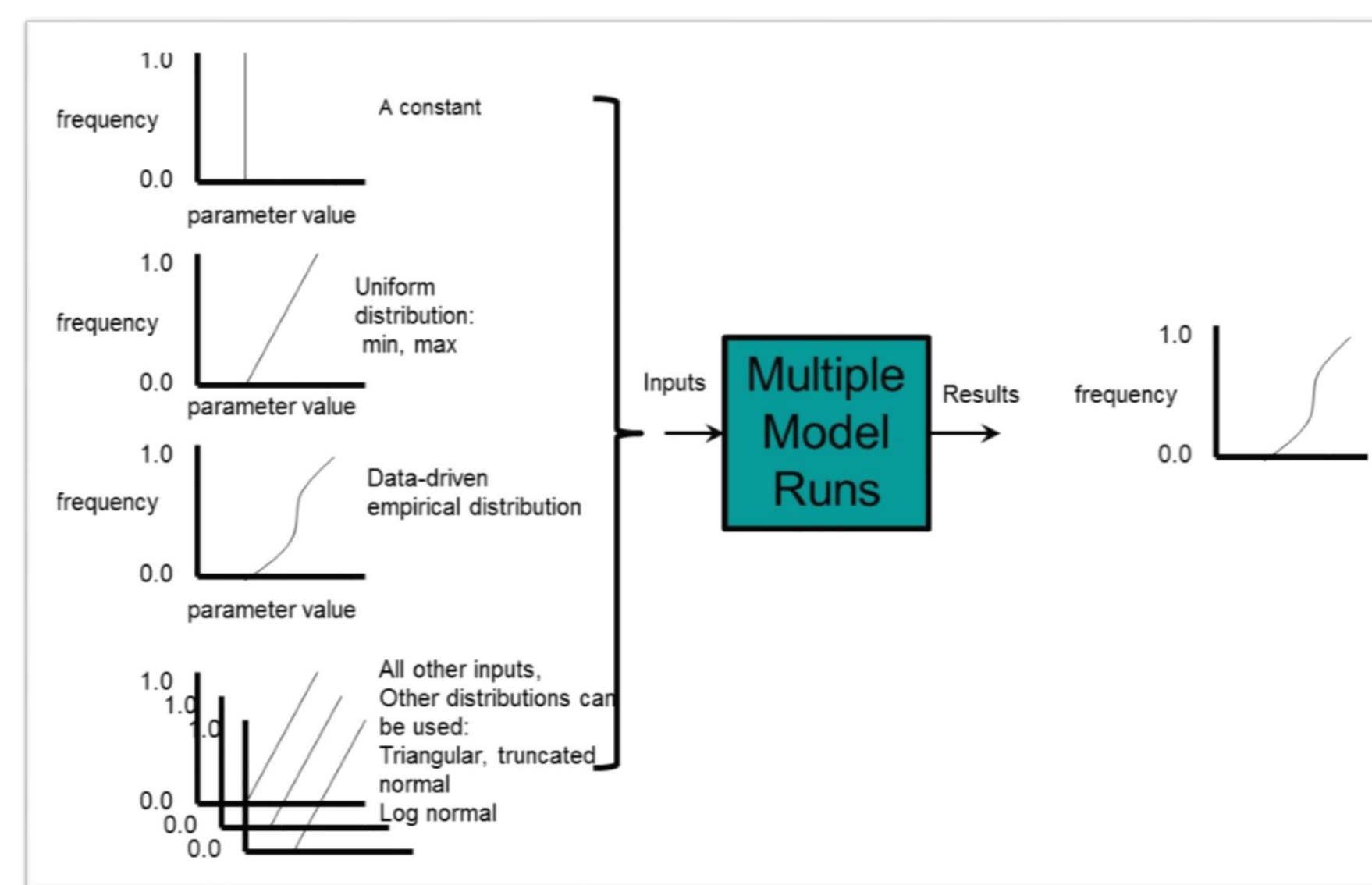
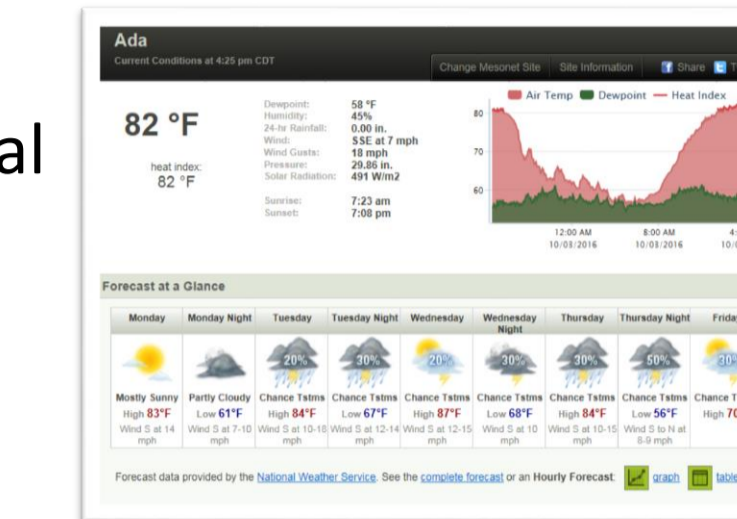
### Highlights

- Because of the limitations of typical site assessment, the inability to determine all parameters, and the expected lack of calibration data to indoor air measurements, a Monte Carlo approach was used.
- Education of the end-user community was an essential part of developing PVIScreen. ORD presented PVIScreen at the National Brownfields Conference, National Tanks Conference, and other State and tribal meetings.
- Results are presented in terms of the fraction of simulations that exceed risk thresholds; when this happens PVI is indicated.
- Test applications have been made to sites in Oklahoma and Utah, which show comparable results to data from field assessments

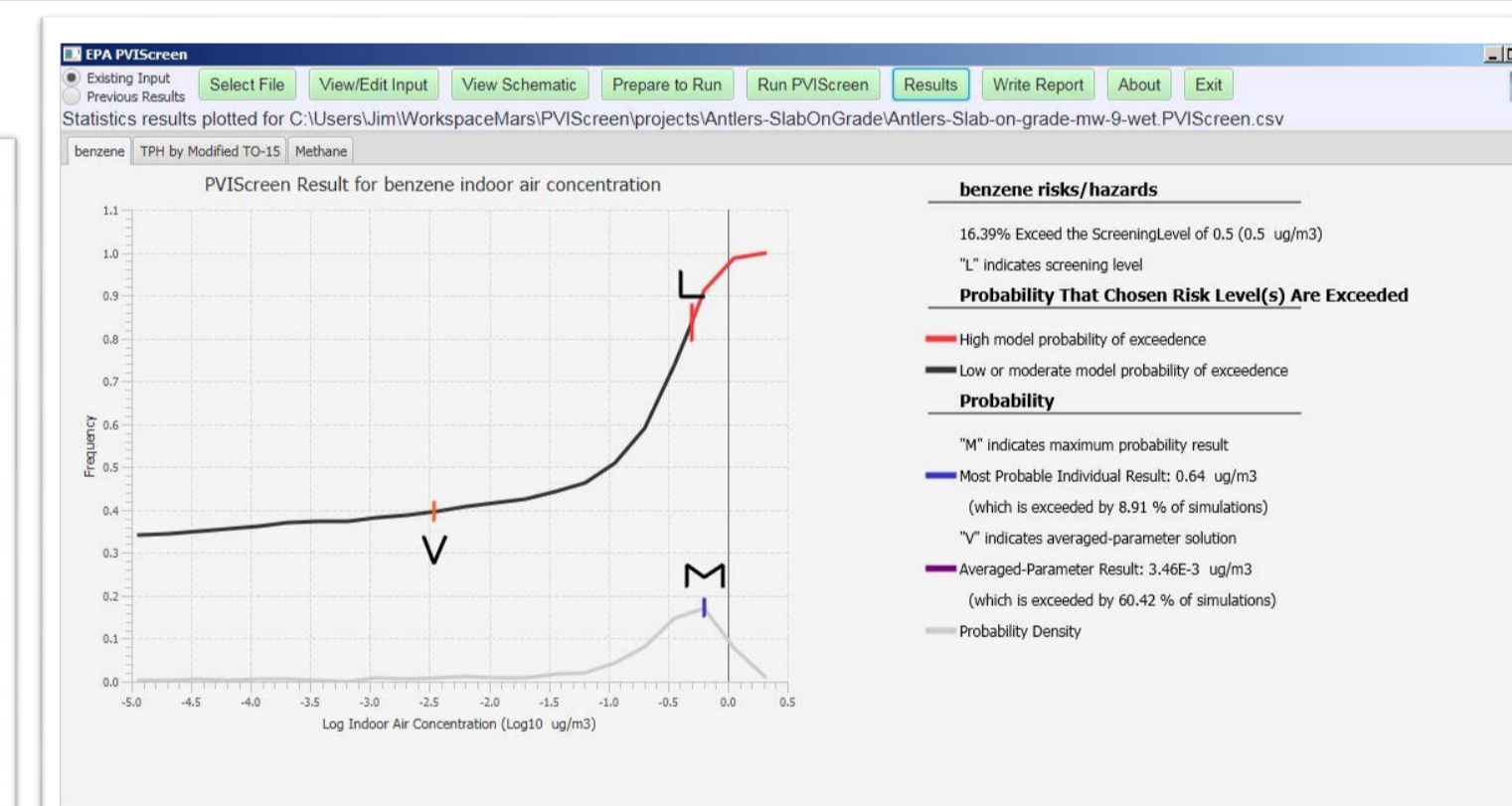


**Figure 1.** Chlorinated solvent (left) and petroleum hydrocarbon (right) vapor intrusion are distinguished by the contaminant source location, which is determined by the liquid density, and by the capacity for aerobic biodegradation. Chlorinated solvents generally do not undergo aerobic biotransformation, while petroleum hydrocarbons readily degrade. Thus chlorinated solvents have a greater potential for impacting indoor air. Petroleum hydrocarbons, however, present a less-certain situation, where the potential for vapor intrusion depends on the location and characteristics of the source, vadose zone, building and microbiota.

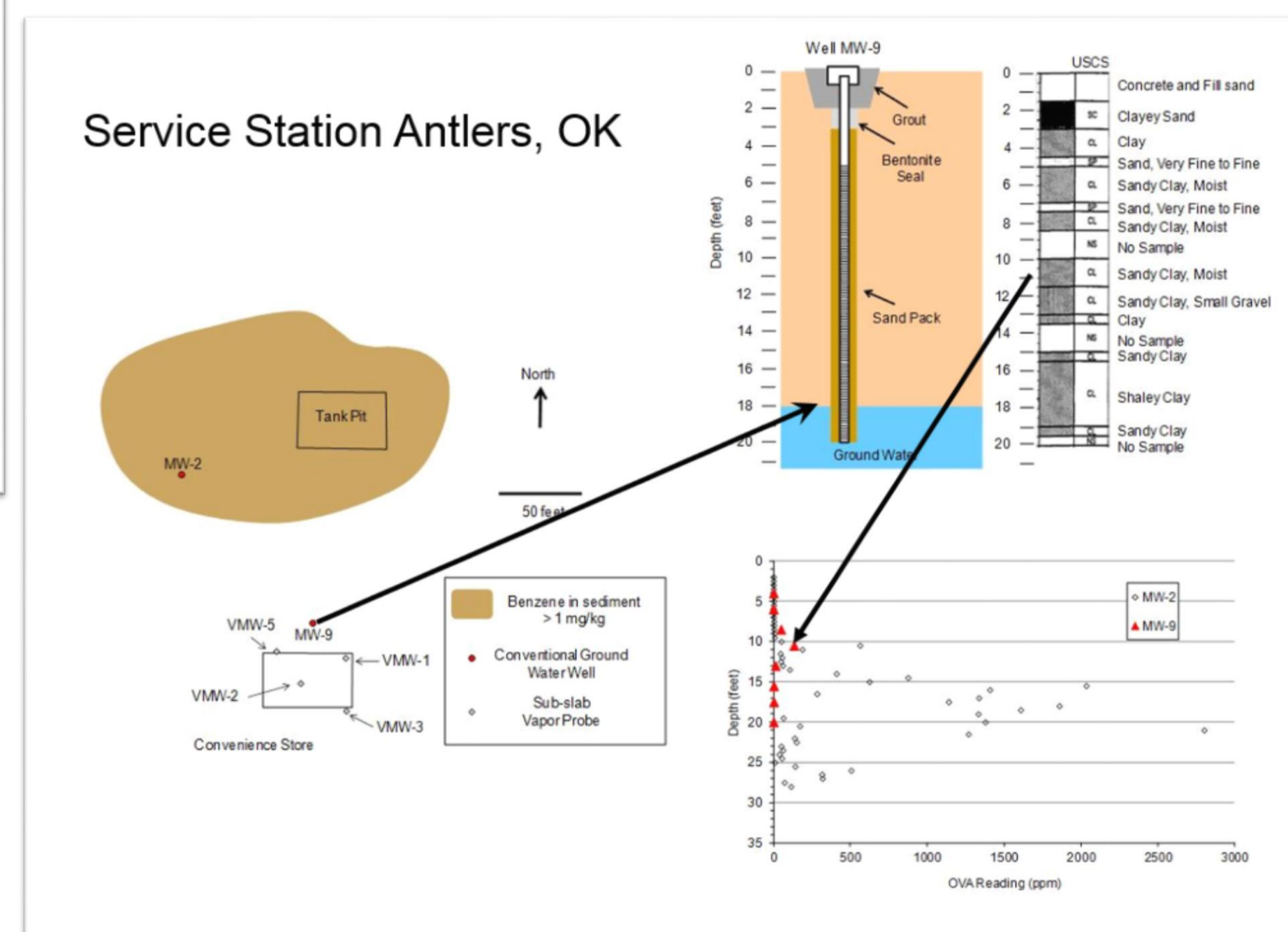
**Figure 2.** Environmental models depend on uncertain parameters, so their results must also be given as being uncertain. Weather forecasts are a good example – the forecast itself is given with uncertainty and, as important, the recipients receive it with uncertainty. PVIScreen is based on this concept, that the forecast is given and received with uncertainty.



**Figure 3.** The various inputs to the model can be considered constant (depth to sample, ceiling height, foundation thickness, length, width), with known minimum and maximum values (porosity, moisture content, air exchange rate) or with empirical data-driven distributions (biodegradation rates). Multiple model runs, typically 1,000, incorporate the variability into an output frequency distribution.



**Figure 4.** The results are presented in two forms for each chemical included in the simulation. On the left is a frequency distribution curve which indicates the fraction of results at or below various indoor air concentrations. The screening level (L), averaged-parameter (V), and most probable (M) concentrations are marked. All simulations above the specified screening level are indicated in red. Any simulations above the screening level could be considered to indicate the possibility of vapor intrusion. On the right, the model results are summarized in a tabular form. Here the screening level exceedance is given as a percentage, as are the most probable and averaged-parameter result.



**Figure 5.** A gasoline leak at a service station in Antlers, OK was investigated and a potential for vapor intrusion into the convenience store was of concern. A maximum soil gas screening level at 10.5 feet depth was used to drive the simulation with other site-specific input parameters. The model indicated a fairly high probability of vapor intrusion (Figure 4), a result which was used to justify additional assessment.

### Application & Translation

- Workshops have been presented to the Association of State and Territorial Solid Waste Management Officials (March, 2016), Tribal Lands and Environmental Forum (August, 2016), and Region 3 Leaking Underground Storage Tank Technical Forum (September, 2016).
- Planned webinar in collaboration with the Office of Underground Storage Tanks.
- Document completed in FY2016: Petroleum Vapor Intrusion Modeling Assessment with PVIScreen, J.W. Weaver and R.V. Davis, EPA/600/R-16/175.

### Intended End Users

- The Underground Storage Tank Program is delegated to the states, so the end-users are state LUST program managers and consultants managing assessment and clean-up at sites.
- Presentation of the results has been designed with feedback from the workshops.
- Because of our continuing interaction with the Office of Underground Storage Tanks, there was a collaborative approach to developing the PVIScreen model. Part of this was to introduce the underlying concepts (model uncertainty) and gain acceptance for them. By this approach ORD developed a user community for the model.

### Lessons Learned

- State programs vary in the way that they conceptualize risk, so the presentation of risk results in PVIScreen must be adaptable.
- End-user education is needed for understanding of the uncertainty analysis approach; results, however have been accepted by the community as an improved use of modeling.