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Subject: Availability of documented background indoor and outdoor air concentrations and/or statistics; Subtask 2.3 Deliverable, EPA Work Assignment 5
EPA Contract No. 68-W-98-215

RTI is submitting this memo report as the technical deliverable under Subtask 2.3 of this work assignment. EPA's Statement of Work for this WA described this task as follows:

- *Expand database to include published or otherwise documented "background" indoor and outdoor air concentrations and/or statistics (including sites undergoing VI investigations). Make this information available to the public and present this information in readily understood graphical and tabular formats which include the date of the data which may indicate time trends and/or geographical representation.*

To accomplish this task, RTI has conducted a review of federal and key state efforts to measure, collect, select, and use indoor air background concentrations for evaluating the vapor intrusion pathway as well as for other purposes.

This deliverable describes the information that has been collected to date and identifies candidate data sets (and their status) for inclusion in the database (Section 2). In addition, Section 3 identifies key issues and questions related to the collection and use of background indoor air data, and recommends next steps for creating an indoor air background dataset and using these data within the context of evaluating the VI pathway.

1.0 Background Information

Section IV.H of OSWER's November 2002 *Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils* (VI Guidance) includes the following statement on considering background indoor air concentrations of volatile organic compounds (VOCs) when evaluating the VI pathway:

It may be a challenge to distinguish "background" (ambient outdoor and indoor air) sources of vapors from site-related contamination. However, we recommend vapors attributable to background sources be accounted for during the "Site Specific Assessment" to properly assess the potential risk posed by exposures via the vapor intrusion pathway. To the extent practicable, we recommend that background sources of contamination be removed or excluded from the site dwellings or occupied buildings selected for sampling before any indoor air sampling is conducted. If this is not possible, then we recommend

the contribution from these sources be carefully considered when evaluating any indoor air sampling results. (See Site-Specific Question # 6)

The guidance addresses background levels in Appendix E, which provides details on sampling indoor air, Appendix F, which presents (in Table F-1) available background level data from 8 sources to compare with the indoor air concentrations in EPA's VI database, Appendix H, which includes a questionnaire for identifying background indoor VOC sources during an indoor air sampling event, and Appendix I, which describes how to consider background in the context of a VI investigation.

Appendix I recommends the use of the *Role of Background in the CERCLA Cleanup Program* (U.S. EPA, 2002), which outlines EPA's preferred approach for the consideration of background constituent concentrations, during VI evaluations and actions. This document includes the following definitions that should be pertinent to this data collection effort as well.

- “*Background* refers to constituents that are not influenced by the releases from a site, and is usually described as naturally occurring or anthropogenic.”
- “*Anthropogenic* refers to natural and human-made substances present in the environment as a result of human activities (not specifically related to the CERCLA release in question).”

For VI sites, the anthropogenic definition would not include the VI incident in question.

2.0 Review of Available Studies

To identify sources of indoor air background data sets, RTI reviewed state information, information from EPA Office of Radiation and Indoor Air (ORIA), and references from Table F-1 in the VI Guidance. Three states (Connecticut, Indiana, and New York) were identified as having active or recently completed programs to assemble VOC background data for use in their VI regulatory programs. The purpose, approach, and status of these efforts is shown in Table 1. Additional detail on the EPA ORIA, New York, and ORIA efforts follows. A full bibliography of pertinent references can be found at the end of this document.

U.S. EPA Office of Radiation and Indoor Air

EPA's Office of Radiation and Indoor Air (ORIA) has been collecting data on indoor air quality, including VOC levels, since the 1980s. Recently ORIA has assembled an indoor air database that is being used to screen national risks to human health from indoor air contaminants. This risk analysis and database are currently under revision after a review by EPA's Science Advisory Board (SAB). EPA's John Girman as the key contact for further information on EPA's background database. Girman led EPA's building assessment survey and evaluation (BASE) study, a survey of VOC levels in 56 commercial buildings (Girman et al., 1999).

Based on information received from Pauline Johnston of ORIA, their database contains monitored concentrations of many indoor air pollutants, including some VOCs. To prepare these data, ORIA selected ten studies from the literature to represent typical pollutant levels in homes,

Table 1. Significant State Program Efforts to Develop Indoor Air Background Concentrations

| State (status) | Activity | Approach |
|------------------------|---|--|
| Connecticut (2003) | Developed indoor air background values for use in volatilization criteria Remediation Standard Regulations | Used weighted average median value from 10 studies to represent background VOC levels. Culled some values. Methods vary by chemical depending on available data. |
| Indiana (in progress) | Develop typical indoor air background levels for use in vapor intrusion indoor air evaluations. Draft values for 13 VOCs. | Cull and rank available studies (including VI Guidance Table F1 references) by chemical. Weight studies by number of samples. Methods vary by chemical depending on available data. |
| New York (in progress) | Measure background indoor air VOC levels for comparing and evaluating elevated residential VOC levels. | Extensive sampling program at 53 control homes from 1989 - 1996 for 57 VOCs. Consistent, appropriate sampling and analytical methods. Questionnaire used to identify homes with unusual VOC sources. |

schools, and offices. The studies span the last 15 years, but most are within the last decade. Of the studies cited within the report two, the BASE study and the schools intervention studies (SIS) were performed by EPA but have not yet been published. The remaining data sources are within the public domain and include the probability-based National Human Exposure Assessment Survey (NHEXAS; Clayton et al., 1999; Gordon et al., 1999), which is now available in raw data form at <http://www.epa.gov/heds> (RTI has downloaded these data for inclusion in the IAVI database). Another is the EPA Total Exposure Assessment Methodology (TEAM) study (U.S. EPA, 1987), a predecessor to NHEXAS. Other data sources include many of those included in the bibliography at the end of this chapter.

New York State Department of Health

The New York State Department of Health (NYSDOH) has conducted an extensive study focused on determining background indoor air concentrations for a variety of VOCs (NDSDOH, 1997; McDonald, 2003). The study was designed to produce statistics from control homes that will be used to compare and evaluate VOC levels in homes suspected of having elevated concentrations, such as from vapor intrusion.

The study involved sampling 53 residences across the NY State over the 1989 to 1996 time frame, along with a review of other published data sources. This sampling exercise resulted in 223 indoor and outdoor air measurements of 57 VOCs. Questionnaires were used to identify VOC sources (e.g., hobbies) at or near the home. Homes were selected that were not impacted by VOC sources such as oil spills, groundwater contamination, ambient air contamination, or recent painting or refinishing. Samples were collected using Summa canisters, with some adsorbent cartridges being used early on in the study (prior to 1992). Most homes were sampled once; one home was sampled at four different dates, five were sampled on three dates, and five were sampled on two dates.

Results of the NYSDOH study are due to be published shortly. Base data and conclusions will be available after publication. Given that this study has been consistently conducted using established, well documented methods, it should produce a valuable dataset for inclusion in the IAVI database.

Indiana Department of Environmental Management

The Indiana Department of Environmental Management (IDEM) is conducting a review of available studies and policies (state and federal) on indoor air background levels. Beginning with the 8 references cited in Table F-1 of the VI guidance, Indiana has expanded their effort to a total of 16 studies and policies from state regulatory efforts and published sources. The effort is directed towards developing a range of typical indoor air background levels for application during vapor intrusion indoor air investigations.

Although still in progress, the IDEM effort has produced valuable information on issues related to collecting data from extant sources (Wolff, 2003). First, the studies and policies vary in objectives, and findings, including defining “background”. Not all studies are readily available and published. With respect to methods, IDEM has found that studies vary by

- Sampling times
- Collection methods
- Analytical methods
- Site characterization detail
- Time of year of sampling
- Data quality
- Data quantity
- Statistical analysis.

Table 2 summarizes preliminary observations on some of the more important studies reviewed so far by IDEM. IDEM is continuing its effort to track down and obtain original data sources and is considering whether to conduct an indoor air background survey of their own. As IDEM’s work progresses, it should provide valuable information for identifying background VOC data for inclusion into the IAVI database.

3.0 Conclusions and Recommendations

In conclusion, by taking advantage of other ongoing work at EPA, states, and elsewhere, we have been able to track down most extant data sets and data summaries on VOC concentrations in indoor air. The bibliography at the end of this report provides a comprehensive listing of the studies and publications identified during this effort. In terms of data quality, based on review of available information we recommend that gathering of background indoor air data for the IAVI be limited to studies for which raw data sets (i.e., individual measurements) are available. Although summaries can be useful for evaluating trends or screening level risk assessments, concerns about data quality and consistency in methods for sampling, analysis, and data analysis can limit the comparability and utility of such studies in a larger context (e.g., is it appropriate to average two “typical” levels that were based on different statistics; what does a range of typical values mean?).

Table 2. VOC Background Studies Reviewed by Indiana Department of Environmental Management

| Study | Description | Comments |
|---|---|---|
| Foster et al. (2002); Kurtz and Folkes (2002) | Study of Denver residences over solvent plume | 1,1-DCE used as indicator compound. Consistent, appropriate methods. 427 samples |
| CA Air Resources Board (Sheldon, 1992) | Extensive home study in CA community to determine IA background levels | Household survey, consistent methods, extensive data analysis (outliers eliminated). Only sampled homes with no VI sources. 104 samples. |
| Stolwijk (1990) | Study to identify VOCs in IA. Combined 4 studies (USA, German, Dutch, and Italian), mostly office buildings. | Sampling methods differed. Used rounded values. Estimated ~50% uncertainty. |
| Vermont DOH (1992) | Limited study of residential homes. | Data not published. Limited information on methods (2 hour grab sample). Values very low. |
| Connecticut DEP (2003) | Used weighted average median value from 10 studies to represent background VOC levels. | Not all VOCs covered by all studies. Some values culled. Methods vary by chemical according to available data. Used median to limit outlier effects. Did not use MADEP values. |
| Massachusetts DEP (1998) | IA background VOC levels used in regulatory background documents. 75th-95th percentile values used for background. | Original data unavailable. Includes data from Shah and Singh (1988) and Stolwijk (1990). Limited information on collection or data analysis methods. |
| Shah and Singh (1988) | First comprehensive data base on indoor air composition.; large sample. 35 indoor chemicals, 66 outdoor chemicals. Variety of data sources, homes and businesses. | 90% of data from CA and NJ. Studies vary in sampling methods. No regard for contaminant sources, data quality (outliers included). Base data unavailable. High detection limits treated at ½ detection limit. |

Source: Wolff (2003)

Several studies have been identified under this effort that should be able to provide data sets of known and acceptable quality for the VI database. These include:

- NYSDOH indoor air background study of residential homes, 1989-1996 (NDSDOH, 1997; McDonald, 2003)
- Study of Denver residences over solvent plume (Foster et al., 2002; Kurtz and Folkes, 2002).
- National Human Exposure Assessment Survey (NHEXAS; Clayton et al., 1999; Gordon et al., 1999)

- EPA ORIA BASE commercial building study (Girman et al., 1999) and SIS school building study
- California study of indoor air quality in portable classrooms (CARB/CDHS, 2003)
- CA Air Resources Board residential home indoor air study (Sheldon, 1992)
- Total Exposure Assessment Methodology (TEAM) study (U.S. EPA, 1987)

Raw data sets are available for most of these studies or will be soon. The status of EPA's BASE and SIS study data is uncertain, and data availability is uncertain for the older studies (e.g., TEAM).

Once EPA has selected and obtained the available datasets, there will be a need to develop plans to clean, cull, and analyze the data. Possible questions and issues that will arise during this process include:

- How will the background levels be used in the context of the VI guidance?
- What statistics are of interest in this context?
- How should nondetects be treated, considering the decrease in detection limits over the past several years?
- Should older datasets be used, given their higher detection limits and recent reduction in certain VOCs in household products (e.g., trichloroethylene)?
- How should outliers be identified and treated?
- Given that there are always differences in methods and goals between studies, how do we define what is acceptable data? What uncertainties result from combining data from different sources?
- How do we statistically combine and analyze data from a probability based survey with a purposive study?
- Should international studies be investigated and added?

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