United States Environmental Protection Agency

This document contains Appendices A-C from the EPA "OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance)," published in November 2002. The reference number is EPA 530-D-02-004. You can find the entire document at http://www.epa.gov/epaoswer/hazwaste/ca/eis/vapor.htm.

OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance)

Appendix A: Data Quality Assurance Considerations

Appendix B: Development of a Conceptual Site Model (CSM) for Assessment of the Vapor Intrusion Pathway

Appendix C: Detailed Flow Diagrams of the Evaluation Approach Used in the Guidance

November 2002

APPENDIX A

DATA QUALITY ASSURANCE CONSIDERATIONS

The assessment of information to determine if there is a problem associated with the migration of volatile compounds from the groundwater will require the collection and assessment of environmental data and possibly the use of modeling as part of the assessment. As the guidance indicates, decisions to screen out sites after the first tier of screening from further analysis should be based either upon definitive measurement data or upon multiple lines of converging information. The ability to measure contamination levels in different media and to characterize the variability associated with sampling are key considerations.

OSWER expects that site-specific projects assess the impact of groundwater contaminants on indoor VOCs will be addressed by an approved Quality Assurance Project Plan (QAPP). This appendix is intended to provide a few recommendations on developing a QAPP, which need to follow EPA Requirements for Quality Assurance Project Plans (QA/R-5).

> *Recommendation 1: Using the Conceptual Site Model, develop the project plan and quality assurance project plan through a process that involves all key players and share these materials with interested parties in draft form so that potential study weaknesses can be addressed early.*

The collection and assessment of data, or the use of a model for the assessment of the data, warrants the development of a Quality Assurance Project Plan as part of a systematic planning process (EPA, 2000a,b, 2001). The EPA Region 1 guidance on the Quality Assurance Project Plan may be a useful reference that can aid site managers (EPA, 1999).

Data Quality Objectives (DQOs) play a central role in the systematic planning process as they help to ensure that the data collected will be of sufficient quality to support their intended use. Data Quality Objectives will generally be addressed within the Quality Assurance Project Plan and are typically a critical element in the planning for much of the work that EPA undertakes. The Agency guidance for DQOs, *Guidance for the Data Quality Objectives Process (G-4)*, provides useful information to implement DQOs (EPA, 2000c).

Table A-1 summarizes the steps in the DQO process, the purpose of each step, and provides some examples of how plans could be structured.

Table A-2 summarizes the sensitivity/detection limits of a variety of currently available methods for the analysis of VOCs along with estimated cost information. Table A-2 has been prepared to summarize some information that can serve as a general guide but should be updated as individual projects are undertaken.

The determination of the analytic and sampling methods to use, the number of samples, location of samples, and timing is a challenging task that will be related to a number of factors, including the values for screening and risk that will use the monitored results. These sampling issues can be addressed, at least in part, by employing software that has been designed to optimize sampling so that confidence in results will be maximized. Visual Sample Plan (VSP)[http://dqo.pnl.gov/vsp/] has been developed to provide statistical solutions to sampling design, mathematical and statistical algorithms, and a user-friendly visual interface, while answering the following two important questions in sample planning:

- How many samples are needed?

  The algorithms involved in determining the number of samples needed can be quite involved and intimidating to the non-expert. VSP aids in the calculation of the number of samples often needed for various scenarios at different costs.

- Where should the samples be taken?

  Sample placement based on professional judgment is prone to bias. VSP provides the alternative of random or gridded sampling locations overlaid on the site map.

References

EPA, 1999. ***EPA New England Compendium of Quality Assurance Project Plan Requirements and Guidance***. EPA, Region 1, Boston, MA. (http://www.epa.gov/NE/measure/qappcompendium.pdf).

EPA, 2000a. ***EPA Order 5360.1.A2, Policy and Program Requirements for the Mandatory Agency-wide Quality System***. EPA, Washington, D.C. (http://www.epa.gov/quality/qs-docs/5360-1.pdf).

EPA, 2000b. ***EPA Quality Manual for Environmental Programs.*** EPA, Washington, D.C. (http://www.epa.gov/quality/qs-docs/5360.pdf).

EPA, 2000c. ***Guidance for the Data Quality Objectives Process (G-4).*** EPA, Washington, D.C. (http://www.epa.gov/quality/qs-docs/g4-final.pdf)

EPA, 2001. ***EPA Requirements for QA Project Plans (QA/R-5)***. EPA, Washington, D.C. (http://www.epa.gov/quality/qs-docs/r5-final.pdf) and (http://www.epa.gov/QUALITY/qapps.html)

Visual Sample Plan (VSP)[http://dqo.pnl.gov/vsp/]

Table A-1. Example of Steps in the DQO Process using Q5©) of guidance

DQO Step	Purpose of the DQO Step	Example Application
1. State the Problem	Summarize the problem that will require new environmental data (the monitoring hypothesis) and modeling (if modeling is to be used).	Do measured or reasonably estimated groundwater concentrations exceed the target media-specific concentrations given in Table 2 (from the main body of the guidance)?
2. Identify the Decision	Identify the decision that requires new data/analysis to address the problem.	The decisions will be whether available information is sufficient to screen the site from further study.
3. Identify the Inputs to the Decision	Identify the information needed to support the decision and specify that inputs will require new information.	Ground water monitoring data will be compared with the screening values provided in guidance along with information to determine what comparisons would be most appropriate (e.g., soil type, screening wells at water table).
4. Define the Boundaries of the Study	Specify the spatial and temporal aspects of the environmental media or endpoints that the data must represent to support the decision.	The boundaries of the study will be defined by the extent to which indoor air contamination can be associated with site-related contamination. Groundwater contamination closest to the residential units would be of greatest relevance but other contamination may pose a risk to residential units in the future.

DQO Step	Purpose of the DQO Step	Example Application
5. Develop a Decision Rule	Develop a logical "if..then" statement that defines the conditions that will inform the decision maker to choose among alternative decisions.	For example, "If any measured VOC concentration in groundwater is above the action level for groundwater screening in Question 5c, then further assessment (including soil gas concentrations, and possibly indoor air concentrations, depending on the magnitude of the concentrations) should be performed as appropriate.
6. Specify Tolerable Limits on Decision Errors	Specify acceptable limits on decision errors, which are used to establish performance goals for limiting uncertainly in the analysis.	Decision errors could result from failing to appreciate uncertainty in sampling, analysis or performing analyses. Decision performance goals may be useful in managing uncertainty. The use of a computer program, such as *Visual Sample Plan* (VSP) can aid in understanding and managing uncertainties associated with sampling and analysis.[1]
7. Optimize the Design for Obtaining Data	Identify the most resource-effective sampling and analysis design for generating the information needed to satisfy the DQOs.	Again, using a tool like VSP may prove very useful in understanding and managing uncertainty in this study. See discussion of VSP.

[1]VSP is a computer program that is useful for optimizing sampling efforts so that the greatest value in confidence of information can be collected for an expenditure of resources.

Table A-2. VOC Analytical Methods, their Detection Limits and Estimated Costs
(compiled July 2002)

Media	Analytical Method / Reference	Description	Average Practical Detection Limits	Analyte List	Estimated Analytical Costs
Water	**OSW - SW 846 Method 8260C** http://www.epa.gov/epaoswer/hazwaste/test/main.htm	Purge and trap GC/MS	5 ug/L	1	$ 100
Water	**OW Drinking Water Method 524.2** http://www.epa.gov/safewater/methods/methods.html	Purge and trap GC/MS	0.5 ug/L	2	$ 90
Water	**OERR/AOC SOW OLM04.2** http://www.epa.gov/superfund/programs/clp/olm42.htm	Purge and trap GC/MS	10 ug/L	3	$ 130
Water	**OERR/AOC SOW OLC03.2** http://www.epa.gov/superfund/programs/clp/olc32.htm	Purge and trap GC/MS	0.5 ug/L	4	$ 100
Soil	**OSW - SW 846 Method 8260C** http://www.epa.gov/epaoswer/hazwaste/test/main.htm	Purge and trap GC/MS	5 ug/kg	1	$ 100
Soil	**OERR/AOC SOW OLM04.2** http://www.epa.gov/superfund/programs/clp/olm42.htm	Purge and trap GC/MS	10 ug/kg	3	$130
Air	**OSW SW846 Method 5041** http://www.epa.gov/epaoswer/hazwaste/test/pdfs/5041a.pdf	Sorbent tubes/Thermal Desorption	0.1 ug/m3	5	$100
Air	**NIOSH Method 1003** Chlorinated VOCs http://www.cdc.gov/niosh/nmam/pdfs/1003.pdf	Charcoal Tubes / GC	0.01mg/L	6	$ 50
Air	**NIOSH Method 1501** http://www.cdc.gov/niosh/nmam/pdfs/1501.pdf	Charcoal Tubes/ GC	0.001 mg/L	7	$ 50

Air	**OAR TO-15** http://www.epa.gov/ttnamti1/airtox.html	Canisters/GC/MS	0.2-0.5 ug/m3 Scan Method 0.02 SIM Method	8	$ 250
Air	**OAR TO-17** http://www.epa.gov/ttnamti1/airtox.html	Sorbent Tubes/GC/MS	0.2-0.5 ug/m3	8	?
Air	**ASTM Method D-1945**	(GC/TCD/FID) .	Reporting Limit = 10 ppmv, O_2 and N_2 = 1000 (0.1%) ppmv, CH_4 = 1 ppmv.	Atmospheric gases plus C_1-C_6 hydrocarbon speciation	
Air	**ASTM Method D-1946** (GC/TCD/FID)	Atmospheric gases		O_2, N_2, CO, CO_2, CH_4, ethane, ethylene	?
Air	**Method TO-5 HPLC** http://www.epa.gov/ttnamti1/airtox.html	Selected aldehydes and ketones collected via dinitrophenylhydrazine (DNPH) midget impinger.	0.05 ug	-	?
Air	**Method TO-11 HPLC** http://www.epa.gov/ttnamti1/airtox.html	Selected aldehydes and ketones collected on a dinitrophenylhydrazine (DNPH) coated Sep-Pak cartridge	0.05 ug.	-	?

VOC Methods Analyte Lists

List 1 Office of Solid Waste SW 846 Method 8260 C	
Acetone	Ethanol
Acetonitrile	Ethyl acetate
Acrolein (Propenal)	Ethylbenzene
Acrylonitrile	Ethylene oxide
Allyl alcohol	Ethyl methacrylate
Allyl chloride	Hexachlorobutadiene
Benzene	Hexachloroethane
Benzyl chloride	2-Hexanone
Bis(2-chloroethyl)sulfide	2-Hydroxypropionitrile
Bromoacetone	Iodomethane
Bromochloromethane	Isobutyl alcohol
Bromodichloromethane	Isopropylbenzene
Bromoform	Malononitrile
Bromomethane	Methacrylonitrile
n-Butanol	Methanol
2-Butanone (MEK)	Methylene chloride
t-Butyl alcohol	Methyl methacrylate
Carbon disulfide	4-Methyl-2-pentanone (MIBK)
Carbon tetrachloride	Naphthalene
Chloral hydrate	Bromobenzene
Chlorobenzene	1,3-Dichloropropane
Chlorodibromomethane	n-Butylbenzene
Chloroethane	2,2-Dichloropropane
2-Chloroethanol	sec-Butylbenzene
2-Chloroethyl vinyl ether	1,1-Dichloropropene
Chloroform	tert-Butylbenzene
Chloromethane	p-Isopropyltoluene
Chloroprene	Chloroacetonitrile
3-Chloropropionitrile	Methyl acrylate
Crotonaldehyde	1-Chlorobutane
1,2-Dibromo-3-chloropropane	Methyl-t-butyl ether
1,2-Dibromoethane	1-Chlorohexane
Dibromomethane	Pentafluorobenzene
1,2-Dichlorobenzene	2-Chlorotoluene
1,3-Dichlorobenzene	n-Propylbenzene
1,4-Dichlorobenzene	4-Chlorotoluene
cis-1,4-Dichloro-2-butene	1,2,3-Trichlorobenzene
trans-1,4-Dichloro-2-butene	Dibromofluoromethane
Dichlorodifluoromethane	1,2,4-Trimethylbenzene
1,1-Dichloroethane	cis-1,2-Dichloroethene
1,2-Dichloroethane	1,3,5-trimethylbenzene
1,1-Dichloroethene	
trans-1,2-Dichloroethene	
1,2-Dichloropropane	
1,3-Dichloro-2-propanol	
cis-1,3-Dichloropropene	
trans-1,3-Dichloropropene	
1,2,3,4-Diepoxybutane	
Diethyl ether	
1,4-Dioxane	
Epichlorohydrin	

VOC Methods Analyte Lists (cont.)

List 2 EPA Office of Water Method 524.2	List 3 OERR (Superfund) CLP Statement of Work OLM04.2
Chloroform	1,1-Dichloroethane
Bromodichloromethane	1,1-Dichloroethene
Bromoform	1,1,1-Trichloroethane
Chlorodibromomethane	1,1,2-Trichloro-
Bromobenzene	1,1,2-Trichloroethane
Bromochloromethane	1,1,2,2-Tetrachloroethane
Bromomethane	1,2-Dibromo-3-chloropropane
n-Butylbenzene	1,2-Dibromoethane
tert-Butylbenzene	1,2-Dichlorobenzene
Chloroethane	1,2-Dichloroethane
Chloromethane	1,2-Dichloropropane
o-Chlorotoluene	1,2,2-trifluoroethane
p-Chlorotoluene	1,2,4-Trichlorobenzene
Dibromomethane	1,3-Dichlorobenzene
m-Dichlorobenzene	1,4-Dichlorobenzene
Dichlorodifluoromethane	2-Butanone [78-93-3]
1,1-Dichloroethane	2-Hexanone
1,3-Dichloropropane	4-Methyl-2-pentanone
2,2-Dichloropropane	Acetone
1,1-Dichloropropene	Benzene
1,3-Dichloropropene	Bromodichloromethane
Fluorotrichloromethane	Bromoform
Hexachlorobutadiene	Bromomethane
Isopropylbenzene	Carbon Disulfide
p-Isopropyltoluene	Carbon Tetrachloride [56-23-5]
Naphthalene	Chlorobenzene
n-Propylbenzene	Chloroethane
1,1,2,2-Tetrachloroethane	Chloroform [67-66-3]
1,1,1,2-Tetrachloroethane	Chloromethane
1,2,3-Trichlorobenzene	cis-1,2-Dichloroethene
1,2,3-Trichloropropane	cis-1,3-Dichloropropene
1,2,4-Trimethylbenzene	Cyclohexane [110-82-7]
1,3,5 -Trimethylbenzene	Dibromochloromethane
	Dichlorodifluoromethane
	Ethylbenzene
	Isopropylbenzene
	Methyl tert-Butyl Ether
	Methyl Acetate
	Methylcyclohexane
	Methylene Chloride
	Styrene
	Tetrachloroethene
	Toluene
	trans-1,2-Dichloroethene
	trans-1,3-Dichloropropene
	Trichloroethene
	Trichlorofluoromethane
	Vinyl Chloride
	Xylenes (total)

VOC Methods Analyte Lists (cont.)

List 4 OERR (Superfund) CLP Statement of Work OLC03.2	List 5 Office of Solid Waste SW 846 Method 5041
1,1-Dichloroethane 1,1-Dichloroethene 1,1,1-Trichloroethane 1,1,2-Trichloro-1,2,2-trifluoroethane 1,1,2-Trichloroethane 1,1,2,2-Tetrachloroethane 1,2-Dibromo-3-chloropropane 1,2-Dibromoethane 1,2-Dichlorobenzene 1,2-Dichloroethane 1,2-Dichloropropane 1,2,3-Trichlorobenzene 1,2,4-Trichlorobenzene 1,3-Dichlorobenzene 1,4-Dichlorobenzene 2-Butanone 2-Hexanone 4-Methyl-2-pentanone Acetone Benzene Bromochloromethane Bromodichloromethane Bromoform Bromomethane Carbon Disulfide Carbon Tetrachloride Chlorobenzene Chloroethane Chloroform Chloromethane cis-1,2-Dichloroethene cis-1,3-Dichloropropene Cyclohexane Dibromochloromethane Dichlorodifluoromethane Ethylbenzene Isopropylbenzene Methyl Acetate Methyl tert-Butyl Ether Methylcyclohexane Methylene Chloride Styrene Tetrachloroethene Toluene trans-1,2-Dichloroethene trans-1,3-Dichloropropene Trichloroethene Trichlorofluoromethane Vinyl Chloride Xylenes (total)	Acetone Acrylonitrile Benzene Bromodichloromethane Bromoform Bromomethane Carbon disulfide Carbon tetrachloride Chlorobenzene Chlorodibromomethane Chloroethane Chloroform Chloromethane Dibromomethane 1,1-Dichloroethane 1,2-Dichloroethane 1,1-Dichloroethene trans-1,2-Dichloroethene 1,2-Dichloropropane cis-1,3-Dichloropropene trans-1,3-Dichloropropene Ethylbenzene Iodomethane Methylene chloride Styrene 1,1,2,2-Tetrachloroethane Tetrachloroethene Toluene 1,1,1-Trichloroethane 1,1,2-Trichloroethane Trichloroethene Trichlorofluoromethane 1,2,3-Trichloropropane Vinyl chloride Xylenes

VOC Methods Analyte Lists (cont.)

List 6 NIOSH Method 1003	List 7 NIOSH Method 1501
Benzyl chloride	1-tert-butyl-4-methylbenzene
Bromoform	a-methylstyrene
Carbon tetrachlorideab	benzene
Chlorobenzene	cumene
Chlorobromomethane	dimethylbenzene (p-xylene) (meta)
Chloroform	ethylbenzene
o-Dichlorobenzene	isopropenylbenzene
p-Dichlorobenzene	isopropylbenzene
1,1-Dichloroethane	methylbenzene
1,2-Dichloroethylene	methylstyrene
Ethylene dichloride	methylvinylbenzene (ortho)
Hexachloroethane	naphthalene
1,1,1-trichloroethane	p-tert-butyltoluene
Tetrachloroethylene	styrene
1,1,2-Trichloroethane	toluene
1,2,3-Trichloropropane	vinylbenzene
	xylene

VOC Methods Analyte Lists (cont.)

List 8 EPA Office of Air and Radiation TO-15 & TO-17	
1,1-Dimethylhydrazine; 1,1,2-Trichloroethane; 1,1,2,2-Tetrachloroethane; 1,2-Dibromo-3-chloropropane; 1,2-Epoxybutane (1,2-butylene oxide); 1,2-Propyleneimine (2-methylazindine); 1,2,4-Trichlorobenzene; 1,3-Butadiene; 1,3-Dichloropropene; 1,3-Propane sultone; 1,4-Dichlorobenzene (p-); 1,4-Dioxane (1,4 Diethylene oxide); 2-Nitropropane; 2,2,4-Trimethyl pentane; Acetaldehyde (ethanal); Acetonitrile (cyanomethane); Acetophenone; Acrolein (2-propenal); Acrylamide; Acrylic acid; Acrylonitrile (2-propenenitrile); Allyl chloride (3-chloropropene); Aniline (aminobenzene); Benzene; Benzyl chloride (a-chlorotoluene); Beta-Propiolactone; Bis(2-Chloroethyl)ether; Bis(chloromethyl) ether; Bromoform (tribromomethane); Carbon tetrachloride; Carbon disulfide; Carbonyl sulfide; Catechol (o-hydroxyphenol); Chloroacetic acid; Chlorobenzene; Chloroform; Chloromethyl methyl ether; Chloroprene (2-chloro-1,3-butadiene); Cresylic acid (cresol isomer mixture); Cumene (isopropylbenzene); Diazomethane; Diethyl sulfate; Dimethyl sulfate; Dimethylcarbamyl chloride; Epichlorohydrin (l-chloro-2,3-epoxy propane); Ethyl acrylate; Ethyl carbamate (urethane); Ethyl chloride (chloroethane); Ethylbenzene; Ethylene dibromide (1,2-dibromoethane);	Ethylene dichloride (1,2-dichloroethane); Ethylene oxide; Ethyleneimine (aziridine); Ethylidene dichloride (1,1-dichloroethane); Formaldehyde; Hexachlorobutadiene; Hexachloroethane; Hexane; Isophorone; m-Xylene; Methanol; Methyl methacrylate; Methyl isobutyl ketone (hexone); Methyl chloride (chloromethane); Methyl bromide (bromomethane); Methyl ethyl ketone (2-butanone); Methyl isocyanate; Methyl iodide (iodomethane); Methyl chloroform (1,1,1 trichloroethane); Methyl tert-butyl ether; Methylene chloride; Methylhydrazine; N-Nitrosodimethylamine; N-Nitrosomorpholine; N-Nitrso-N-methylurea; Nitrobenzene; N,N-Dimethylaniline; N,N-Dimethylformamide; o-Cresol; o-Xylene; p-Xylene; Phenol; Phosgene; Propionaldehyde; Propylene dichloride (1,2-dichloropropane); Propylene oxide; Styrene oxide; Styrene; Tetrachloroethylene; Toluene; Trichloethylene; Triethylamine; Vinyl acetate; Vinyl bromide (bromoethene); Vinyl chloride (chloroethene); Vinylidene chloride (1,1-dichloroethylene); Xylenes (isomer & mixtures);

APPENDIX B

DEVELOPMENT OF A CONCEPTUAL SITE MODEL (CSM) FOR ASSESSMENT OF THE VAPOR INTRUSION PATHWAY

1. Introduction

A conceptual site model (CSM) is a simplified version (picture and/or description) of a complex real-world system. A CSM is not an analytical or mathematical computer model (although a detailed CSM may serve as a foundation for such models). The goal for developing a CSM in the assessment of the vapor intrusion pathway is to assemble a comprehensive (as possible) three-dimensional "picture" based on available reliable data describing the sources of the contamination, the release/transport mechanisms, the possible subsurface pathways, and the potential receptors, as well as historical uses of the site, cleanup concerns expressed by the community, and future land use plans. All the important features relevant to characterization of a site should be included in a CSM and any irrelevant ones excluded. The CSM should present both a narrative and a visual representation of the actual or predicted relationships between receptors (humans and/or ecological entities) and the contaminants at the site, as well as reflect any relevant background levels.

Development of a CSM is an important first step in planning and scoping any site assessment designed to determine the potential impacts of contamination on public health and the environment. In documenting current site conditions, a CSM should be supported by maps, cross sections and site diagrams, and the narrative description should clearly distinguish what aspects are known or determined and what assumptions have been made in its development. The CSM should provide all interested parties a conceptual understanding of the potential for exposure to any hazardous contaminants at a site. As such, it serves as an essential tool to aid management decisions associated with the site and also serves as a valuable communication tool both internally with the "site team" and externally with the community.

A well-defined, detailed CSM will facilitate the identification of additional data needs and development of appropriate Data Quality Objectives (DQOs) in planning any sample collection/analyses to support the site risk assessment. It can also provide useful information for prompt development of a strategy for early response actions if the vapor intrusion pathway is considered to be complete and may pose an imminent potential risk to public health.

Because the CSM is likely to evolve over the course of the site assessment process, it should be considered dynamic in nature. Integration of newly developed information is an iterative process that can occur throughout the early stages of the site assessment process. This should include stakeholder input from persons who are knowledgeable about the community and activities which may have generated the contaminants or affected their movement. As additional data become available during implementation of the site assessment DQO process, the CSM should be updated. Such updates could also suggest iterative refinement of the DQO process (optimization step), since changes in the CSM may lead to identification of additional data or

information not previously recognized as needed. As a fundamental site assessment tool, the CSM warrants prompt updating and distribution to interested parties during the site assessment process.

2. Collecting Existing Site Data

The following general types of information are important for preparing a CSM:

- site maps, sample location maps, aerial photos
- historical site activity, chronology of land use, populations information
- State soil surveys
- published data on local and regional climate, soils, and hydrogeology
- any previous site studies and actions (e.g. Preliminary Assessment/Site Investigation)
- an overview of the nature and extent of the contamination

The CSM developed should identify, in as comprehensive a manner as possible, all potential or suspected sources of contamination (soil, groundwater, soil gas, etc.); the types and concentrations of contamination detected at the site; all potential subsurface pathways, including preferential pathways; and the media and buildings associated with each pathway cleanup. Additional considerations that may be important to include in developing an optimal CSM for use in management decisions are presented below.

3. Additional Considerations for CSM Development for the Vapor Intrusion Pathway

- sensitive populations, including but not limited to:
  - the elderly
  - pregnant or nursing women
  - infants
  - children
  - people suffering from chronic illnesses

- people exposed to particularly high levels of contaminants

- circumstances where a disadvantaged population is exposed (Environmental Justice situation)

- significant contamination sources
  - NAPLs
  - very shallow contaminated groundwater or soil

- vapor transport pathways (see Figure B-1)
  - diffusion upwards
  - lateral vapor transport
  - preferential vapor pathways such as fractured sediments or utility features

- potential non-site related sources of contaminants
  - ambient (outdoor) air sources
  - indoor air emission sources

- building construction quality
  - foundation type (basement, slab on grade, crawlspace)
  - foundation integrity

- building use
  - open windows (etc.)

4. Organizing Existing Site Data for Inclusion in a CSM

The ***Conceptual Site Model Summary*** presented in Attachment A of the ***Soil Screening Guidance: User's Guide*** contains four detailed forms for compiling site data useful in developing a CSM for soil screening purposes. These CSM Summary forms systematically organize the site data according to general site information, soil contaminant source characteristics, exposure pathways and receptors. ***Planning Table 1*** presented in the ***Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual, Part D - Standardized Planning, Reporting, and Review of Superfund Risk Assessments*** may be used in a similar manner to prepare/supplement the CSM. ***Planning Table 1*** is intended to accompany the CSM and present the possible receptors, exposure routes, and exposure pathways, as well as the rationale for selection or exclusion of each potential exposure pathway. The exposure pathways that were examined and excluded from analysis and the exposure pathways that will be evaluated qualitatively or quantitatively in the site risk assessment are clearly reflected when ***Planning Table 1*** is used. Either of these systematic site information organizing formats that are useful for CSM development can also be used to communicate risk information about the site to interested parties outside EPA. The systematic and comprehensive approach encouraged by compilation of data and information in these standard formats, like other steps in the site risk assessment process, may suggest further refinement of the CSM.

- **Constructing Conceptual Site Model Diagrams**

An example of a complete CSM including diagrams prepared for soil screening purposes can be found in ***Attachment A*** of the ***Soil Screening Guidance: User's Guide.*** A software application that can generate CSM diagrams and reflect relevant site data has been developed (DOE). The ***Site Conceptual Exposure Model Builder*** can be found on the internet.
(URL = http://tis-nt.eh.doe.gov/oepa/programs/scem.cfm)

- **Additional Resources for CSM Development Guidance**

(1) The following provide more specific guidance for developing a CSM for cleanup programs:

Soil Screening Guidance: User's Guide. **Part 2.1 and Attachment A**; EPA-540-R-96-018. Office of Emergency and Remedial Response/EPA. July 1996.

Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites Office of Emergency and Remedial Response/EPA

Risk Assessment Guidance for Superfund (RAGS): Volume I - Human Health Evaluation Manual, Part D - (Standardized Planning, Reporting, and Review of Superfund Risk Assessments), Final December 2001. Pub. # - 9285.7-47; *Chapter 2 - Risk Considerations in Project Scoping*; EPA - Office of Emergency and Remedial Response.

Site Conceptual Exposure Model Builder - User Manual - for PC (Windows version) application to assist in preparing a site model; U.S. Dept of Energy, RCRA/CERCLA Division; July 1997.

Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA. EPA 540-G-89-004. Office of Emergency and Remedial Response/EPA . 1989.

Expedited Site Assessment Tools for Underground Storage Tank Sites: A Guide for Regulators. Chapter 2. EPA 510-B-97-001; Office of Underground Storage Tanks/EPA; March 1997.

(2) Selected risk assessment guidance and related documents that contain discussions concerning necessary problem formulation, and planning and scoping prior to conducting a risk assessment can provide some additional perspective to consider in preparation of a Conceptual Site Model.

Quality Assurance Guidance for Conducting Brownfields Site Assessments, EPA 540-R-98-038; OSWER 9230.0-83P; PB98-963307; September 1998.

Guidelines for Ecological Risk Assessment, EPA 630-R-95-002F, Federal Register Vol 63, pp.26846-26924; May 14, 1998.

Framework for Cumulative Risk Assessment - External Review Draft, EPA 630-P-02-001A; Risk Assessment Forum; April 23, 2002.

Risk Characterization Handbook, EPA 100-B-00-002, December 2000.

Guidance For The Data Quality Objectives Process - EPA QA/G-4; EPA-600-R-96-055; September 1994.

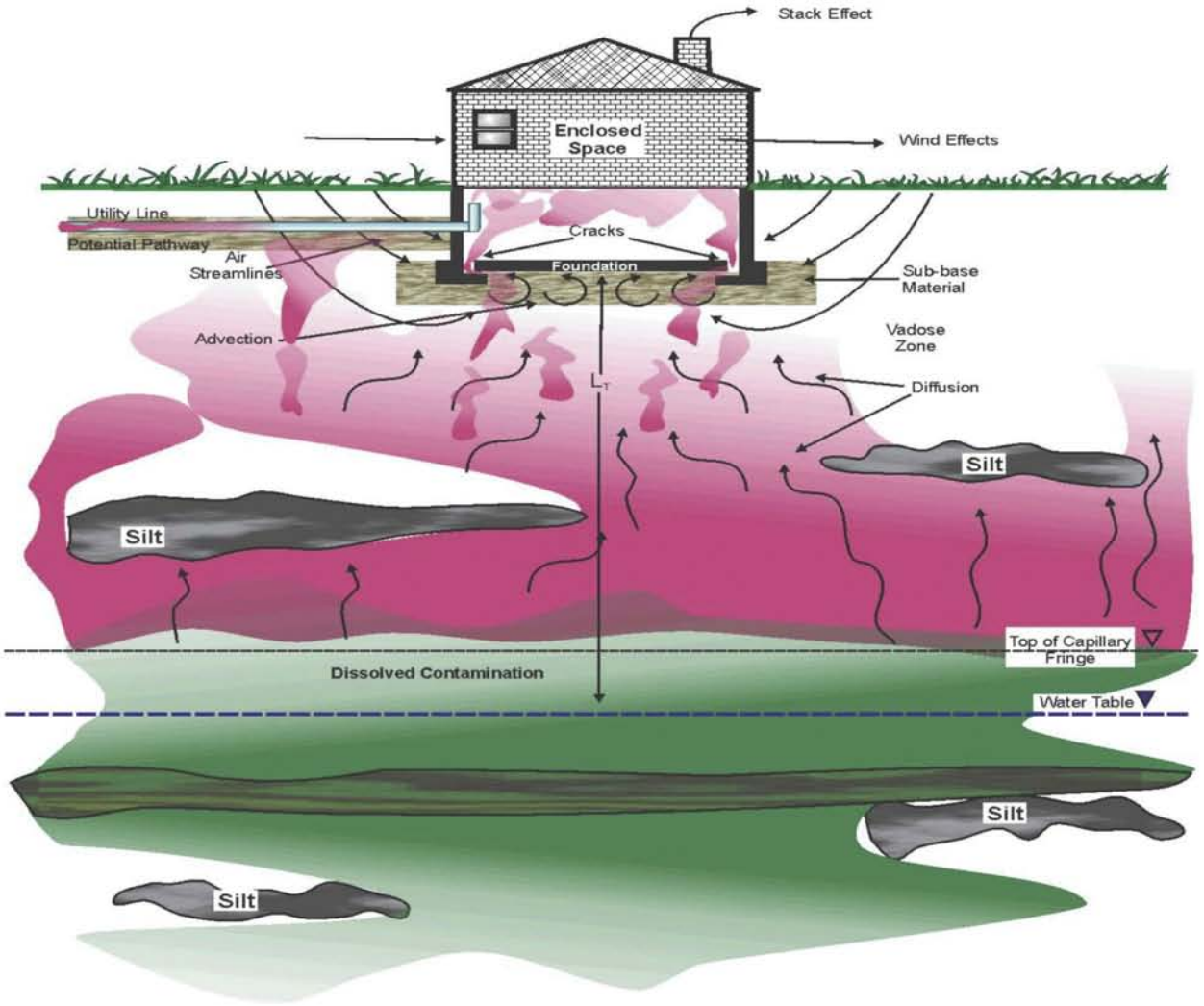
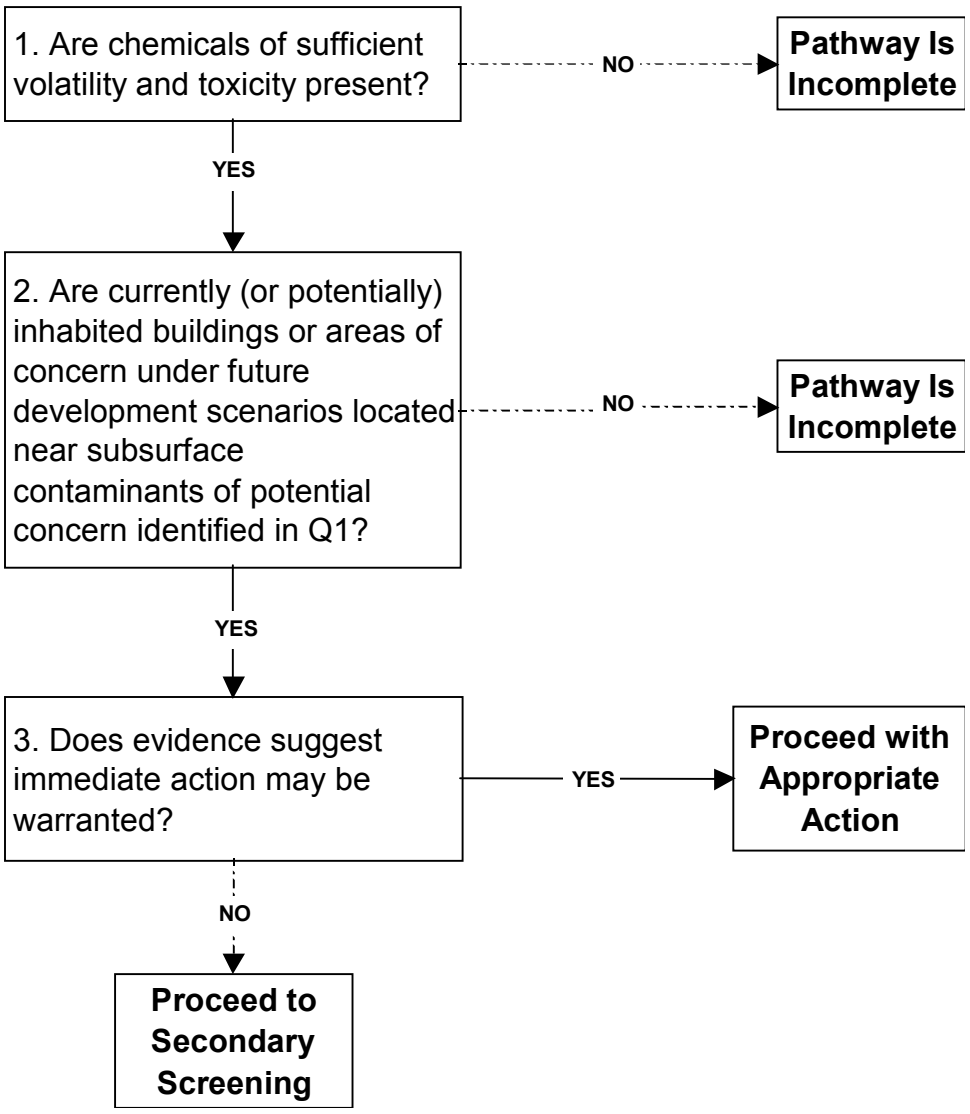


Figure B-1. Example of Conceptual Site Model cross section diagram illustrating potential subsurface vapor intrusion pathways

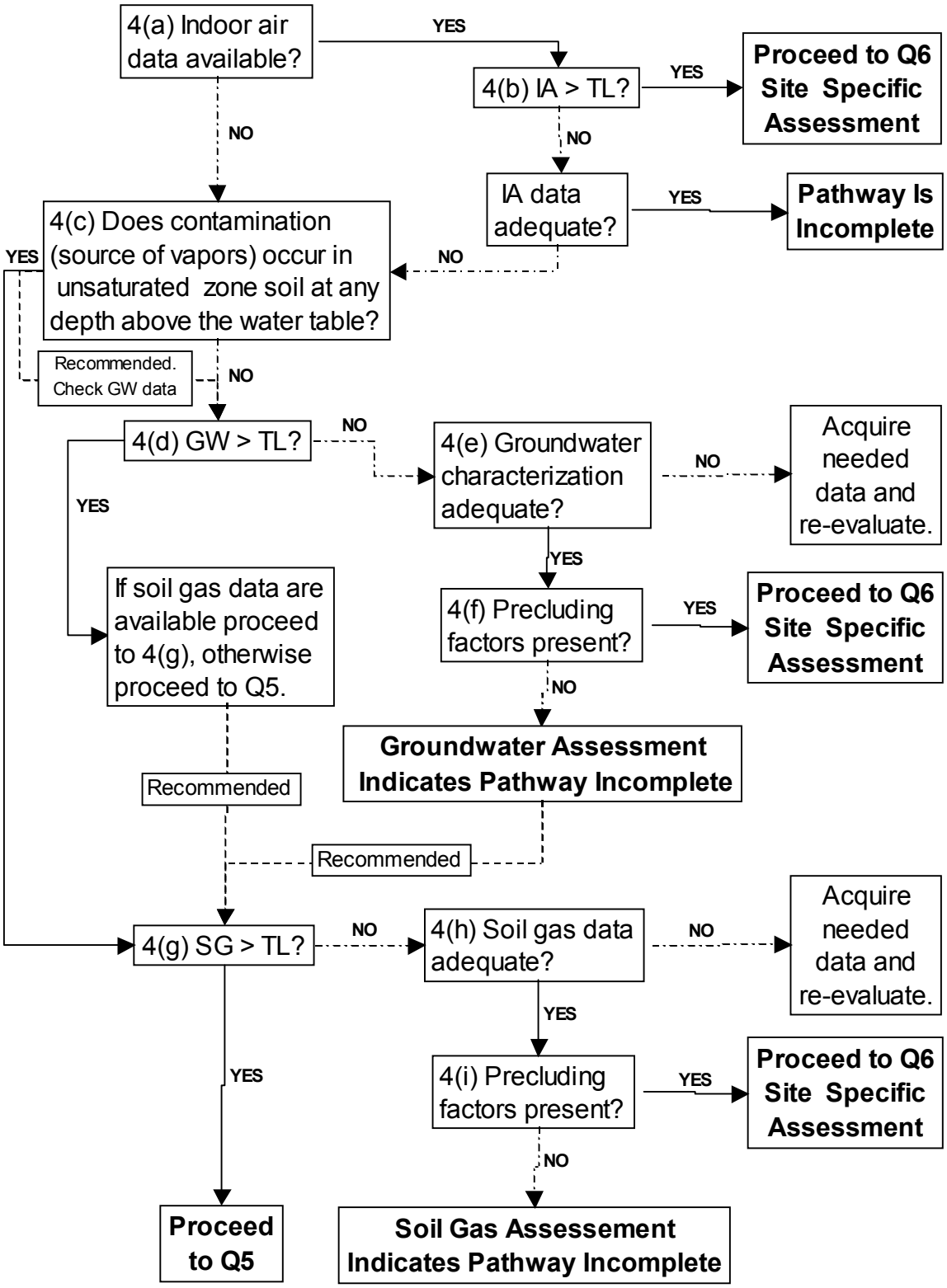
APPENDIX C

DETAILED FLOW DIAGRAMS OF THE EVALUATION APPROACH USED IN THE GUIDANCE

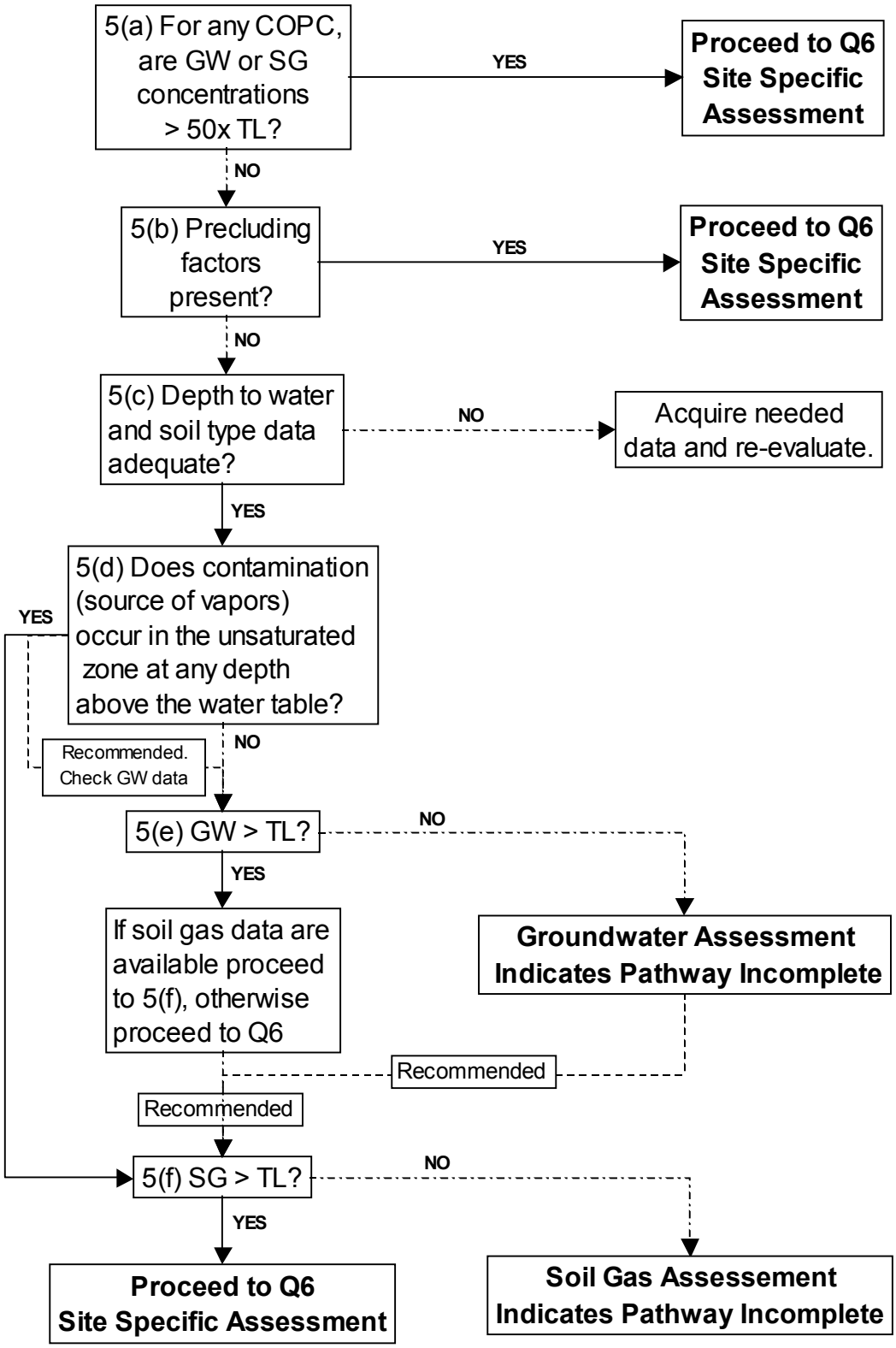
PRIMARY SCREENING



SECONDARY SCREENING
Question 4 – Generic Screening
(TL = appropriate media specific target level)



SECONDARY SCREENING
Question 5 – Semi-Site Specific Screening
(TL = appropriate media specific target level)



SITE SPECIFIC SCREENING
Question 6
(TL = appropriate media specific target level)