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Standard Guide for Vapor Encroachment Screening on Property Involved in Real Estate Transactions[1]

This standard is issued under the fixed designation E2600; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 *Purpose*—The purpose of this guide is to provide practical guidance and a useful process for conducting a *vapor encroachment screen (VES)* on a property parcel involved in a *real estate transaction* in the United States of America with respect to *chemicals of concern (COC)* that may migrate as vapors into the vadose zone of a property as a result of contaminated soil and/or groundwater on or near the property. This guide may be used in conjunction with Practice E1527 but does not alter or in any way define the scope of that practice. In addition, performance of this guide is not a requirement of and does not constitute, expand, or in any way define "all appropriate inquiry" as defined and approved by the U.S. Environmental Protection Agency (EPA) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the regulations there under, including 40 CFR Sec. 312.11.

1.1.1 *Vapor Encroachment Condition (VEC)*—The goal of conducting a *VES*, as established by this guide, on a parcel of property is to identify a *vapor encroachment condition (VEC)*, which is the presence or likely presence of *COC* vapors in the vadose zone of the *target property (TP)* caused by the release of vapors from contaminated soil and/or groundwater either on or near the *TP* as identified by Tier 1 (see Section 8) or Tier 2 (see Section 9) procedures.

1.1.2 *Federal, State, and Local Environmental Laws*—This guide does not address requirements of any federal, state, or local laws with respect to vapor intrusion. *Users* are cautioned that federal, state, and local laws, regulations, or policy may impose vapor encroachment screening or vapor intrusion assessment obligations that are beyond the scope of this guide (information is provided in Appendix X5 and Appendix X9). *Users* should also be aware that there may be other legal obligations, for example, disclosure, with regard to *COC* or *COC* vapors discovered on the *TP* that are not addressed in this guide.

1.1.3 *Documentation*—The scope of this guide includes investigation and reporting actions. Sufficient documentation of all sources, records, and resources used in the investigation procedures that are set out in this guide should be provided in the *VES report* (refer to Section 10).

1.2 *Objectives*—Objectives guiding the development of this guide are: *(1)* to synthesize and put into writing a practical guide for conducting a *VES* on a property involved in a *real estate transaction* and *(2)* to provide that the process to screen for a *VEC* is practical and reasonable.

1.3 *Considerations Outside the Scope*—The use of this guide is strictly limited to the scope set forth in this section. Section 11 of this guide identifies, for informational purposes, certain tasks (not an all-inclusive list) that may be conducted on a property that are beyond the scope of this guide but that may warrant consideration by parties to a *real estate transaction*. Whether to include an investigation of any such conditions in the *environmental professional's* scope of services should be evaluated by the *user* and should be agreed upon between the *user* and *environmental professional* as additional services beyond the scope of this guide before initiation of a *Phase I ESA* conducted in conjunction with a *VES* or initiation of an independent *VES*.

1.4 *Units*—The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.5 *Organization of this Guide*—This guide has eleven sections and nine appendices. The appendices are included for informational purposes and are not part of the procedures prescribed in this guide.

Section 1	contains the scope of the guide.
Section 2	includes the referenced documents.
Section 3	has definitions of terms pertinent to this guide, terms used in this guide but defined in Practice E1527, and acronyms.
Section 4	is directed at the significance and use of this guide.
Section 5	discusses the relationship between this guide and Practice E1527.
Section 6	describes the *user's* responsibilities under this guide.
Sections 7 – 10	consist of the main body of the *VES* process, including evaluation and *report* preparation.
Section 11	provides information regarding non-scope considerations (see 1.3).

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Appendix X1	provides legal background for vapor encroachment screening.
Appendix X2	provides guidance on suggested qualifications for the *environmental professional* conducting the *VES*.
Appendix X3	provides a sample questionnaire for the *environmental professional* to obtain pertinent information for the *VES* from the *property owner/operator/occupants*.
Appendix X4	provides a recommended table of contents and report format for the *VES* investigation when not incorporated into a *Phase I ESA* report.
Appendix X5	includes a listing of federal and state agency web sites that discuss vapor intrusion assessment policies and guidance.
Appendix X6	includes a list of *chemicals of potential concern*.
Appendix X7	provides general guidance for vapor intrusion assessment and mitigation.
Appendix X8	provides general guidance and references for data collection in the conduct of vapor intrusion investigations.
Appendix X9	provides a supplemental bibliography of federal and state vapor intrusion guidance and other publications that may assist the *environmental professional* conducting a *VES* or vapor intrusion assessment.

1.6 *This guide does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this guide to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.7 *This guide cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this guide may be applicable in all circumstances. This ASTM guide is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this guide be applied without consideration of a project's many unique aspects. The word "Standard" in the title means only that the guide has been approved through the ASTM consensus process.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E1527 Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process

E1903 Practice for Environmental Site Assessments: Phase II Environmental Site Assessment Process

2.2 *Federal Statutes:*

42 U.S.C. U.S. Code, Title 42, The Public Health and Welfare, Solid Waste Disposal, Identification and Listing of Hazardous Wastes, §6901, 6903, 6921; 42 U.S.C. U.S. Code, Title 42, Comprehensive Environmental Response, Compensation and Liability Act, 9605, 9601, *et seq*.

2.3 *USEPA Documents:*

40 CFR Title 40, Protection of Environment, Chapter 1, Environmental Protection Agency, Parts 300, 302, 312, 355, *et seq*.

OSWER Publication 9200.2-154, OSWER Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air, June 2015

EPA 510-R-15-001, Technical Guide for Addressing Petroleum Vapor Intrusion at Leaking Underground Storage Tank Sites, June 2015

2.4 *Other Documents:*

NTP National Toxicology Program, "Annual Report on Carcinogens," (latest edition)

IARC International Agency for Research on Cancer "Monographs" (latest editions)

NIOSH National Institute for Occupational Safety and Health, "Registry of Toxic Effects of Chemical Substances"

3. Terminology

3.1 This section provides definitions and descriptions of terms used in this guide, terms used in this guide extracted from Practice E1527 (some of which have been modified to be consistent with this guide), and a list of acronyms for keywords used in this guide. The terms are an integral part of this guide and are critical to an understanding of the guide and its use.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *approximate minimum search distance, n*—defined in subsection 8.1.3 and also defines the default *area of concern (AOC)*.

3.2.2 *aquifer, n*—rock or sediment in a formation, a group of formations, or part of a formation that is saturated and sufficiently permeable to transmit water to wells or springs.

3.2.3 *area of concern (AOC), n*—defined in subsections 8.1.2, 8.1.3 and 8.1.4 and is defined by the *approximate minimum search distance* adjusted as appropriate. When the *AOC* is defined by the *approximate minimum search distance* without adjustment, the *AOC* is the default *AOC*.

3.2.4 *biodegradation, n*—process by which microbial organisms transform or alter (through metabolic, enzymatic, or other action) the structure of chemicals present in the environment.

3.2.5 *chemical(s) of concern, COC, n*—chemical that is present in the subsurface environment, has a vapor pressure greater than 1 mm of mercury, or a Henry's Law Constant greater than 1×10^{-5} atm m^3/mole at ambient temperature and pressure, and can potentially migrate as a vapor into the vadose zone of the *TP*.

3.2.5.1 *Discussion—COC* generally meet specific criteria for *volatility* (see 3.2.39) and *toxicity* (see 3.2.34) and include volatile organic compounds, semi-volatile organic compounds, petroleum hydrocarbons, and volatile inorganic analytes (such as mercury). A list of *COC* is presented in Appendix X6. A chemical's molecular weight has also been suggested as a criterion for volatility (with a threshold of 200 g/mole). However, EPA indicated in its June 2015 Vapor Intrusion Guidance that it is not considering a chemical's molecular weight because molecular weight is only a weak predictor of volatility. Those chemicals with a molecular weight greater than 200 g/mole are identified with an asterisk in Appendix X6.

3.2.6 *conduit, n*—preferential pathway along which vapors released from contaminated soil and/or groundwater may migrate onto the *TP* or away from the *TP*.

3.2.7 *contaminant, n*—any physical, chemical, biological, or radiological substance or matter that has an adverse effect on air, water, or soil.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

3.2.8 *contaminated plume, n*—plume in which concentrations of *COC* are known to be present in the soil or groundwater or both at concentrations exceeding levels that generally would be the subject of an enforcement action if brought to the attention of appropriate governmental agencies.

3.2.8.1 *Discussion*—A *contaminated plume* can take the form of a groundwater *contaminated plume* or a soil *contaminated plume*. In a groundwater *contaminated plume*, *COC* may be conveyed as *solutes* away from the point at which they were introduced into groundwater. They move with the migrating groundwater mass in the direction of groundwater flow. When dispersion within the groundwater *contaminated plume* brings a dissolved *COC* to the groundwater-soil gas interface, the *COC* may transition from the dissolved state to the vapor state and migrate from groundwater into soil gas in the vadose zone. Once a *COC* migrates into soil gas in the vadose zone, its migration may no longer be dependent on or related to groundwater movement. In a soil *contaminated plume*, *COC* volatilized from the soil mix freely with soil gas that exists within soil voids in the vadose zone. *COC* in the soil gas can also be introduced from underlying contaminated groundwater, as a result of a liquid spill into vadose zone soils, or by the direct release of vapors from a leaking underground source. Migration of *COC* contaminated soil gas through the vadose zone may be in any direction; however, it preferentially follows the path of least resistance. Fluctuations in barometric pressure may cause movement of air and vapors into and out of the vadose zone through preferential pathways.

3.2.9 *contaminated property, n*—property on which soil or groundwater or both contains *chemicals of concern (COC)* or otherwise hazardous substances at concentrations exceeding levels that generally would be the subject of an enforcement action if brought to the attention of appropriate governmental agencies.

3.2.10 *critical distance, n*—defined in subsection 9.2.

3.2.11 *dwelling, n*—structure or portion thereof used for residential habitation.

3.2.12 *environmental professional, n*—person meeting the education, training, and experience requirements as set forth in 40 CFR 312.10(b), which is the requirement set forth in Practice E1527 (see subsection 3.3.5).

3.2.13 *findings, n*—defined in subsection 10.2.2.

3.2.14 *fracture, n*—break in a rock formation.

3.2.14.1 *Discussion*—Faults, shears, joints, and planes of fracture cleavage are types of fractures. The presence of fractures may accelerate migration of *COCs* along the fracture.

3.2.15 *groundwater, n*—water contained in the pore spaces of saturated geologic media.

3.2.16 *Henry's law, n*—relationship between the partial pressure of a compound in air and the concentration of that compound in water under equilibrium conditions; *Henry's law* constants are temperature dependent.

3.2.17 *hydrocarbon, n*—chemical compound composed only of carbon and hydrogen atoms.

3.2.18 *moisture content (of soil), n*—amount of water lost from soil upon drying to a constant weight expressed as the weight per unit weight of dry soil or as the volume of water per unit bulk volume of the soil.

3.2.18.1 *Discussion*—For a fully saturated medium, moisture content expressed as a volume fraction equals the porosity.

3.2.19 *nonaqueous phase liquid, NAPL, n*—substances that do not dissolve readily in water and that remain in the original bulk liquid form in the subsurface.

3.2.19.1 *Discussion*—Light NAPL (LNAPL), such as gasoline, is less dense than water and can accumulate above the water table, while dense NAPL (DNAPL), such as many chlorinated solvents, including trichloroethylene and perchloroethylene, are more dense than water and can penetrate into the water table.

3.2.20 *permeability, n*—qualitative description of the relative ease with which rock, soil, or sediment will transmit a fluid (that is, a liquid or gas).

3.2.21 *petroleum, n*—crude oil or any fraction thereof that is liquid at standard conditions of temperature and pressure (60°F at 14.7 psia).

3.2.21.1 *Discussion*—The term includes substances comprised of a complex blend of hydrocarbons derived from crude oil through the process of separation, conversion, upgrading, and finishing, such as motor fuels, jet oils, lubricants, and petroleum solvents, and also includes used oils.

3.2.22 *petroleum hydrocarbon chemicals of concern, n*—for the purpose of this guide, those volatile petroleum hydrocarbon compounds are a subset of *COC* and readily biodegrade to carbon dioxide and water by soil microbes in aerated environments.

3.2.22.1 *Discussion—Petroleum hydrocarbon chemicals of concern* may be present in several forms in environmental media, including adsorbed to soil, as constituents of LNAPL above the water table, as dissolved solutes in groundwater, or as vapors in soil gas.

3.2.23 *Phase I environmental site assessment, ESA, n*—process described in Practice E1527.

3.2.24 *porosity, n*—volume fraction of a rock or unconsolidated sediment not occupied by solid material but usually occupied by liquids, gas, and/or air.

3.2.25 *preferential pathway, n*—pathway that has the least amount of constraint on the migration of *COC* vapors.

3.2.25.1 *Discussion*—Preferential pathways are natural or man-made and may provide direct contact between the subsurface of a property and the vapor contaminant source (that is, the location on a property where the contaminated vapor intersects the preferential pathway). Natural preferential pathways may include, for example, vertically fractured bedrock where the fractures are interconnected and in direct contact with the subsurface of a property and the vapor contaminant source. Man-made preferential pathways may include, for example, utility conduits and sewers. The presence of preferential pathways may also direct migrating *COC* vapors away from a *TP*.

3.2.26 *real estate, n*—undeveloped real property, real property used for industrial, retail, office, agricultural, other

commercial, medical, or educational purposes, or property used as a single family or multi-family residential *dwelling*.

3.2.27 *real estate transaction, n*—transfer of title to or possession of real property or receipt of a security interest in real property.

3.2.28 *report, n*—document prepared by an *environmental professional* pursuant to Section 10.

3.2.29 *saturated zone, n*—zone in which all of the voids in the rock or soil are filled with water at a pressure that is greater than atmospheric.

3.2.29.1 *Discussion*—The *water table* is the top of the *saturated zone* in an unconfined *aquifer*.

3.2.30 *semi-volatile organic compound, n*—general term for an organic compound that has sufficient vapor pressure at standard temperature (20°C) and pressure (1 atm) to vaporize (albeit at a slower rate than *volatile organic compounds*) and enter the atmosphere.

3.2.31 *solute, n*—substance such as a contaminant that is dissolved in another substance such as groundwater.

3.2.32 *target property, TP, n*—property involved in the *real estate transaction* that is the subject of the *VES* defined by this guide.

3.2.33 *toxic chemical, n*—chemical whose vapor concentration of the pure component poses either an incremental lifetime cancer risk (ILCR) or a non-cancer hazard quotient greater than acceptable values established by applicable federal, state, or local regulatory agencies.

3.2.34 *toxicity, n*—effect on human health that is exhibited by a *toxic chemical*; for the purposes of this guide, toxicity is defined as a chemical exhibiting an incremental lifetime cancer risk greater than 10^{-6} or a non-cancer Hazard Index greater than 1.

3.2.35 *user, n*—party who commissions the performance of a *VES* pursuant to this guide.

3.2.35.1 *Discussion*—Commonly, the *user* is the prospective purchaser of a parcel of property.

3.2.36 *vadose zone (or unsaturated zone), n*—zone between the land surface and the water table within which moisture content is less than saturation (except in the capillary fringe) and pressure is less than atmospheric.

3.2.36.1 *Discussion*—Soil pore space typically contains air or other gases. The capillary fringe is included in the *vadose zone*.

3.2.37 *vapor encroachment condition, VEC, n*—presence or likely presence of *COC* vapors in the vadose zone of the *TP* caused by the release of vapors from contaminated soil and/or groundwater either on or near the *TP* as identified by the Tier 1 (see Section 8) or Tier 2 (see Section 9) procedures in this guide.

3.2.37.1 *Discussion*—Conditions may exist where there could be no vadose zone, such as the case of a building foundation sitting below the water table. In this case, it may be possible for *COC* vapors to adversely impact the indoor air without migrating through a vadose zone.

3.2.38 *volatile organic compound, VOC, n*—general term for an organic compound that has sufficient vapor pressure (for example, greater than 1 mm Hg) at standard temperature (20°C) and pressure (1 atm) to significantly vaporize and enter the atmosphere.

3.2.39 *volatility, n*—chemical is considered to be sufficiently *volatile* if its *Henry's law* constant is greater than 10^{-5} atm-m^3-mol^{-1} and its vapor pressure is greater than 1 mm Hg at room temperature.

3.2.39.1 *Discussion*—A chemical's molecular weight has also been used as an indicator of volatility, with the threshold molecular weight being approximately 200 g/mole. EPA in its June 2015 Vapor Intrusion Guidance does not use the molecular weight criterion because this criterion is believed to be only a weak predictor of volatility.

3.2.40 *water table, n*—top of the *saturated zone* in an unconfined *aquifer*.

3.3 *Practice E1527 Terms Used in This Guide*—Some terms have been modified to be consistent with this guide.

3.3.1 *adjoining properties, n*—any real property or properties the border of which is contiguous or partially contiguous with that of the *target property*, or that would be contiguous or partially contiguous with that of the *target property* but for a street, road, or other public thoroughfare separating them.

3.3.2 *business environmental risk, n*—risk that can have a material environmental or environmentally driven impact on the transaction or the business associated with the current or planned use of a parcel of *real estate*, not limited to environmental issues that are investigated pursuant to this guide. Consideration of *business environmental risk* issues may involve addressing one or more non-scope considerations, some of which are identified in Section 11 of this guide.

3.3.3 *Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS), n*—list of sites compiled by EPA that EPA has investigated or is currently investigating for potential *hazardous substance* contamination and for possible inclusion on the *National Priorities List* (the CERCLIS information system supporting CERCLA has been retired by EPA and replaced by SEMS, the Superfund Enterprise Management System).

3.3.4 *CORRACTS list, n*—list of *hazardous waste* treatment, storage, or disposal facilities and other RCRA-regulated facilities (because of past interim status or storage of *hazardous waste* beyond 90 days) that have been notified by the EPA to undertake corrective action under RCRA. The *CORRACTS list* can be derived from the EPA database that manages RCRA data.

3.3.5 *environmental professional, n*—person meeting the education, training, and experience requirements as set forth in 40 CFR 312.10(b). The person may be an independent contractor or an employee of the *user*.

3.3.6 *environmental site assessment, ESA, n*—process by which a person or entity seeks to determine if a particular parcel of real property (including improvements) is subject to *recognized environmental conditions* (see subsection 3.3.22).

3.3.7 *fire insurance maps, n*—maps produced for private fire insurance map companies that indicate uses of properties at specified dates and that encompass the property. These maps are often available at local libraries, historical societies, private resellers, or from the map companies who produced them.

3.3.8 *hazardous substance, n*—substance defined as a *hazardous substance* pursuant to CERCLA 42 U.S.C. 9601(14), as interpreted by EPA regulations and the courts.

3.3.9 *hazardous waste, n*—any *hazardous waste* having the characteristics identified under or listed pursuant to Section 3001 of RCRA, as amended (42 U.S.C. 6921) (but not including any waste the regulation of which under RCRA (42 U.S.C. 6901-6992k) has been excluded by Act of Congress). RCRA defines a *hazardous waste*, at 42 U.S.C. 6903, as: "a solid waste, or combination of solid wastes, which because of its quantity, concentration or physical, chemical or infectious characteristics may (A) cause, or significantly contribute to an increase in mortality or an increase in serious irreversible or incapacitating reversible illness; or (B) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported or disposed of, or otherwise managed."

3.3.10 *landfill, n*—place, location, tract of land, area, or premises used for the disposal of solid wastes as defined by state solid waste regulations. The term is synonymous with the term *solid waste disposal site* and is also known as a garbage dump, trash dump, or similar term.

3.3.11 *local government agencies, n*—those agencies of municipal or county government having jurisdiction over the *target property*. Municipal and county government agencies include but are not limited to cities, parishes, townships, and similar entities.

3.3.12 *local street directories, n*—directories published by private (or sometimes government) sources that show ownership, occupancy, and/or use of sites by reference to street addresses. Often *local street directories* are available at libraries, or historical societies, and/or local municipal offices.

3.3.13 *National Priorities List, NPL, n*—list compiled by EPA pursuant to CERCLA 42 U.S.C. §9605(a)(8)(B) of properties with the highest priority for cleanup pursuant to EPA's Hazard Ranking System. See 40 C.F.R. Part 300.

3.3.13.1 *Discussion*—The CERCLIS information system supporting CERCLA has been retired by EPA and replaced by SEMS, the Superfund Enterprise Management System.

3.3.14 *obvious, adv*—that which is plain or evident; a condition or fact that could not be ignored or overlooked by a reasonable observer while visually or physically observing the property.

3.3.15 *occupants, n*—those tenants, subtenants, or other persons or entities using a property or a portion of the property.

3.3.16 *operator, n*—person responsible for the overall operation of a facility.

3.3.17 *owner, n*—generally the fee *owner* of record of the property.

3.3.18 *petroleum products, n*—those substances included within the meaning of the petroleum exclusion to CERCLA, 42 U.S.C. §9601(14), as interpreted by the courts and EPA, that is: petroleum, including crude oil or any fraction thereof which is not otherwise specifically listed or designated as a *hazardous substance* under Subparagraphs (A) through (F) of 42 U.S.C. §9601(14), natural gas, natural gas liquids, liquefied natural gas, and synthetic gas usable for fuel (or mixtures of natural gas and such synthetic gas). (The word fraction refers to certain distillates of crude oil, including but not limited to gasoline, kerosene, diesel oil, jet fuels, and fuel oil, pursuant to Standard Definitions of Petroleum Statistics.[3])

3.3.19 *publicly available, adj*—information that is *publicly available* means that the source of the information allows access to the information by anyone upon request.

3.3.20 *practically reviewable, adj*—information that is *practically reviewable* means that the information is provided by the source in a manner and in a form that, upon examination, yields information relevant to the property without the need for extraordinary analysis of irrelevant data. The form of the information should be such that the *user* can review the records for a limited geographic area. Records that cannot be feasibly retrieved by reference to the location of the property or a geographic area in which the property is located are not generally *practically reviewable*. Most databases of public records are *practically reviewable* if they can be obtained from the source agency by the county, city, zip code, or other geographic area of the facilities listed in the record system. Records that are sorted, filed, organized, or maintained by the source agency only chronologically are not generally *practically reviewable*. Listings in *publicly available* records that do not have adequate address information to be located geographically are not generally considered *practically reviewable*.

3.3.21 *reasonably ascertainable, adj*—information that is *(1) publicly available*, *(2)* obtainable from its source within reasonable time and cost constraints, and *(3) practically reviewable*.

3.3.22 *recognized environmental condition, REC, n*—the presence or likely presence of any hazardous substances or petroleum products in, on, or at a property: *(1)* due to any release to the environment; *(2)* under conditions *indicative of a release* to the environment; or *(3)* under conditions that pose a material threat of a future release to the environment.

3.3.22.1 *Discussion—de minimis conditions*—The *REC* term is not intended to include *de minimis conditions* that generally do not present a material risk of harm to public health or the environment and that generally would not be the subject of an enforcement action if brought to the attention of appropriate governmental agencies. Conditions determined to be *de minimis* are not *RECs*.

3.3.23 *records review, n*—that part that is contained in Section 8 of this guide that addresses which records should or may be reviewed.

3.3.24 *solid waste disposal site, n*—place, location, tract of land, area, or premises used for the disposal of solid wastes as

[3] *Standard Definitions of Petroleum Statistics*, American Petroleum Institute, Fourth Edition, 1988.

defined by state solid waste regulations. The term is synonymous with the term *landfill* and is also known as a garbage dump, trash dump, or similar term.

3.3.25 *solvent, n*—chemical compound that is capable of dissolving another substance and may itself be a *hazardous substance*, used in a number of manufacturing/industrial processes including but not limited to the manufacture of paints and coatings for industrial and household purposes, equipment clean-up, and surface degreasing in metal fabricating industries.

3.3.26 *standard environmental record sources, n*—those records specified in subsection 8.1.3 of this guide.

3.3.27 *standard historical sources, n*—those sources of information about the history of uses of a property as specified in subsection 8.4 of this guide.

3.4 *Acronyms:*

3.4.1 *AOC*—Area of concern

3.4.2 *CERCLA*—Comprehensive Environmental Response, Compensation and Liability Act of 1980 (as amended, 42 U.S.C. §§9601 *et seq*.)

3.4.3 *CFR*—Code of Federal Regulations

3.4.4 *COC*—Chemical(s) of concern

3.4.5 *DNAPL*—Dense nonaqueous phase liquid (a separate phase groundwater contaminant that is both denser than water and its concentration exceeds its solubility in water)

3.4.6 *EPA*—United States Environmental Protection Agency

3.4.7 *ESA*—Environmental site assessment

3.4.8 *LNAPL*—Light nonaqueous phase liquid (a separate phase groundwater contaminant that is less dense than water and its concentration exceeds its solubility in water)

3.4.9 *NAPL*—Nonaqueous phase liquid

3.4.10 *NPL*—National Priorities List

3.4.11 *REC*—Recognized environmental condition

3.4.12 *TP*—Target property

3.4.13 *USC*—United States Code

3.4.14 *USGS*—United States Geological Survey

3.4.15 *VEC*—Vapor encroachment condition

3.4.16 *VES*—Vapor encroachment screen

3.4.17 *VOC*—Volatile organic compound

4. Significance and Use

4.1 *Uses*—This guide is intended for use on a voluntary basis by parties who wish to conduct a *VES* on a parcel of *real estate* to determine if a *VEC* is identified for the *TP* (that is, the presence or likely presence of *COC* vapors in the vadose zone of the *TP* caused by the release of vapors from contaminated soil and/or groundwater either on or near the TP as identified by the Tier 1 or Tier 2 procedures in this guide). The process defined in this guide is a screening process that requires information similar to information generally collected as part of a Practice E1527 *Phase I ESA* as well as additional information described in subsection 5.3 and Section 8 of this guide. If a *VEC* is identified by this screening process, the *user* may conduct further investigation. This guide, however, defines a procedure for determining in connection with a property involved in a *real estate transaction* whether a *VEC* exists or does not exist. A "*VEC* exists" determination is appropriate, for example, when there is known *COC* contamination in, at or on the *TP*, such as may be the case when *COC*-contaminated groundwater exists in the subsurface of the *TP*. A "*VEC* does not exist" determination is appropriate, for example, when subsurface sampling has confirmed that *COC's* are not present. The guide can be applied to property with existing structures, property with structures that will be substantially rehabilitated, property without existing structures but having planned structures (for example, property in development), or property without existing structures and with no planned structures (for example, undeveloped property with no planned development).

4.2 *Clarifications on Use:*

4.2.1 *Use in Conjunction with Practice E1527 Phase I ESA*—This guide, when used in conjunction with Practice E1527 *Phase I ESA*, may assist the *user* and *environmental professional* in developing information about *VECs* associated with a *TP*. This guide has utility for a wide range of persons, including those who may not be involved in a *real estate transaction*.

4.2.2 *Independent Use*—This guide may be used independent of a Practice E1527 *Phase I ESA* to determine if a *VEC* exists or does not exist.

4.2.3 *Site-Specific*—This guide is property specific in that it relates to screening of *VECs* associated with a specific parcel of *real estate*. Consequently, this guide does not address many additional issues raised in transactions such as purchases of business entities or interests therein, or of their assets, that may well involve environmental liabilities pertaining to properties previously owned or operated or other off-site environmental liabilities. The guide does not replace a *Phase I ESA* conducted by an *environmental professional* or any obligation of the *environmental professional* under Practice E1527 to identify all *recognized environmental conditions (RECs)* related to the *TP*.

4.3 *Who May Conduct*—A *VES* should be performed by an *environmental professional*. No practical standard can be designed to eliminate the role of professional judgment and the value and need for experience in the party performing the investigation. The professional judgment of an *environmental professional* is, consequently, vital to the performance of this screening (refer also to Appendix X2).

4.4 *Additional Services Contracted For*—Additional services may be contracted for between the *user* and the *environmental professional*. Such additional services may include *business environmental risk* issues not included within the scope of this guide (see subsection 11.3 for some possible examples).

4.5 *Principles*—The following principles are an integral part of this guide and are intended to be referred to in resolving any ambiguity or exercising such discretion as is accorded the *user* or *environmental professional* in performing a *VES*.

4.5.1 *Uncertainty Not Eliminated in Screening*—No vapor encroachment screen, such as included in Sections 8 and 9 of this guide, can wholly eliminate uncertainty regarding the

identification of *VECs* in connection with a *TP*. Screening is intended to reduce, but not eliminate, uncertainty regarding whether or not a *VEC* exists in connection with a property.

4.5.2 *Not Exhaustive*—The guide is not meant to be an exhaustive screening. There is a point at which the cost of information obtained or the time required to gather it outweighs the usefulness of the information and, in fact, may be a material detriment to the orderly completion of *real estate transactions*. One of the purposes of this guide is to identify a balance between the competing goals of limiting the costs and time demands inherent in performing a *VES* and the reduction of uncertainty about unknown conditions resulting from additional information.

4.5.3 *Level of Investigation is Variable*—Not every property will warrant the same level of screening. The appropriate level of screening should be guided by the nature of the property subject to screening and the information already available or developed in the course of the investigation.

4.5.4 *Comparison with Subsequent Investigation*—It should not be concluded or assumed that an investigation was not adequate because the investigation did not identify *VECs* in connection with a property. The *VES* must be evaluated based on the reasonableness of judgments made at the time and under the circumstances in which they were made. Subsequent *VESs* should not be considered valid bases to judge the appropriateness of any prior screening if based on hindsight, new information, use of developing technology or analytical techniques, or similar factors.

4.6 *Continued Viability of VES*—Subject to subsection 4.7, a *VES* conducted according to the procedures presented in this guide and completed less than 180 days before the date of acquisition of the property or, for transactions not involving an acquisition, the date of the intended use of the *VES*, is presumed to be valid. Subject to subsection 4.7 and the *user's* responsibilities set forth in Section 6, a *VES* conducted according to the procedures presented in this guide and for which the information was collected or updated within one year before the date of acquisition of the property or, for transactions not involving an acquisition, the date of the intended use of the *VES* may be used provided that the following components of the investigation were conducted or updated within 180 days of the date of purchase or the date of the intended transaction:

4.6.1 Reviews of federal, tribal, state, and local government records;

4.6.2 Update on the operations existing at the *TP*;

4.6.3 Evaluation of any new potential preferential pathways for vapor migration;

4.6.4 Screening of any new *contaminated plume* migration that might cause a *VEC* on the *TP*; and

4.6.5 Screening of any new contaminant releases in the *AOC* that might cause a *VEC* on the *TP*.

4.7 *Use of a Prior VES Screen*—This guide recognizes that *VESs* performed in accordance with this guide will include information that subsequent *users* may want to use to avoid undertaking duplicative screening procedures. Therefore, this guide describes procedures to be followed to assist *users* in determining the appropriateness of using information in *VESs* performed more than one year prior to the date of acquisition of the property or, for transactions not involving an acquisition, the date of the intended use of the *VES*. The use of a prior *VES* is based on the following principles that should be adhered to in addition to the specific procedures set forth elsewhere in this guide:

4.7.1 *Use of Prior Information*—Subject to the criteria set forth in subsection 4.6, *users* and *environmental professionals* may use information in a prior *VES* provided such information was generated as a result of procedures that are consistent with the procedures presented in this guide. However, such information should not be used without current investigation of conditions likely to affect *VECs* in connection with the *TP*. Additional investigation may be necessary to document conditions that may have changed materially since the prior *VES* was conducted.

4.7.2 *Contractual Issues Regarding Use of a Prior VES*—The contractual and legal obligations between prior and subsequent *users* of a *VES* or between *environmental professionals* who conducted the prior *VES* and those who would like to use such a prior *VES* are beyond the scope of this guide.

4.8 *Actual Knowledge Exception*—If the *user* or *environmental professional* conducting a *VES* has *actual knowledge* that the information being used from a prior *VES* is not accurate or if it is *obvious*, based on other information obtained by means of a Phase I and/or Phase II *ESA* or known to the person conducting the Phase I and/or Phase II *ESA*, that the information being used is not accurate, such information from a prior *VES* may not be used.

4.9 *Rules of Engagement*—The contractual and legal obligations between an *environmental professional* and a *user* (and other parties, if any) are outside the scope of this guide. No specific legal relationship between the *environmental professional* and the *user* is necessary for the *user* to implement the procedures presented in this guide.

5. Relationship to Practice E1527 Phase I ESA

5.1 *Identification of a REC Pursuant to a Phase I ESA*—*RECs* are identified only through the performance of a Practice E1527 *Phase I ESA*. Thus, a finding pursuant to this guide that a *VEC* exists at the *TP* is not a determination that a *REC* exists at the *TP*. Whether a *REC* exists at a *TP* as a result of the impact of possible vapor migration into the vadose zone of the *TP* is a separate determination to be made by the *environmental professional* pursuant to Practice E1527. This guide does not constitute or meet the requirements for conducting "all appropriate inquiry" or any part of "all appropriate inquiry" as defined by U.S. EPA under CERCLA and the regulations there under, including 40 CFR Sec. 312.11.

5.2 *VES*—The *VES* established by this guide is intended to be used independently of or in conjunction with Practice E1527 *Phase I ESA*.

5.2.1 The *VES* may be conducted concurrently with the Practice E1527 *Phase I ESA*.

5.2.2 The *VES* may be conducted independent of a Practice E1527 *Phase I ESA*. When conducting a *VES* pursuant to this guide, the data collection actions specified in this guide should be implemented (see subsection 5.3 and Section 8).

5.3 *Use of Information Collected in a Phase I ESA Conducted in Accordance with the Practice E1527 Standard*—The screening (see Section 8) identified in this guide makes use of information similar to information generally collected as part of a Practice E1527 *Phase I ESA* as well as additional information described below and in Section 8 of this guide. The information that should be collected includes, but is not limited to, federal, state, local, and tribal government records, chemical use and historical records of prior uses on the *TP* and within the *AOC* surrounding the *TP* as determined by the procedures set out in Section 8, soil characteristics, geological characteristics, contaminant characteristics, *contaminated plume* migration, significant conduits that might provide preferential pathways for vapor migration, groundwater depth and groundwater flow direction data, and property information data.

5.4 *Assumptions Made in the Practice E1527 Phase I ESA*—Any assumptions or limitations made in the conduct of a *Phase I ESA* on the *TP* and that are applicable in the *VES* process as described in this guide should be specifically identified.

6. User's Responsibilities

6.1 *Scope*—The purpose of this section is to describe tasks that should be performed by the *user* that will help the *environmental professional* identify the possibility for a *VEC* to exist in connection with the *TP*. These tasks do not require the technical expertise of an *environmental professional*, although a *user* could ask the *environmental professional* to perform those tasks that could be performed by an *environmental professional*. In a *real estate transaction*, it is common to find the *user* to be the prospective property purchaser (although the *user* could be a lender or other entity with an interest in conducting a screening pursuant to this guide), with the *environmental professional* working for the *user*. Although the property *owner* (that is, the seller), *operator*, and/or *occupants* may possess information that would be useful to the *VES* established by this guide, absent an applicable legal requirement, the property *owner*, *operator*, and/or *occupants* are not required to provide the *user* with information about the *TP*. The *user* or the *environmental professional* or both need to determine the best methods for obtaining information that may be useful in the conduct of the *VES*, recognizing that, absent an applicable legal requirement, the property *user*, *operator*, and/or *occupants* are not required to provide such information to the *user* or the *environmental professional*. Subsection Appendix X3 provides a sample questionnaire that identifies information on the *TP* that may be useful in conducting a *VES* and identifying *VECs* in connection with the *TP*.

6.2 *Specialized Knowledge or Experience of the User*—The *environmental professional* conducting the *VES* should ask the *user* if the *user* has any specialized knowledge or experience that may be important to the screening of *VECs* in connection with the *TP*. It is the *user's* responsibility to respond to the questions asked by the *environmental professional* with information based on such specialized knowledge or experience. The *user* should respond to the *environmental professional's* questions before the *environmental professional* conducts the *VES*. Such specialized knowledge might include, for example, tenant odor complaints or occupancy-related health issues.

6.3 *Commonly Known or Reasonably Ascertainable Information*—The *environmental professional* conducting the *VES* should ask the *user* if the *user* is aware of any information commonly known or *reasonably ascertainable* within the local community about the *TP* that the *environmental professional* informs the *user* may be important to the screening of *VECs* in connection with the *TP*. It is the *user's* responsibility to respond to questions asked by the *environmental professional*. The *user* should respond to the *environmental professional's* questions before the *environmental professional* conducts the *VES*. Such information might include, for example, the existence locally of publicized area-wide *COC-contaminated groundwater plumes*.

6.4 *Requests for Information from the Property Owner, Operator, and/or Occupants*—Because, absent an applicable legal requirement, the property *owner*, *operator*, and/or *occupants* do not have an obligation to provide information about the *TP* to the *user* or the *environmental professional* or both, any requests for information about the *TP* submitted by the *user* or the *environmental professional* or both to the property *owner*, *operator*, and/or *occupants* should not suggest or imply that such persons are under any obligation to provide the information, unless an applicable legal requirement applies. Accordingly, the *user* or *environmental professional* or both should identify and be prepared to pursue methods for obtaining information about the *TP* relevant to the *VES* other than by obtaining such information from the property *owner*, *operator*, and/or *occupants*.

6.5 *Other*—Either the *user* should inform the *environmental professional* why the user wants to have the *VES* performed or, if the *user* does not identify the purpose of the *VES*, the *environmental professional* should assume the purpose is to identify whether a *VEC* exists at the *TP*. The *user* and the *environmental professional* may also need to modify the scope of services performed under this guide for special circumstances, including, but not limited to, unique local or site-specific conditions.

7. General Vapor Encroachment Screening Process

7.1 The purpose of a *VES* is to determine, to the extent feasible pursuant to the procedures presented in this guide, if a *VEC* exists at the *TP*. The *VES* process is intended to be used independently of, or in conjunction with, but not as a replacement of, the existing Practice E1527 *Phase I ESA*. It is possible that the *VES* process described in this guide may complement requirements of existing federal, state, local, or other applicable vapor encroachment or intrusion laws, regulations, policies, or guidance. Subsections Appendix X5 and Appendix X9 identify selected federal, state, local, and other vapor encroachment and intrusion evaluation resources.

7.2 *General VES Process*—The *VES* process is a two-tiered screening process. The information to conduct a Tier 1 screen is similar to information generally collected as part of a *Phase I ESA* investigation and includes additional information described in subsection 5.3 and Section 8 of this guide and is

typically focused on known or suspected contaminated properties that may exist in the *AOC* but should not necessarily be so limited. Tier 2 focuses on characteristics of the *contaminated plume* associated with *contaminated properties* and the proximity of said *contaminated plume* to the *TP*. The information to conduct a Tier 2 screen is often found in state regulatory files and may also be obtained from other available documents or may be collected via sampling in the field or both.

7.3 *Report*—A separate *report* should be prepared (see Section 10), unless the *VES* is being performed in conjunction with a *Phase I ESA* conducted on the *TP*, in which case the *VES* findings and conclusions can be provided with the Phase 1 report.

7.4 *Coordination of Parts:*

7.4.1 *Parts Used in Concert*—The government and historical *records review*, and other information collected, such as from the *Phase I ESA*, are intended to be used in concert with each other. If information from one source indicates the need for more information, other sources may be available to provide information.

7.4.2 *User's Obligations*—The *environmental professional* should note in the *report* whether or not the *user* has reported to the *environmental professional* information pursuant to Section 6 of this guide.

7.5 *Who May Conduct a VES:*

7.5.1 *Environmental Professional's Duties*—The *VES* should be performed by an *environmental professional* or conducted under the supervision of an *environmental professional*. This can be the same individual(s) responsible for conducting the Practice E1527 *Phase I ESA*. The individual(s) conducting the *VES* should possess sufficient training and experience necessary to conduct the screening and evaluation in accordance with this guide and have the ability to identify issues relevant to *VECs* in connection with the *TP* (refer also to Appendix X2). At a minimum, the *environmental professional* should be involved in planning the screening scope of work and in reviewing and interpreting information upon which the *report* is based.

7.5.2 *Information Obtained From Others*—Information for the *records review* needed for completion of a *VES* may be provided by a number of parties including government agencies, third-party vendors, the *user*, and present and past *owners*, *operators*, and *occupants* of the property, provided that the information is obtained by or under the supervision of an *environmental professional* or is obtained by a third-party vendor specializing in retrieval of such information. Prior *Phase I ESAs* may also contain information that could be appropriate for use in a current *VES*. The *environmental professional(s)* responsible for the *report* should review the information provided.

7.5.3 *Reliance*—An *environmental professional* is not required to verify independently the information provided by others and may rely on the information provided unless in the exercise of professional judgment it would be unreasonable to do so or the *environmental professional* has *actual knowledge* that certain information is incorrect or unless it is *obvious* that certain information is incorrect based on other information obtained in the *VES* or otherwise actually known to the *environmental professional*.

8. Tier 1 Screening

8.1 *Introduction:*

8.1.1 *Objective*—The purpose of Tier 1 is to conduct a screen for vapor encroachment using information collected in the *Phase I ESA* or similar type of investigation to determine if a *VEC* exists at the *TP*. Tier 1 may be performed in conjunction with a Practice E1527 *Phase I ESA* or stand on its own if not conducted in conjunction with a *Phase I ESA*. When used in conjunction with a *Phase I ESA*, the *environmental professional* should use to the maximum extent possible information collected in the *Phase I ESA* and should also use additional information as described in subsection 5.3 and this section. If the Tier 1 screen identifies that a *VEC* exists, a Tier 2 screen can be conducted to obtain greater certainty.

8.1.2 Tier 1 screening begins with the default *AOC* defined by the *approximate minimum search distances* (see 8.1.3), adjusted as appropriate for local conditions, and then determining if known or suspected contaminated properties with *COCs* exist within the established *AOC*.

8.1.3 *Approximate minimum search distances* surrounding the *TP* to identify the default *AOC* are provided below. The default *AOC* is one third of a mile around the *TP* for *COCs* and one-tenth of a mile for petroleum hydrocarbon *COCs*. The *AOC* is measured from the *TP* boundary to a *contaminated property* with known or suspected *COC* contamination of soil or groundwater or both (for example, a dry cleaner site using perchloroethylene as the cleaning solvent). The term *approximate minimum search distance* is used in lieu of radius to include irregularly shaped properties.

Standard Environmental Record Sources (where available)	Default Approximate Minimum Search Distance—Surrounding the Target Property, miles	
	Chemicals of Concern	Petroleum Hydrocarbon Chemicals of Concern
Federal *NPL* site list	⅓	1/10
Federal CERCLIS list[A]	⅓	1/10
Federal RCRA CORRACTS facilities list	⅓	1/10
Federal RCRA non-CORRACTS TSD facilities list	⅓	1/10
Federal *RCRA generators list*	*property* only	*property* only
Federal institutional control/engineering control registries	*property* only	*property* only
Federal *ERNS list*	*property* only	*property* only
State and tribal lists of *hazardous waste* sites identified for investigation or remediation:		
State- and tribal-equivalent *NPL*	⅓	1/10
State- and tribal-equivalent CERCLIS	⅓	1/10
State and tribal *landfill* and/or *solid waste disposal site* lists	⅓	1/10
State and tribal leaking storage tank lists	⅓	1/10
State and tribal registered storage tank lists	*property* only	*property* only
State and tribal institutional control/ engineering control registries	*property* only	*property* only
State and tribal voluntary cleanup sites	⅓	1/10

Standard Environmental Record Sources (where available)	Default Approximate Minimum Search Distance—Surrounding the Target Property, miles	
	Chemicals of Concern	Petroleum Hydrocarbon Chemicals of Concern
State and tribal Brownfield sites	1/3	1/10

[A] The CERCLIS information system supporting CERCLA has been retired by EPA and replaced by SEMS (Superfund Enterprise Management System).

8.1.4 *Adjusting the Default AOC*—The default *AOC* may be expanded or reduced by the *environmental professional* (adjusted *AOC*) using experience and professional judgment. Consideration may be given, for example, to groundwater flow direction, subsurface characteristics, surficial features and man-made features.

8.1.4.1 *Groundwater flow direction.*

(1) If groundwater flow direction is known or can be inferred, for example, from the *Phase I ESA* investigation of the *TP*, the default *AOC* in the down-gradient direction may be reduced to the area within the critical distance, i.e., 100 feet. The *AOC* in the cross-gradient direction may also be reduced, depending upon the *critical distance* and the width of the *COC-contaminated plume* associated with a known or likely *COC-contaminated property* located in a cross-gradient direction from the *TP*. For this guide, the *critical distance* is defined in subsection 9.2.

(2) Down-Gradient Off-Site COC Contaminated Property—For a *COC-contaminated property* identified in Tier 1 located down-gradient from the *TP*, it is not necessary to have information on migrating groundwater *contaminated plume* dimensions as the *critical distance* is measured from the nearest *TP* boundary to the source of contamination at the off-site down-gradient property. In this case, the *AOC* may be reduced to the area within the *critical distance* (see subsection 9.2).

(3) Cross-Gradient Off-Site Contaminated Property—For a *contaminated property* identified in Tier 1 located cross-gradient from the *TP*, the *AOC* will be the area within the *critical distance* plus one half of a reasonable estimation of the *contaminated plume* width (at the point nearest the closest *TP* boundary) that might be associated with the nearby known or suspected *COC-contaminated property* (that is, the *COC-contaminated property* where the groundwater contamination originated). The *environmental professional's* judgment and experience can be used to estimate the width of the *COC-contaminated plume* that might be associated with the nearby known or suspected *COC-contaminated property*. If it is not possible to estimate the *contaminated plume* width, then the *AOC* cannot be reduced in the cross-gradient direction.

8.1.4.2 *Subsurface characteristics.*

(1) Low-permeability soil, such as soil high in clay or silt content or both generally tends to restrict soil gas movement, as also may soil with high-moisture content or high organic carbon content. High permeability soil tends to enhance soil gas movement;

8.1.4.3 *Surface natural features*—Surface natural features such as surface water and wetlands.

8.1.4.4 *Surface man-made features*—Surface man-made features such as the presence of potential vapor interceptors including utility corridors that may direct migrating vapors away from the *TP*.

8.1.5 Once the *AOC* is established, Tier 1 screening involves evaluating whether any known or suspected properties that may be associated with *COCs* are located within the established *AOC*. If the *VES* is conducted in conjunction with a Practice E1527 *Phase 1 ESA*, Tier 1 uses information collected during the *Phase 1 ESA* process and additional information as described in subsection 5.3 and this section.

8.1.6 It is recommended that, at a minimum, a Tier 1 screen include the following information:

8.1.6.1 Existing/planned use of the *TP* (that is, developed, undeveloped, industrial, commercial, or residential), if it can be ascertained. If the future use is uncertain, then the *environmental professional* should assume the most conservative use for the category in which the property is zoned. If zoning information is not available, then the *environmental professional* should assume residential use.

8.1.6.2 Type of structures existing or planned on the *TP* (for example, single-family residential, multifamily residential, office, industrial, retail, hotel, warehouse, institutional, and so forth).

8.1.6.3 Surrounding area description.

8.1.6.4 Federal, state, local, and tribal government records on the *TP* and for the established *AOC* to identify known or suspected potentially *contaminated property* sources with *COC* on or within the *AOC* (see subsection 8.1.3).

8.1.6.5 Historical records related to prior use of the *TP* and surrounding properties within the established *AOC* to identify known or suspected potentially *contaminated property* sources having *COC* within the established *AOC*, including on the *TP* (see subsection 8.4.2).

8.1.6.6 General physical setting information including local soil type, and geological, hydrological, hydrogeological, and topographical information.

8.1.6.7 Significant natural or man-made conduits that can serve as preferential pathways, such as utility corridors, sewers, storm drains, Karst terrain, fractured bedrock, and so forth, that may provide a more direct path for vapors to encroach upon the *TP*.

8.1.6.8 *User*-specialized knowledge, experience, and commonly known or *reasonably ascertainable* information related to the *TP* and the area within the established *AOC* that has been provided to or collected by the *environmental professional*.

8.1.6.9 If the *VES* is conducted in conjunction with a *Phase I ESA*, all of the information collected in the *Phase I ESA* investigation as well as additional information collected pursuant to this guide (see subsection 5.3 and this section), including information collected in site reconnaissance and interviews and actual or probable chemical usage on the *TP* or within the established *AOC*, should be considered in conducting the *VES*. If the *VES* is not conducted in conjunction with a *Phase I ESA*, the *environmental professional* should collect and review the information identified in subsections 8.1.6.1 – 8.1.6.8 on the *TP* and within the established *AOC*, including information (such as *COC* usage and the potential for release)

obtained from site reconnaissance and as a result of interviews of knowledgeable site personnel.

8.1.7 Prior *VESs* associated with the *TP* should be considered and evaluated by the *environmental professional* consistent with the provisions of 4.6 and 4.7.

8.2 *Government Records Review:*

8.2.1 *Area of Concern* (default *AOC* when defined by the *Approximate Minimum Search Distance*, or the adjusted *AOC* when the default *AOC* is adjusted by the *environmental professional*)—Records to be reviewed pertain to the *TP* and to properties within the established *AOC*.

8.2.2 *Accuracy and Completeness*—Accuracy and completeness of record information varies among information sources, including governmental sources. Record information is often inaccurate or incomplete. The *user* or *environmental professional* is not obligated to identify mistakes or insufficiencies in information provided. However, the *environmental professional* reviewing records should make a reasonable effort to compensate for mistakes or insufficiencies in the information reviewed that are *obvious* in light of other information of which the *environmental professional* has actual knowledge.

8.2.3 *Reasonably Ascertainable/Standard Sources*—Availability of record information varies from information source to information source, including governmental jurisdictions. The *user* or *environmental professional* is not obligated to identify, obtain, or review every possible record that might exist with respect to a property. Instead, this guide identifies record information that should be reviewed from standard sources, and the *user* or *environmental professional* should review only record information that is *reasonably ascertainable* from those standard sources. Record information that is *reasonably ascertainable* means *(1)* information that is *publicly available*, *(2)* information that is obtainable from its source within reasonable time and cost constraints, and *(3)* information that is *practically reviewable*.

8.2.3.1 *Publicly Available*—Information that is *publicly available* means that the source of the information allows access to the information by anyone upon request.

8.2.3.2 *Reasonable Time and Cost*—Information that is obtainable within reasonable time and cost constraints means that the information will be provided by the source within 20 calendar days of receiving a written, telephone, or in-person request at no more than a nominal cost intended to cover the source's cost of retrieving and duplicating the information. Information that can only be reviewed by a visit to the source is *reasonably ascertainable* if the visit is permitted by the source within 20 days of request.

8.2.3.3 *Practically Reviewable*—Information that is *practically reviewable* means that the information is provided by the source in a manner and in a form that, upon examination, yields information relevant to the property without the need for extraordinary analysis of irrelevant data. The form of the information should be such that the *user* can review the records for a limited geographic area. Records that cannot be feasibly retrieved by reference to the location of the property or a geographic area in which the property is located are not generally *practically reviewable*. Most databases of public records are *practically reviewable* if they can be obtained from the source agency by the county, city, zip code, or other geographic area of the facilities listed in the record system. Records that are sorted, filed, organized, or maintained by the source agency only chronologically are not generally *practically reviewable*. Listings in *publicly available* records that do not have adequate address information to be located geographically are not generally considered *practically reviewable*.

8.2.4 *Alternatives to Standard Sources*—Alternative sources may be used instead of standard sources if they are of similar or better reliability and detail or if a standard source is not *reasonably ascertainable*.

8.2.5 *Coordination*—If records are not *reasonably ascertainable* from standard sources or alternative sources, the *environmental professional* should attempt to obtain the requested information by other means specified in this guide.

8.2.6 *Sources of Standard Source Information*—Standard source information or other record information from government agencies may be obtained directly from these government agencies or from commercial services. Government information obtained from nongovernmental sources may be considered current if the source updates the information at least every 90 days or, for information that is updated less frequently than quarterly by the government agency, within 90 days of the date the government agency makes the information available to the public.

8.2.7 *Documentation of Sources Checked*—The *report* should document each source that was used, even if a source revealed no findings. Sources should be sufficiently documented, including name, date request for information was filled, date information provided was last updated by source, and date information was last updated by original source (if provided other than by original source). Supporting documentation should be included in the *report* or adequately referenced to facilitate reconstruction of the screening by an *environmental professional* other than the *environmental professional* who conducted it.

8.2.8 *Significance*—If a *standard environmental record source* (including, if relevant, a source used in the course of conducting a *Phase I ESA* on the *TP*) identifies the *TP* or a *contaminated property* within the *AOC* defined by subsections 8.1.3 and 8.1.4, the *report* should include the *environmental professional's* judgment about the significance of the listing with respect to analysis of *VECs* in connection with the *TP*.

8.3 *Environmental Information:*

8.3.1 *Standard Environmental Record Sources*—The *standard environmental record sources* identified in 8.1.3 should be reviewed to identify if there are known or suspected sources of *COC-contamination* within the established area of concern (*AOC*), which is the default *AOC* when defined by the *approximate minimum search distances* or as the adjusted *AOC* when the default *AOC* is adjusted by the *environmental professional*. The *approximate minimum search distance* is based upon the type of *COC*, that is, petroleum hydrocarbons versus nonpetroleum hydrocarbons, and the location of the known or suspected source of contamination with respect to the *TP*. The search radii for the *approximate minimum search distances* are defined in subsection 8.1.3 and should be measured from the nearest *TP* boundary. The *VES* process to be

followed using these criteria is described in subsection 8.5. The *approximate minimum search distances* may be expanded or reduced (adjusted *AOC*) in the up-gradient, down-gradient, and/or cross-gradient directions by the *environmental professional* conducting the *VES* based upon experience in the local area and applying professional judgment to factors such as groundwater flow direction, hydrogeological and hydrologic considerations, subsurface geologic features, topographical gradients, and/or available groundwater flow information, which factors *(1)* are known to the *environmental professional* and/or *(2)* have been collected in a *Phase I ESA* on the *TP*, and/or collected in a *Phase II* delineation of contamination *report* associated with the *TP* and/or collected in similar reports associated with contaminated properties within the established *AOC*. If there are known or suspected property sources of contamination within the established *AOC*, the *environmental professional* should evaluate whether *COC* may be present at the *TP*. *Petroleum hydrocarbon chemicals of concern* are distinguished from other *COC* because petroleum hydrocarbons often undergo more rapid biodegradation in the vadose zone in the presence of oxygen.

8.3.2 *Physical Setting Characteristics*—Information about the geologic, hydrologic, hydrogeologic, and topographic characteristics of a site should be considered to assist in the screening for the possibility of *COC* vapors to migrate from contaminated soil or groundwater or both to the *TP*.

8.4 *Current and Historical Use Information:*

8.4.1 *Objective*—The objective of reviewing current property use and consulting historical sources is to develop a history of the uses of the *TP* and within the established *AOC* to help identify the likelihood of uses leading to *VECs* in connection with the *TP*. The boundaries of the *AOC* (defined by the *approximate minimum search distance* (default *AOC*) or the *AOC* as adjusted by the *environmental professional*) for evaluating past uses involving *COC* should be established consistent with subsections 8.1.3, 8.1.4.1, 8.2.3, and 8.3.1. Current or past uses such as gas stations (using petroleum hydrocarbons), dry cleaning establishments (using chlorinated volatile organic compounds such as perchloroethylene), former manufactured gas plant sites (using volatile and semi-volatile organic compounds) and former industrial sites such as those that had vapor degreasing or other parts cleaning operations on site (using chlorinated volatile organic compounds such as trichloroethylene) are of particular concern for a *VES*.

8.4.2 *Standard Historical Sources:*

8.4.2.1 *Applicable Historical Sources*—The standard historical sources (which are identified in Practice E1527 *Phase I ESA*) that will provide the most useful information for conducting the *VES* include: *(1)* fire insurance maps, *(2)* local street directories, *(3)* aerial photographs, and *(4)* USGS topographic maps.

NOTE 1—It is recognized that, depending upon the site setting, one or more of these four historical sources may not be available or useful. In addition, when conducted in conjunction with a *Phase I ESA*, at the minimum, only those historical sources relied upon in performing the *Phase I ESA* are necessary for purposes of a *VES*

8.4.2.2 *Fire Insurance Maps*—The term *fire insurance maps* means maps produced for private fire insurance map companies that indicate uses of properties, at specified dates, that are within the established *AOC*. These maps are often available at local libraries, historical societies, private resellers, or from the map companies that produced them.

8.4.2.3 *Local Street Directories*—The term *local street directories* means directories published by private (or sometimes government) sources and showing ownership and/or use of sites by reference to street addresses. Often *local street directories* are available at libraries of local governments, colleges or universities, or historical societies.

8.4.2.4 *Aerial Photographs*—Historical *aerial photographs*, typically going back to the early 1930s, may allow identification of activities on the *TP* and within the established *AOC*. *Aerial photographs* are often available from government agencies, commercial aerial photography companies, and private collections unique to a local area.

8.4.2.5 *USGS Topographic Maps*—Historical USGS *topographic maps* may provide an indication of past uses of the *TP* and of properties within the established *AOC*. These maps are available from the U.S. Geological Survey.

8.4.2.6 *Other Historical Sources*—The term *other historical sources* means any source or sources other than those designated in subsections 8.4.2.2 – 8.4.2.5 that are credible to a reasonable person and identify past uses of the *TP* and properties within the established *AOC*. This category includes, but is not limited to, miscellaneous maps, newspaper archives, internet sites, community organizations, local community knowledge, local libraries, historical societies, current *owners* or *occupants* of neighboring properties, or records in the files and/or personal knowledge of the property *owner*, *operator*, and/or *occupants*, if such personal knowledge is provided to the *user* and/or the *environmental professional*.

8.5 *Tier 1 Screening Evaluation:*

8.5.1 The Tier 1 *VES* consists of the following:

8.5.1.1 *Environmental professional* determination of the *AOC* (i.e., default *AOC* or adjusted *AOC*);

8.5.1.2 Review of the information included in subsections 8.1.3, 8.1.6.1 – 8.1.6.8, combined with the application of professional judgment, to identify known or suspected *COC-contaminated sites* within the established *AOC* (refer to Appendix X6 for a list *COCs*);

8.5.1.3 Professional opinion on whether or not a *VEC* exists;

(1) Location of the known or suspected COC-contaminated property in the established AOC—The closer a known or suspected *COC-contaminated property* is to the *TP*, the greater the probability for a *VEC* to exist, subsurface conditions being equal. When evaluating the location of known or suspected *COC-contaminated properties* within the established *AOC*, the *environmental professional* should also take into consideration locations where the existing groundwater gradient can change significantly, for example, as a result of seasonal influences, tidal influences, and so forth. Soil gas migration may be independent of the groundwater gradient.

(2) Depth to Groundwater—The greater the depth to potentially contaminated groundwater containing *COC*, the greater the distance *COC* vapors may have to travel in the vadose zone, assuming there are no preferential pathways and subsurface conditions being equal. If *COC-contaminated*

groundwater exists in the subsurface of the *TP* regardless of its depth, a *VEC* exists. However, the depth of the contaminated groundwater may influence the decision on whether or not the *VEC* represents a *REC* on the *TP*.

(3) Vapor Conduits that may Result in Significant Preferential Pathways—Man-made conduits such as utility corridors, sanitary sewers, and storm sewers and significant natural conduits such as Karst terrain or fractured bedrock can sometimes create a sufficiently direct pathway from a vapor contaminant source to the subsurface of the *TP* such that vapor encroachment may be a concern. Vapor encroachment may also be influenced by the age and design of infrastructure features associated with these conduits. When indications of significant preferential pathways exist, the *environmental professional* should take these into consideration in developing an opinion with respect to the potential for vapors to encroach upon the *TP* and result in a *VEC*;

(4) Cleanup Status of COC-Contaminated Property—Factors to consider include when the release occurred, how much *COC* was released, and what remedial action was taken. If a source has been remediated but residual contamination allowed to remain (for example, when remediation includes natural attenuation), the potential for a *VEC* should be evaluated, including an evaluation of whether *COCs* are involved and any information provided in a remediation plan, if available.

8.6 *Tier 1 Conclusions*—The conclusion from the Tier 1 screening is *(1)* a *VEC* exists, or *(2)* a *VEC* does not exist.

8.7 *If a VEC Exists:*

8.7.1 *If the VES is Conducted in Conjunction with an E1527 Phase I ESA*—The source resulting in the *VEC* should be identified and discussed in the *Phase I ESA*. If a *VEC* exists, the *environmental professional* should determine whether or not the *VEC* represents a recognized environmental condition (*REC*). If the *VEC* represents a *REC*, when the environmental professional meets with the user to discuss Phase I investigation results, the user, in consultation with the *environmental professional*, can determine if further investigation, such as conducting a Tier 2 screen as defined in this practice, is warranted.

8.7.2 *If the VES is Conducted Independent of a Phase I ESA*—The *environmental professional* should submit the *VES report* to the *user* (see Section 10 and Appendix X4) with the conclusion that a *VEC* exists and why. The *user*, in consultation with the *environmental professional*, can determine if further investigation, such as conducting a Tier 2 screen as defined in this practice, is warranted.

8.8 *If a VEC Does Not Exist*—If a *VEC* does not exist, the *VES* process is completed in accordance with this guide. The *environmental professional* should report in the *VES report* this conclusion and the data and reasons that support the conclusion.

9. Tier 2 Screening

9.1 *Objective*—If a *VEC* exists as a determined by the Tier 1 screen in accordance with subsections 8.7.1 or 8.7.2, the *user* can undertake more refined screening as provided in Tier 2. Tier 2 applies numeric screening criteria to existing or newly collected soil, soil gas, and/or groundwater testing results to provide greater certainty to whether or not a *VEC* exists. Tier 2 has two data collection components: one non-invasive and one invasive.

9.1.1 *Non-Invasive Data Collection*—If information on the source of contamination and its migration in the subsurface is available and accessible in regulatory files or other available documents, or both, the Tier 2 investigation can be non-invasive. The non-invasive investigation includes review at the appropriate regulatory agency of available extent of contamination *reports* (often referred to as *Phase II reports*) and/or other available documents on known or suspected *contaminated properties* within the established *AOC*. The objective of the non-invasive component of the Tier 2 screen is to identify from existing *Phase II reports* (or similar) and other available information in regulatory agency files and/or from other available information the status of remediation, the size of the *contaminated plume* and its behavior, the specific *COC* and their respective concentrations. Using this information, the plume test (see subsection 9.2) can be performed.

9.1.2 *Invasive Data Collection*—If information on the source of contamination and its migration in the subsurface is not available or accessible or if there are preferential pathways, the Tier 2 screening investigation can be invasive. An invasive investigation may include sampling of soil, soil gas, and/or groundwater on the *TP*, at the *TP* boundary, or off site. The invasive component of the Tier 2 screen requires careful planning by the *environmental professional* to ensure that an appropriate sampling strategy is implemented (see subsection 9.3.1.2).

9.2 *Plume Test and Critical Distance Determination*—If information related to the boundaries of the *contaminated plume* from known *contaminated properties* is available, the *critical distance* test can be conducted. The *critical distance* is the lineal distance in any direction between the nearest edge of the *contaminated plume* and the nearest *TP* boundary, and is equal to 100 ft (30.5 m) for *COC* or 30 ft (9 m) for dissolved petroleum hydrocarbon *COC*. The *critical distance* for petroleum hydrocarbon *COC* as LNAPL is the same as for nonpetroleum hydrocarbon *COC* (that is, 100 ft (30.5 m)). The *critical distance* represents an estimate of the lineal distance *COC* vapors volatilized from contaminated groundwater or contaminated soil might migrate in the vadose zone to the *TP*, which estimate the *environmental professional* should evaluate to determine if it is appropriate for the *VES* being performed (that is, whether the 100- or 30-ft (30.5- or 9-m) distances or both are appropriate or should be modified). The *environmental professional* may modify either of the *critical distance* distances based on experience and the *environmental professional's* evaluation of relevant factors that may include, but are not limited to, the completeness of the *COC*, LNAPL, and/or petroleum hydrocarbon delineation investigation; site-specific conditions, such as, but not limited to, the amount of oxygen in the soil, the physical setting of the *TP* and properties within the established *AOC*, and possible chemical contaminants in the soil that may impact oxygen availability for biodegradation of *COC*, LNAPL, and/or petroleum hydrocarbons; and applicable

state policy or regulation that may specifically address the distance over which *COC* vapors might travel to encroach upon a *TP*. If the *critical distance* is modified by the *environmental professional*, the basis for this modification needs to be documented in the *report*. If the plume test identifies that the *TP* boundary is within the *critical distance* from the nearest edge of the *contaminated plume*, then the *environmental professional* should, through investigation and analysis of data and information compiled as part of the screening evaluation, determine if a *VEC* exists at the *TP*.

9.2.1 If the plume test identifies the distance between the nearest edge of the *contaminated plume* and the nearest *TP* boundary as equal to or greater than the *critical distance*, as determined by the *environmental professional* pursuant to subsection 9.2, then the *environmental professional* may conclude that migrating vapor from the edge of the groundwater or soil *contaminated plume* is not likely to reach the subsurface of the *TP* and the *VES* investigation is completed in accordance with this guide, unless factors such as preferential pathways (see subsection 8.5.1.3*(3)*) or other factors could result in the migration of vapors to the *TP* from a distance greater than the *critical distance*.

9.2.2 *Influence of Off-Site Contaminated Property Location on Tier 2 Screening Data Collection Requirements*—For off-site property sources (for example, a former dry cleaner property that used perchloroethylene) with known or suspected soil and/or groundwater contamination by *COC* located in the established *AOC*, the specific location of such *COC* sources with respect to the *TP* will impact the data collection requirements to conduct a Tier 2 screen. Some examples associated with groundwater *contaminated plumes* are provided in subsections 9.2.2.1 – 9.2.2.3.

9.2.2.1 *Up-Gradient Off-Site Contaminated Property*—For a *COC-contaminated property* located up-gradient of the *TP*, it is necessary to have information on the length (and movement, if available) and depth of the groundwater *contaminated plume* for the *critical distance* determination. Such information is needed to determine the lineal distance (in any direction) from the groundwater *contaminated plume* edge to the nearest *TP* boundary.

9.2.2.2 *Cross-Gradient Off-Site Contaminated Property*—For a *COC-contaminated property* located cross-gradient from the *TP*, the *critical distance* determination requires knowledge of the width and depth of the *contaminated plume* nearest the *TP* boundary. Groundwater *contaminated plume* length information may not be necessary for the evaluation.

9.2.2.3 *Down-Gradient Off-Site Contaminated Property*—For a *COC-contaminated property* located down-gradient from the *TP*, it is not necessary to have information on *contaminated plume* dimensions as the *critical distance* is measured from the nearest *TP* boundary directly to the *COC* source on the off-site down-gradient property that is the origin of the contamination (with understanding the contamination is migrating away from the *TP*).

9.3 *Data Needs*—Data needs for the Tier 2 investigation include:

9.3.1 Soil, soil gas, and/or groundwater testing results associated with the known or suspected source(s) of contamination as determined in the Tier 1 investigation and *(1)* obtained from regulatory agency records review (for example, review of *Phase II reports* on the delineation of contamination or ongoing groundwater monitoring *reports*) or obtained from other sources, *(2)* collected by field sampling; or (3) obtained from a combination thereof.

9.3.1.1 If the regulatory records review or review of other available documents identifies the existence of a *report* on the delineation of contamination, the following information should be reviewed and evaluated by the *environmental professional*: data adequacy, the specific contaminants and their respective concentrations in soil, soil gas, and/or groundwater at the *contaminated plume* boundaries closest to the *TP* and points within the *critical distance*; the depth to the contamination; the direction of groundwater flow; the length and width of the *contaminated plume*; and the status of remedial activity.

9.3.1.2 If sampling of soil, soil gas, and/or groundwater is part of the Tier 2 investigation, an appropriate sampling strategy (typically at the perimeter of the *TP* closest to the off-site source of *COC* vapors, for example, a groundwater *contaminated plume*) should be developed (refer also to Practice E1903) to determine if a *contaminated plume* or *COC* vapors have migrated onto the *TP*.

9.4 *Tier 2 Conclusions*—The conclusion from the Tier 2 screening is: *(1)* a *VEC* exists, or *(2)* a *VEC* does not exist.

10. Evaluation and Report Preparation

10.1 *Report Format*—The *report* for the *VES* should generally follow the recommended *report* format provided in Appendix X4 for presenting the results of the *VES* conducted pursuant to this guide unless otherwise required by the *user*. A separate vapor encroachment *report* is not necessary for either Tier 1 or Tier 2 if the *VES* is conducted in conjunction with the *Phase I ESA*, in which case all of the *VES* developed information, findings, opinions, and conclusions (including, as appropriate, other information described in the following and Appendix X4) can be included as a supplement or an appendix to the *report* prepared pursuant to the *Phase I ESA*.

10.2 *Contents of Report*—The *report* should include information that the *environmental professional* develops from implementing this guide's procedures and provisions, including information that is described in specific provisions of this guide as appropriate for inclusion in the *report* and the information that is described in Appendix X4 ("Recommended Table of Contents and Report Format"), which information includes but is not limited to the following:

10.2.1 *Scope of Services*—The *report* should describe the specific scope of services conducted, including which tiers of the evaluation process have been completed. The *report* should describe all services performed and assumptions made (for example, assumptions and limitations carried over from a *Phase I ESA* investigation) in sufficient detail to permit another party to reconstruct the analysis conducted.

10.2.1.1 *Additional Services Contracted for*—Any additional services contracted for between the *user* and the *environmental professional*, including a broader scope of screening, a detailed vapor intrusion assessment, more detailed conclusions, liability/risk evaluations, recommendation for

additional testing, remediation techniques, and so forth, are beyond the scope of this guide and should be included in the *report* only if so specified in the terms of the engagement letter between the *user* and the *environmental professional*.

10.2.2 *Findings*—The *report* should have a findings section that summarizes the results of the investigation, including whether a *VEC* exists or does not exist (collectively, the "*findings*").

10.2.3 *Opinion*—The *report* should explain the logic and reasoning used by the *environmental professional* in evaluating information collected during the course of the investigation related to the *environmental professional's findings*. The opinion should specifically include the *environmental professional's* rationale for the *findings*.

10.2.4 *Conclusions*—The *report* should include a conclusions section that summarizes the *findings*.

10.2.5 *Deviations*—All deletions and deviations from this guide's procedures (if any) should be listed individually and in detail in the *report*, including *user* -imposed constraints, and all additions should be listed.

10.2.6 *Documentation*—The *findings*, opinions, and conclusions in the *VES report* should be supported by documentation. If the *environmental professional* has chosen to exclude certain documentation from the *report*, the *environmental professional* should identify in the *report* the reasons for doing so (for example, a confidentiality agreement). Supporting documentation should be included in the *report* or adequately referenced to facilitate reconstruction of the screening by an *environmental professional* other than the *environmental professional* who conducted the screening. Sources that revealed no *findings* also should be documented.

10.2.7 *References*—The *report* should include a references section to identify published referenced sources (for example, groundwater plume dimensions from different types of sources, groundwater flow direction, and so forth) relied upon in preparing the *VES*. Each referenced source should be adequately annotated to facilitate retrieval by another party.

10.2.8 *Signature*—The *environmental professional(s)* responsible for the *VES* should sign the report.

10.2.9 *Appendices*—The *report* should include an appendix section containing supporting documentation and the qualifications of the *environmental professional* and the qualifications of the personnel conducting the *VES*.

11. Non-Scope Considerations

11.1 *General*—There may be environmental issues or conditions at a *TP* that parties may wish to assess in connection with a *real estate transaction* that are outside the scope of this guide (that is, non-scope considerations).

11.2 *Other Standards*—There may be standards or protocols for the assessment of non-scope considerations developed by governmental entities, professional organizations, or other private entities. The *environmental professional* should be aware of any requirements related to vapor encroachment screening or vapor intrusion assessment or both, for example, as identified by federal, state, local, or other applicable guidance, policy, or regulation.

11.3 *List of Additional Issues*—Following are several non-scope considerations that persons may want to assess in connection with a *real estate transaction*. No implication is intended as to the relative importance of investigation into such non-scope considerations, and this list of non-scope considerations is not intended to be all inclusive:

11.3.1 Indoor air quality;

11.3.2 Explosion hazard assessment, such as may be appropriate for the case of methane intrusion and buildup. Methane, for example, is a common landfill gas (produced by the bacterial decomposition of organic waste within the landfill) that if not properly vented at the landfill site may migrate to nearby structures and present a health and safety problem. Depending on the nature of the subsurface geology, methane can travel over distances greater than ¼ mile from a landfill;

11.3.3 Naturally occurring gases such as radon associated with certain types of subsurface geology and hydrogen sulfide and methane from oil fields;

11.3.4 Vapor intrusion assessment at the *TP* and/or vapor mitigation system selection, design, and implementation at the *TP* (see Appendix X7, Generalized Guidance on Vapor Intrusion Assessment and Mitigation Alternatives);

11.3.5 Health threat assessment notification or communication; and

11.3.6 Vapor encroachment or intrusion assessment not at the *TP*.

APPENDIXES

(Nonmandatory Information)

X1. LEGAL BACKGROUND IN SUPPORT OF VEC SCREENING PRACTICE

INTRODUCTION

The purpose of this legal appendix is to describe the relationship between this *Standard Guide for Vapor Encroachment Screening on Property Involved in Real Estate Transactions, E2600* ("VE Standard Guide") and "all appropriate inquiries" under the federal Comprehensive Environmental Response, Compensation, and Liability Act, 42 U.S.C. §§ 9601, *et seq*. ("CERCLA"), at 9601(35)(B) and the U.S. Environmental Protection Agency ("USEPA") regulations promulgated to provide the standards and practices that comprise "all appropriate inquiries" under CERCLA, 40 C.F.R. Part 312

("AAI Rules"). This legal appendix also discusses the relationship between the VE Standard Guide and ASTM's *Standard Practice for Environmental Assessments: Phase I Environmental Site Assessment Process* (E1527-13).

X1.1 Introduction and Summary

X1.1.1 "All appropriate inquiries" under CERCLA are conducted to evaluate whether hazardous substances(**1**)[4] from a release are or may be present at the property that is the subject of the proposed acquisition (**2**). The term hazardous substance in CERCLA is not limited to solids and liquids, and USEPA has consistently taken the view that the vapor phase of volatile hazardous substances shall be considered and addressed under CERCLA. Therefore, the potential presence of volatile chemicals in gas or vapor form in the subsurface of a property (from a CERCLA release at the property itself or a nearby property) is appropriately considered in the conduct of all appropriate inquiries under CERCLA, the AAI Rules, and a Phase I environmental site assessment ("Phase I ESA") pursuant to E1527 (**3**).

X1.1.2 The stated objectives for the development of the VE Standard Guide include synthesizing and putting in writing a practical guide and a reasonable screening process to assess whether a volatile chemical (**4**) from a release may encroach upon a property that is the target of a proposed acquisition (**5**).

X1.1.3 The VE Standard Guide does not hold itself out as a "good commercial and customary" standard or practice for determining whether a CERCLA hazardous substance is or is likely present at the target property. The good commercial and customary standards and practices that constitute "all appropriate inquiries" are those that USEPA establishes by regulation. USEPA has not determined that the VE Standard Guide is appropriate or necessary to satisfy all appropriate inquiries under CERCLA, nor that it satisfies any requirement of the AAI Rules.

X1.1.4 The VE Standard Guide also is not part of E1527-05 or 13,[5] nor is it a supplement to, amendment of, or replacement for any part of E1527-13.

X1.1.5 In summary, the VE Standard Guide is not a requirement or component of all appropriate inquiries, and its results are not determinative of whether hazardous substances from a release are or may be present at the property for the sake of all appropriate inquiries or E1527-13. However, conducting a VE Standard Guide vapor encroachment screen may be helpful to the prospective buyer and the environmental professional in conducting an environmental site assessment of a target property.

X1.2 Background: Owner Liability and Liability Protections

X1.2.1 In general, a building or property at which a hazardous substance has been disposed or at which a hazardous substance has otherwise come to be located is a "facility" subject to CERCLA (**6**). The owner of a facility is a party liable for response costs and natural resource damages under CERCLA (**7**), unless the owner can establish by a preponderance of evidence each of the elements of one of the limited defenses or the landowner liability protections that the statute provides.

X1.2.2 CERCLA provides three core "defenses" to liability that, stated generally as to an owner, are that the release and damages from the release were caused by: *(1)* act of God; *(2)* act of war; or *(3)* act of a third party unaffiliated (including by contractual relationship) with the owner if the owner *(a)* exercised due care with regard to the hazardous substance and *(b)* took precautions against foreseeable acts and omissions of third parties and the related consequences (this third defense is referred to hereafter as "Third Party Defense") (**8**).

X1.2.3 For the purposes of the Third Party Defense, a land contract or deed is a contractual relationship (**9**). To provide some relief to unwitting "innocent" buyers of property at which releases had occurred in the past, Congress established the so-called "innocent landowner" or "innocent purchaser" provision. This provision makes the Third Party Defense potentially available to buyers of properties at which releases occurred before they acquired the properties if the buyers meet each of the innocent landowner requirements in the definition of "contractual relationship" at Section 9601(35), including having no reason to know of the presence of the hazardous substance at the property after performing pre-acquisition all appropriate inquiries.

X1.2.4 An owner of property that is affected by a hazardous substance migrating from a release at a separate, nearby property often has had no contractual or other relationship with the party that caused the release. If this "off-site" landowner is determined to be the owner of a CERCLA facility, it may be eligible for the Third Party Defense, if he or she can establish the exercise of due care as to the hazardous substance at issue and the taking of precautions against foreseeable acts of others. Note that where no contractual relationship exists with the person who caused the release, the Third Party Defense does not include a requirement that the landowner perform pre-acquisition all appropriate inquiries (**10**).

X1.2.5 In addition, in 2002, Congress added a provision (referred to as the "contiguous property provision") to CERCLA that provides that owners (and operators) of property to which hazardous substances have migrated from a nearby release will not be considered "owners or operators" for CERCLA liability purposes if they meet a number of criteria. These criteria include having no reason to know of the presence of the hazardous substance at the properties after performing pre-acquisition all appropriate inquiries (**11**).

[4] The boldface numbers in parentheses refer to the list of references at the end of this standard.

[5] ASTM E1527-05 was incorporated into the AAI Rules effective November 1, 2006. ASTM revised E1527-05 in 2013 (E1527-13). On December 31, 2013, EPA issued a final rule incorporating E1527-13 into the AAI Rules at 40 C.F.R. 312.11(c). The reference to E1527-05 is eliminated from 40 CFR 312.11(a) effective October 15, 2015.

X1.2.6 A more significant protection for landowners (both for owners of lands that are the sources of releases and those to which the hazardous substances have migrated) added by Congress in 2002 is the *bona fide* prospective purchaser provision, which provides liability protection even when property is purchased with knowledge of contamination, if pre-acquisition all appropriate inquiries are performed and all of the other requirements of the protection are satisfied (**12**).

X1.2.7 Innocent landowner, contiguous property owner, and bona fide prospective purchaser are commonly referred to as CERCLA's landowner liability protections. As noted above, an element of each of the landowner liability protections (note that this does not include the Third Party Defense in which no contractual relationship exists) is that a buyer of commercial or industrial property has conducted pre-acquisition "all appropriate inquiries" to determine whether the property is a place at which a hazardous substance is present or is likely to be present as a result of a CERCLA release (**13**). In other words, if a buyer of real property hopes to qualify for a landowner liability protection, the buyer shall have conducted all appropriate inquiries to determine whether the property he or she is buying may be a "facility" as defined by CERCLA because of a CERCLA release before acquiring the property (**14**).

X1.3 AAI under CERCLA Is Pre-Acquisition Inquiry into the Presence of Hazardous Substances from a Release at a Property

X1.3.1 As noted above, a prerequisite for each of the landowner liability protections is that the owner conduct "all appropriate inquiries" into the previous ownership and uses of the target property "in accordance with generally accepted good commercial and customary standards and practices," as established by USEPA by regulation, before buying the property.

X1.3.2 The object of these pre-acquisition inquiries is to determine whether the target property is a CERCLA "facility" as to which CERCLA liability may arise, that is, whether "any hazardous substance that is the subject of the release or threatened release was disposed of on, in, or at the [property]." (**15**)

X1.3.3 *AAI Rules Establish Standards and Practices for the Inquiry into the Presence of Hazardous Substances from a Release at a Property:*

X1.3.3.1 Congress established interim criteria for meeting the "all appropriate inquiries" standard under CERCLA but mandated that USEPA promulgate regulations to establish "standards and practices" for how all appropriate inquiries would be performed (**16**). USEPA's original AAI Rules were issued November 2005 and became effective on November 1, 2006 (**17**).

X1.3.3.2 According to USEPA, and consistent with CERCLA, the scope of the AAI Rules is:

"In the case of persons claiming one of the CERCLA landowner liability protections, the scope of today's rule includes the conduct of all appropriate inquiries for the purpose of identifying releases and threatened releases of hazardous substances on, at, in or to the property that would be the subject of a response action ...." (**18**)

X1.3.3.3 The environmental professional hired to perform AAI shall provide:

An opinion as to whether the inquiry has identified *conditions indicative of releases or threatened releases of hazardous substances ... on, at, in, or to the subject property*. 40 C.F.R.§ 312.21(C)(1) (emphasis added).

X1.3.3.4 Therefore, all appropriate inquiries, under CERCLA and the AAI Rules, is a process for determining whether hazardous substances have been released at the target property through the application of good commercial and customary standards and practices established by USEPA in the AAI Rules.

X1.3.4 *AAI Is Not Limited to Releases that Originate at the Target Property:*

X1.3.4.1 Consistent with CERCLA's requirements, USEPA has provided that AAI includes consideration by the environmental professional of environmental conditions at properties adjoining or nearby the subject property that could result in the presence of hazardous substances at the subject property. CERCLA required USEPA to include in the AAI Rules the review of records concerning "contamination at or near the facility" and visual inspections of "adjoining properties." (**19**)

X1.3.4.2 Similarly, CERCLA includes in the definition of "facility" sites where hazardous substances have "otherwise come to be located," (**20**) and the contiguous property owner landowner liability protection in the statute expressly requires that the landowner has conducted all appropriate inquiries and "did not know or have reason to know that the property was or could be contaminated by a release ... *from other real property not owned or operated*" by the landowner (**21**).

X1.3.4.3 The AAI Rules establish distances from the target property within which the environmental professional should gather and consider information on environmental conditions (**22**). According to the AAI Rules, these distances can be modified based on a number of factors, including, "potential migration pathways (for example, groundwater flow direction, [and] prevalent wind direction)." (**23**)

X1.3.4.4 Therefore, the overall objective of AAI is to determine whether, in the environmental professional's judgment, any hazardous substance is present at the target property as a result of a CERCLA "release" at or near the property (**24**).

X1.3.5 *AAI Rules and Practice E1527-13:*

X1.3.5.1 In December 2013, USEPA amended the AAI Rules at 40 C.F.R. § 312.11(c) to establish that the E1527-13 standard may be used to conduct AAI. (**25**) The amended rule provides that "parties seeking liability relief under CERCLA's landowner liability protections, as well as recipients of brownfields grants for conducting site assessments, will be considered to have met the standards and practices for all appropriate inquiries . . . if such parties follow the procedures provided in E1527-13." (**26**) In October 2014, EPA removed its prior reference to E1527-05 as an alternative standard that may be used to conduct AAI. (**27**)

X1.3.5.2 E1527-13 updates prior versions of that ASTM Standard Practice to specifically address contamination from vapor. It clarifies that the Phase 1 ESA "must include, within the scope of the investigation, an assessment of the real or

potential occurrence of vapor migration and vapor releases on, at, in, or to the subject property," (28) because "the presence within a building of hazardous substances such as vapors that have migrated into a building from a 'release into the environment' (i.e. from a release outside of the building) can result in CERCLA liability." (29) The new standard also added a reference to vapor in the definition of activity and use limitations, and revised the definition of migrate/migration to specifically reference CERCLA's definition of "migration" (30).

X1.3.5.3 The express purpose of E1527-13 is to set forth a practice that constitutes "all appropriate inquiries into the previous ownership and uses of the property consistent with good commercial or customary practice" as defined at 42 U.S.C. § 9601(35)(B) (31). Consistent with CERCLA and the AAI Rules, the express goal of the process established by E1527-13 is to identify "the presence or likely presence of any hazardous substances or petroleum products on a property under conditions that indicate an existing release, a past release, or a material threat of a release of any hazardous substances or petroleum products into structures on the property or into the ground, ground water, or surface water of the property." (32)

X1.4 Chemicals in a Gas or Vapor Form Are Hazardous Substances Subject to All Appropriate Inquiries

X1.4.1 *Chemicals in Gas or Vapor Form May Be Hazardous Substances:*

X1.4.1.1 The definition of "hazardous substance" in CERCLA is broad and it is not limited to chemicals in solid or liquid forms (33). For example, the term hazardous substance specifically includes hazardous air pollutants listed under Section 112 of the Clean Air Act (34). Hazardous air pollutants include benzene, trichloroethylene ("TCE"), and tetrachloroethylene ("PCE"), common groundwater contaminants that may migrate to a property in groundwater and in soil gas (35).

X1.4.1.2 In addition, the definition of "release" in CERCLA includes "emitting" and "escaping" into the "environment," which is itself defined to include ambient air (36).

X1.4.2 *Migration of Hazardous Substances as Vapors Is Subject to CERCLA Assessment and Remediation:*

X1.4.2.1 USEPA has long recognized that CERCLA hazardous substances can volatilize and migrate from releases as vapor. For example, USEPA addressed that potential as part of the CERCLA risk assessment process (37). USEPA has determined that hazardous substances that migrate from CERCLA releases are subjects for risk assessment and potentially other response actions under CERCLA (38). Courts have included costs of investigation and remediation of hazardous substance vapors as potentially recoverable response costs under CERCLA (39).

X1.4.3 *All Appropriate Inquiries and the AAI Rules Are Not Limited to Solid and Liquid Forms of Hazardous Substances or to Particular Migration Pathways:*

X1.4.3.1 The language in CERCLA does not limit all appropriate inquiries only to certain types, phases, or forms of hazardous substances. In addition, while recognizing that the hazardous substance might originate at an adjoining or nearby property, the statute does not identify only certain migration pathways to be evaluated or considered.

X1.4.3.2 Similarly, the AAI Rules use the term hazardous substance and are not expressly limited to certain types, phases, or forms of hazardous substance (40). The AAI Rules specifically include "potential migration pathways" "(for example, groundwater flow direction, prevalent wind direction)" (41) among the factors an environmental professional may consider in adjusting search distances.

X1.4.3.3 No basis appears to exist for excluding the gaseous or vapor form of a chemical from the definition of hazardous substances under CERCLA or from the hazardous substances whose presence in the subsurface of a property could cause the property to be considered a facility under CERCLA. Similarly, no basis appears to exist for excluding the evaluation of the potential presence of the gaseous or vapor forms of hazardous substances in the subsurface in the performance of all appropriate inquiries to the contrary. In the preamble to the amended rule, USEPA also clarified that "in its view, vapor migration has always been a relevant potential source of release or threatened release that, depending on site-specific conditions, may warrant identification when conducting all appropriate inquiries," and determined that adding E1527-13 to the AAI Rules would "reduce previous confusion on how to conduct a thorough [AAI] investigation." (42).

X1.5 Relationship of the VE Standard Guide to a E1527 Phase I Environmental Site Assessment

X1.5.1 In the VE Standard Guide, it is made clear that it is not part of or required by CERCLA or by the AAI Rules. In addition, it is also made clear in the VE Standard Guide that performance of its screening process does not determine whether a recognized environmental condition does or does not exist at the property for the purposes of an E1527-13 Phase I (43).

X1.5.2 Section 5.1 of the VE Standard Guide states:

5.1 *Identification of a REC Pursuant to a Phase I ESA – RECs* are identified only through the performance of Practice E1527 *Phase I ESA*. Thus, a finding pursuant to this guide that a *VEC* exists at the *TP* is not a determination that a *REC* is identified at the *TP*. Whether a *REC* exists at a *TP* as a result of the impact of possible vapor migration to the subsurface of the *TP* is a separate determination to be made by the *environmental professional* pursuant to Practice E1527. This guide does not constitute or meet the requirements for conducting "all appropriate inquiry" or any part of "all appropriate inquiry" as defined by USEPA under CERCLA and the regulations thereunder, including 40 C.F.R. §312.11.

X1.5.3 The stated objectives in the development of the VE Standard Guide were "(1) to synthesize and put into writing a practical guide for conducting a [vapor encroachment screen]... and (2) to provide that the process to screen for [vapor encroachment] is practical and reasonable." (44)

X1.5.4 The VE Standard Guide is a guide and a screening mechanism developed by Subcommittee E50.02 for the purpose of assisting proposed property buyers and environmental professionals in determining whether volatile chemical constituents in vapor may encroach upon the property. The VE

Standard Guide identifies concepts and considerations that may be helpful in the environmental site assessment of a property. However, conduct of the VE Standard Guide does not substitute for or constitute any part of AAI.

X1.6 Relationship between Vapor Encroachment and Vapor Intrusion

X1.6.1 As noted in Section X1.2 above, the stated objectives for the development of the VE Standard Guide include synthesizing and putting in writing a practical guide and a reasonable screening process to assess whether a volatile chemical from a release may encroach upon a property that is the target of a proposed acquisition. Thus, vapor encroachment is the potential for migration of vapor contaminants onto (or through the subsurface of) the target property. Vapor encroachment is a separate and distinct concept from vapor intrusion. Vapor intrusion evaluates potential exposure risks to persons within a building resulting from vapor migration into structures.

X1.6.2 Vapor Intrusion is beyond the scope of this guide. However, Vapor intrusion concerns are often the drivers for regulatory actions at properties under CERCLA and other laws. Similarly, there is much case law evaluating exposure or threatened exposure to vapors migrating from the subsurface into structures. Because these liabilities associated with vapor intrusion may drive decision-making in the context of a commercial property transaction, this standard includes references to state and federal vapor intrusion regulatory programs to aid the user in Appendix X5.

X1.6.3 Similarly, vapor intrusion assessment methodologies are beyond the scope of this guide. However, to aid the user, guidance on these issues are provided in Appendix X7 and Appendix X8.

X1.7 Conclusion

X1.7.1 The presence of a hazardous substance in vapor or gas form at a property from a CERCLA release may cause the property to be a facility under CERCLA and may subject the owner to potential CERCLA liability. Therefore, the conduct of all appropriate inquiries appropriately includes consideration of whether volatile chemicals from a CERCLA release have migrated to or encroached upon the subsurface of the property and the AAI process shall be performed in accordance with and as mandated by 40 CFR Part 312.

X1.7.2 The VE Standard Guide is not part of or required by all appropriate inquiries and does not determine whether a REC exists. However, it may be helpful to the environmental professional in environmental site assessment, especially in determining whether vapor migration is likely to be an issue at a property.

LEGAL REFERENCES FOR APPENDIX X1

(1) "Hazardous substance" includes all substances designated as hazardous under other statutes referred to in CERCLA or designated as hazardous substance by USEPA under CERCLA itself. 42 U.S.C. § 9601(14). Petroleum, including crude oil and any fraction thereof, and natural gas are excluded.

(2) Note that "all appropriate inquiries" are, as USEPA says, "legally distinct" from the more general concepts or processes of "environmental site assessment" and "environmental due diligence." See, for example, USEPA's discussion of this matter in its preamble to the final AAI Rules, 70 Fed. Reg. 66069, 66072 (Nov. 1, 2005).

(3) This Legal Appendix does not address the separate issue, not raised by the VE Standard Guide, of whether *vapor intrusion* analysis, as described in guidance issued by USEPA and state agencies, would ever be required under the AAI Rules or to satisfy the definition of recognized environmental condition under E1527-13 Phase I. Vapor intrusion analysis determinations are sensitive and complex and the information necessary to complete them would not typically be gathered by the environmental professional performing all appropriate inquiries or a Phase I under E1527-13. See X1.6 for more information.

(4) Note that the VE Standard Guide is not limited to CERCLA "hazardous substances."

(5) VE Standard Guide, Section 1.2.

(6) 42 USC § 9601(9).

(7) 42 USC § 9607(a)(1).

(8) 42 U.S.C. § 9607(b).

(9) 42 U.S.C. § 9601(35)(A).

(10) See, for example, *Town of New Windsor v. Tesa Tuck, Inc.*, 935 F.Supp.310 (S.D.N.Y. 1996) (landowner established the Third Party Defense despite having not taken steps to discover the contamination at its property from the encroachment of a neighboring landfill).

(11) 42 U.S.C. § 9607(q). This provision was added in the "Small Business Liability Relief and Brownfields Revitalization Act of 2002," the stated purpose of which was to "provide certain relief for small businesses from liability" under CERCLA and "to promote the cleanup and reuse of brownfields…." It is likely inconsistent with these purposes for the contiguous property owner provision to be read to effectively incorporate the requirements of the contiguous property owner provision into the 'due care' or 'precaution' requirements of the Third Party Defense (9607(b)(3)(a) and (b)) for offsite landowners. However, USEPA guidance has not addressed this nor has it been directly addressed in case law to date.

(12) 42 U.S.C. § 9607(r);) 42 U.S.C.§ 9601(40).

(13) AAI is only one component of these landowner liability protections. Others include that the landowner is not otherwise liable under CERCLA or affiliated with a liable party; did not cause, contribute to or consent to the release; and has satisfied what is referred to as 'continuing obligations' with regard to the property. *See e.g.*, USEPA OFFICE OF ENFORCEMENT AND COMPLIANCE ASSURANCE INTERIM GUIDANCE REGARDING CRITERIA LANDOWNERS MUST MEET IN ORDER TO QUALIFY FOR BONA FIDE PROSPECTIVE PURCHASER, CONTIGUOUS PROPERTY OWNER, OR INNOCENT LANDOWNER LIMITATIONS ON CERCLA LIABILITY", (2003).

(14) CERCLA's definition of "facility" is intended to be expansive and includes every place where hazardous substances come to be located. *United States v. Conservation Chemical Company*, 619 F. Supp. 162, 185 (W.D. Mont. 1985).

(15) 42 U.S.C. § 9601(35)(A)(i).

(16) 42 U.S.C. § 9601(35)(B)(ii).

(17) 70 Fed. Reg. at 66070 (codified at 40 C.F.R. Part 312).

(18) Preamble to the Final AAI Rules, 70 Fed. Reg. at 66076.

(19) 42 U.S.C. §§ 9601(35)(B)(iii)(V)-(VI).

(20) 42 U.S.C. § 9601(9)(B).
(21) 42 U.S.C. § 9607(q)(1)(A)(viii)(II) (emphasis added). For more on USEPA's views on the contiguous property owner liability protection, the potential liability of offsite property owners, and USEPA exercise of enforcement discretion in this regard, see, for example, USEPA OFFICE OF ENFORCEMENT AND COMPLIANCE ASSURANCE, INTERIM ENFORCEMENT DISCRETION GUIDANCE REGARDING CONTIGUOUS PROPERTY OWNERS (2004); USEPA OFFICE OF SITE REMEDIATION ENFORCEMENT ,FINAL POLICY TOWARDS OWNERS OF PROPERTY CONTAINING CONTAMINATED AQUIFERS(1995); and USEPA OFFICE OF SOLID WASTE AND EMERGENCY RESPONSE, POLICY TOWARDS OWNERS OF RESIDENTIAL PROPERTY AT SUPERFUND SITES (1991).
(22) 40 C.F.R. § 312.26(c).
(23) 40 C.F.R. § 312.26(d)(6).
(24) CERCLA defines "release" to include "any spilling, leaking, pumping, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the environment . . . ." 42 U.S.C. § 9601(22).
(25) 78 Fed. Reg. 79319.
(26) 78 Fed. Reg. 79320.
(27) 79 Fed. Reg. 60087 (October 6, 2014).
(28) 78 Fed. Reg. 79319, 79321 (Dec. 30, 2013)
(29) E1527-13 X1.1.1.2(4)
(30) E1527-13 3.2.2, 3.2.56.
(31) E1527-05 and E1527-13, Section 1.1.
(32) E1527-05 and E1527-13, Section 1.1.1. Note that both E1527-05 and E1527-13 include petroleum and is not limited to CERCLA hazardous substances. See Section 1.1.2 of E1527-05 and E1527-13 that explains that E1527-05 and E1527-13 include petroleum products because they are a concern in assessing real estate but not because of any applicability of CERCLA to petroleum products.
(33) 42 U.S.C. § 9601(14).
(34) 42 U.S.C. § 9601(14)(E).
(35) 40 C.F.R. 61.01(a)-(b); *Original List of Hazardous Air Pollutants*, USEPA TECHNOLOGY TRANSFER NETWORK – AIR TOXICS WEB SITE, http://www.epa.gov/ttn/atw/188polls.html (last visited May 29, 2014).
(36) 42 U.S.C. § 9601(22).
(37) See for example, 1 USEPA OFFICE OF EMERGENCY AND REMEDIAL RESPONSE," RISK ASSESSMENT GUIDANCE FOR SUPERFUND HUMAN HEALTH EVALUATION MANUAL" (1989); USEPA OFFICE OF AIR QUALITY PLANNING AND STANDARDS, "ASSESSING POTENTIAL INDOOR AIR IMPACTS FOR SUPERFUND SITES" (1992); USEPA OFFICE OF AIR QUALITY PLANNING AND STANDARDS, "OPTIONS FOR DEVELOPING AND EVALUATING MITIGATION STRATEGIES FOR INDOOR AIR IMPACTS AT SUPERFUND SITES" (1993).
(38) 67 Fed. Reg. 71169 (Nov. 29, 2002).
(39) See for example, *Action Manufacturing Co., Inc. v. Simon Wrecking Co.*, 428 F. Supp. 2d 288, 307, 332 (E.D. Pa. 2006.
(40) See, for example, 40 C.F.R. § 312.1(c)(1).
(41) 40 C.F.R. § 312.26(d)(6).
(42) 78 Fed. Reg. 79322.
(43) Note, among other differences, that the search distances for offsite releases in the VE Standard Guide do not satisfy the search distance criteria set forth in E1527-13. Only E1527-05 and E1527-13 have been evaluated and deemed by USEPA to satisfy the AAI Rules and all appropriate inquiries.
(44) VE Standard Guide, Section 1.2.

X2. ENVIRONMENTAL PROFESSIONAL QUALIFICATIONS AND RELEVANT EXPERIENCE

X2.1 Environmental Professional

X2.1.1 *Environmental professional* is defined in subsections 3.2.12 and 3.3.5, which definitions are the same as the definition in Practice E1527 and in 40 CFR § 312.10(b). The term refers to a person who possesses the education, training, and experience requirements necessary to exercise professional judgment to develop opinions and conclusions in conducting a *VES* and preparing a *VES* report (see Section 10). The person may be an independent contractor or an employee of the *user*.

X2.1.2 Specific expertise necessary to conduct a *VES* depends on the scope of work agreed upon. Thus, an *environmental professional* retained to perform a scope of work limited to Tier 1 and the non-invasive component of Tier 2 may not need as much expertise in vapor encroachment screening as would be needed to perform a scope of work that included Tier 2.

X2.1.3 An *environmental professional* should remain current in his or her field through participation in relevant continuing education or other activities such as participation in conferences, workshops, seminars, professional organizations, and so forth dealing with vapor encroachment and intrusion issues.

X2.1.4 Use of an *environmental professional* does not preempt state professional licensing or registration requirements. Before commencing work, the *environmental professional* and *user* should determine the applicability of state professional licensing or registration laws to the activities to be undertaken as part of the *VES*.

X2.1.5 A person who does not qualify as an *environmental professional* may contribute to and participate in the *VES* on the condition that duties performed will be under the supervision or responsible charge of a person who is an *environmental professional*.

X2.2 Relevant Experience

X2.2.1 Relevant experience includes the experience described in Practice E1527, Appendix X2, Section X2. Relevant experience also includes experience in evaluating vapor migration of *COCs*.

X3. QUESTIONNAIRE

X3.1 Information such as that described in the following and Section 6, if available, should be provided by the *user* to the *environmental professional* selected to conduct the *VES*. If the property *owner* or *operator* is not the user, then, absent an applicable legal requirement, the property *owner* or *operator* is not required to provide any information to the user or the *environmental professional*. The information described in the following is intended to assist the *environmental professional* in conducting the *VES*.

X3.2 Assuming the *VES* is being conducted for a prospective purchaser of a property, the following information, to the extent available, should be collected from the prospective purchaser:

X3.2.1 The reason why the *VES* is being conducted;

X3.2.2 Current or planned use of the property;

X3.2.3 The type of property, for example, industrial, commercial, or residential, and type of property transaction, for example, sale, purchase, exchange, and so forth;

X3.2.4 The complete and correct address for the property (a map or other documentation showing property location and boundaries would be helpful;

X3.2.5 The scope of services desired for the *VES* (including whether it is being conducted in conjunction with Practice E1527 *Phase I ESA*;

X3.2.6 Identification of all parties who will rely on the *VES* report, such as a lender;

X3.2.7 Identification of the site contact and how the contact can be reached;

X3.2.8 Any special terms and conditions (such as confidentiality) that shall be agreed upon by the *environmental professional*; and

X3.2.9 Any other knowledge or experience with the property that may be pertinent to the *environmental professional* (for example, copies of any available prior reports that have been prepared in accordance with a *Phase I ESA*, vapor intrusion reports, documents, correspondence, and so forth, concerning the property and its environmental condition).

X3.3 The following questionnaire may be completed by the user to the extent the *user* has the information requested. Absent an applicable legal requirement, the property *owner* or *operator* is not required to provide any information to a prospective purchaser. If the *VES* is being conducted on behalf of a prospective purchaser, the following questionnaire may be submitted to the *owner* or *operator* of the property, but the *owner* or *operator* should be informed that it is not obligated to provide any responses to the questionnaire, absent an applicable legal requirement.

PROJECT NAME:

PROPERTY ADDRESS:

DATE OF RESPONSE :

QUESTIONNAIRE COMPLETED BY:

NAME:
TITLE:
ADDRESS:
CITY/STATE/ZIP:
TELEPHONE:
EMAIL ADDRESS:

1	Property type	[ ] Commercial	[ ] Industrial	[ ] Multi-Tenant	[ ] Vacant Land
2	Are there any buildings/ structures on the property?	Yes [ ]	No [ ]	Unknown [ ]	
		If yes, type construction _____			
3	Will buildings/structures be constructed on the property in the future?	Yes [ ]	No [ ]	Unknown [ ]	
		If yes, type construction _____			
4	If buildings exist or are proposed, do/will they have elevators?	Yes [ ]	No [ ]		
5	Type of level below grade (existing or proposed)?	[ ] Full Basement	[ ] Crawl Space	[ ] Slab on Grade	
		[ ] Parking Garage	[ ] Multi-level		
6	Ventilation in level below grade?	Yes [ ]	No [ ]	Unknown [ ]	
7	Sump pumps, floor drains, or trenches (existing or proposed)?	Yes [ ]	No [ ]	Unknown [ ]	
8	Radon or methane mitigation system installed?	Yes [ ]	No [ ]	Unknown [ ]	
9	Heating system type (existing or proposed)?	(CHECK ALL THAT APPLY)			
		[ ] Hot Air Circulation		[ ] Electric Baseboard	
		[ ] Hot Air Radiation		[ ] Heat Pump	
		[ ] Hot Water Radiation		[ ] Wood Stove	
		[ ] Kerosene Heater		[ ] Steam Radiation	
		[ ] Fireplace		[ ] Coal Furnace	
		[ ] Radiant Floor Heat		[ ] Hot Water Circulation	
		[ ] Fuel Oil Furnace		[ ] Gas Furnace	
		[ ] Other			
10	Type of fuel energy (existing or proposed)?	(CHECK ALL THAT APPLY)			
		[ ] Natural Gas		[ ] Electric	
		[ ] Propane		[ ] Fuel Oil	
		[ ] Kerosene		[ ] Wood	
		[ ] Coal		[ ] Solar	
		[ ] Other			
11	Has a local, state or federal agency identified any environmental problems at the property?	Yes [ ]	No [ ]	Unknown [ ]	
		If yes, describe _____			
12	Has/does/will a gas station or dry cleaner operate anywhere on the property?	Yes [ ]	No [ ]	Unknown [ ]	
13	Do any tenants use hazardous chemicals in relatively large quantities on the property?	Yes [ ]	No [ ]	Unknown [ ]	
		If yes, describe _____			
14	Have any tenants ever complained about odors in the building or experienced health-related problems that may have been associated with the building?	Yes [ ]	No [ ]	Unknown [ ]	
15	Are the operations (or proposed operations to be performed) on the property OSHA regulated?	Yes [ ]	No [ ]	Unknown [ ]	
16	Are there any existing or proposed underground storage tanks (USTs) or above ground storage tanks (ASTs) on the property?	Yes [ ]	No [ ]	Unknown [ ]	
17	Are there any sensitive receptors (for example, children, elderly, people in poor health, and so forth) that occupy or will occupy the property?	Yes [ ]	No [ ]	Unknown [ ]	

Parcel ID # _____

X4. RECOMMENDED TABLE OF CONTENTS AND REPORT FORMAT (For a VES conducted independent of a Phase I ESA)

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X4.2.2 Detailed scope of service

X4.2.3 Significant assumptions

X4.2.4 Limitations and exceptions

X4.2.5 Special terms and conditions

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X4.2.7 *User* reliance

X4.3 Site Description

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X4.3.2 Site and vicinity general characteristics

X4.3.3 Current/planned use of the property

X4.3.4 Descriptions of structures, roads, and other improvements on the site

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X4.5.5 Historical use information on *adjoining* properties

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X4.6 Findings: Summary of Results of Investigation

X4.7 Conclusion

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X4.11.4 Regulatory records documentation

X4.11.5 Historical research documentation (fire insurance maps, city directories, and so forth)

X5. FEDERAL AND STATE AGENCY VAPOR INTRUSION WEB RESOURCES

NOTE X5.1—The U.S. Environmental Protection Agency (USEPA) published a draft vapor intrusion guidance in 2002. The draft final guidance document was published for public comment in April 2013. EPA issued the final guidance document in June 2015. EPA also published at the same time its final guidance to address petroleum vapor intrusion at leaking underground storage tank sites. Other federal agencies have also published vapor intrusion guidance, such as the Department of Defense Vapor Intrusion Handbook (January 2009). Most states that have vapor intrusion guidance follow a tiered evaluation approach similar to that in USEPA's 2002 draft vapor intrusion guidance. As of 2013, 35 states were identified as having some form of vapor intrusion guidance (see below).

Significant differences exist among the state guidance documents. In addition, private sector organizations have published vapor intrusion guidance documents such as the vapor intrusion and petroleum vapor intrusion guidance documents published by the Interstate Technology Regulatory Council (ITRC) (listed below). *Pertinent state and local vapor intrusion guidance documents should be reviewed by the environmental professional before conducting a vapor intrusion investigation. Because federal and state agencies and private sector organizations often revise their guidance documents, the environmental professional should obtain the current guidance issued by the agency or entity whose vapor intrusion guidance the environmental professional is reviewing.*

TABLE X5.1 Vapor Intrusion Guidance

Federal	
U.S. EPA:	www.epa.gov/oswer/vaporintrusion/
	www.epa.gov/oswer/riskassessment/airmodel/johnson_ettinger.htm
	www.epa.gov/oswer/vaporintrusion/documents/OSWER-Vapor-Intrusion-Technical-Guide-Final.pdf
	www.epa.gov/oswer/vaporintrusion/documents/PVI-Guide-Final.pdf
U.S. EPA Region III:	www.epa.gov/reg3hwmd/risk/index.htm
U.S. EPA Region IX:	www.epa.gov/region09/waste/sfund/prg/index.htm
DOD:	https://clu-in.org/download/char/dodvihdbk200901.pdf
	http://aec.army.mil/portals/3/restore/DOD_VI_Handbook_2009.pdf
	www.denix.osd.mil/references/upload/Tri-Serv_VI_Handbook_Final.pdf
	www.navfac.navy.mil/content/dam/navfac/Specialty%20Centers/Engineering%20and%20Expeditionary
	www.frtr.gov/pdf/meetings/nov09/presentations/long-presentation.pdf
State	
AL:	www.adem.state.al.us/programs/land/landforms/ARBCAManual.pdf
AK:	www.dec.state.ak.us/spar/csp/guidance/Vapor%20Intrusion%20Guidance.pdf
CA:	www.dtsc.ca.gov/AssessingRisk/upload/Final_VIG_Oct_2011.pdf
CO:	www.colorado.gov/pacific/cdphe/approach-soil-screening-values
CT:	www.ct.gov/deep/lib/deep/site_clean_up/remediation_regulations/RvVolCri.pdf
DE:	www.dnrec.state.de.us/dnrec2000/Divisions/AWM/sirb/policy%20concern07008.pdf
GA:	https://epd.georgia.gov/vapor-intrusion-technical-guidance
HI:	www.hawaiidoh.org/tgm-pdfs/HTGM%20Section%2007.pdf
ID:	www.deq.idaho.gov/media/967306-rem_2004_appendix_less_appendix_m.pdf
IN:	www.in.gov.idem/files/la-073-gg.pdf
IA:	www.iowadnr.gov/Portals/idnr/uploads/consites/Chapter133_comparisontocurrent.pdf
KS:	www.kdheks.gov/ber/download/Ks_VI_Guidance.pdf
LA:	www.deq.louisiana.gov/portal/Portals/0/RemediationServices/RECAP/RECAP%202013%20Draft%20Appendix%20G.pdf
ME:	www.maine.gov/dep/spills/publications/guidance/rags/vi1-14-2010/1-VI_Guide_1_13_10Final.pdf
MA:	www.mass.gov/eea/docs/dep/cleanup/laws/vifin.pdf
MD:	www.mde.state.md.us/assets/document/MDE%20VCP%20Vapor%20Intrusion%20080708.pdf
MI:	www.michigan.gov/documents/deq/deq-rrd-VIGuidanceDoc-May2013_422550_7.pdf
MN:	www.pca.state.mn.us/index.php/view-document.html?gid=14165
MO:	www.dnr.mo.gov/env/hwp/tanks/mrbca-pet/docs/mrbca-pet-appendix-c.pdf
MT:	http://deq.mt.gov/statesuperfund/viguide.mcpx
NE:	www.deq.state.ne.us/Publica.nsf/23e5e39594c064ee852564ae004fa010/66fdec793aefc4b286256a93005b8db8/$FILE/RBCA_GD_MAY_2009. pdf
NH:	http://des.nh.gov/organization/divisions/waste/hwrb/documents/vapor_intrusion.pdf
NJ:	www.nj.gov/dep/srp/guidance/vaporintrusion/vig.htm
NY:	www.health.ny.gov/environmental/investigations/soil_gas/svi_guidance/
NC:	http://portal.ncdenr.org/web/wm/dwm-new-vapor-guidance
OH:	www.epa.ohio.gov/portals/30/rules/vapor%20intrusion%20to%20indoor%20air.pdf
OR:	www.deq.state.or.us/lq/tanks/hot/screeningmodel.htm
PA:	www.elibrary.dep.state.pa.us/dsweb/Get/Document-49951/253-0300-100.pdf
RI:	www.dem.ri.gov/pubs/regs/regs/waste/remreg04.pdf
SC:	www.scdhec.gov/environment/docs/PermittingDecisions/AVX_Written_Comments.pdf
SD:	http://denr.sd.gov/des/gw/LookUpTables/Lookup_Tables.aspx
TN:	www.tn.gov/environment/underground-storage-tanks/docs/tgd016.pdf
VA:	www.deq.state.va.us/programs/LandProtectionRevitalization/RemediationProgram/VoluntaryRemediationProgram/VRPRiskAssessmentGuidance/Tables.aspx
WA:	www.ecy.wa.gov/programs/tcp/policies/VaporIntrusion/VI_guid_revs_final_10-9-09.pdf
WI:	http://dnr.wi.gov/files/PDF/pubs/rr/RR800.pdf
Other	
ITRC:	www.itrcweb.org/GuidanceDocuments/VI-1A.pdf
	www.itrcweb.org/GuidanceDocuments/VI-1.pdf
	www.itrcweb.org/PetroleumVI-Guidance/Content/Resources/PVIPDF.pdf

X6. CHEMICALS OF POTENTIAL CONCERN FOR THE VAPOR ENCROACHMENT SCREEN

NOTE X6.1—The chemicals of concern list is derived from the "contaminants of potential concern" identified in EPA's June 2015 final vapor intrusion guidance document (the universe of chemicals and EPA's evaluation are provided in EPA's online Vapor Intrusion Screening Level (VISL) Calculator). While recognizing that molecular weight (with a threshold of 200 g/mole) may be an additional criterion for volatility, molecular weight is not retained in EPA's guidance document as a volatility criterion because it is a relatively weak predictor of volatility. Those chemicals of concern with a molecular weight greater than 200 g/mole are identified with an asterisk in Table X6.1.

NOTE X6.2—Methane may be of concern to environmental professionals conducting property due diligence because of safety issues related to a potential explosion hazard. However, explosion hazard assessment is beyond the scope of this guide. Petroleum hydrocarbons (such as gasoline, diesel, fuel oil, kerosene, jet fuel, and so forth) are a subset under chemicals of concern (*COC*) and are identified in Table X6.1 by the major components. For example, the major components of gasoline would include benzene, xylene, toluene, and ethylbenzene (BTEX).

TABLE X6.1 Chemicals of Potential Concern

Acetaldehyde
Acetone
Acetone Cyanohydrin
Acetonitrile
Acrolein
Acrylic Acid
Acrylonitrile
Aldrin*
Allyl Alcohol
Allyl Chloride
Ammonia
Amyl Alcohol, tert-
Aroclor 1016*
Aroclor 1221
Aroclor 1232*
Aroclor 1242*
Aroclor 1248*
Aroclor 1254*
Aroclor 1260*
Azobenzene
Benz(a)anthracene*
Benzene
Benzyl Chloride
Biphenyl, 1,1'-
Bis(2-chloro-1-methylethyl)ether
Bis(2-chloroethyl)ether
Bis(chloromethyl)ether
Boron Trichloride
Boron Trifluoride
Bromo-2-chloroethane, 1-
Bromobenzene
Bromochloromethane
Bromodichloromethane
Bromoform*
Bromomethane
1,3-Butadiene
Butyl alcohol, sec-
Carbon disulfide
Carbon tetrachloride
Chlordane*
Chlorine
Chlorine Dioxide
Chloro-1,1-difluoroethane, 1-
2-Chloro-1,3-butadiene (chloroprene)
Chlorobenzene
Chlorobenzotrifluoride, 4-
Chlorodifluoromethane
Chloroform
Chloromethane
Chloromethyl Methyl Ether
Chloropicrin
Cumene
Cyanide (CN-)
Cyclohexane
Cyclohexanone
Cyclohexene
DDE, p,p-*
Dibromochloromethane*
1,2-Dibromo-3-chloropropane*
Dibromochloromethane*
1,2-Dibromoethane (ethylene dibromide)
Dibromomethane (methylene bromide)
Dichloro-2-butene, 1,4-
Dichloro-2-butene, cis-1,4-
Dichloro-2-butene, trans-1,4
1,2-Dichlorobenzene
1,4-Dichlorobenzene
Dichlorodifluoromethane
1,1-Dichloroethane
1,2-Dichloroethane
Dichloroethylene, 1,1
Dichloroethylene, cis-1,2
1,2-Dichloropropane
1,3-Dichloropropene
Dicyclopentadiene
Difluoroethane, 1,1-
Dihydrosafrole
Diisopropyl Ether
Dimethylformamide
Dimethylhydrazine, 1,1-
Dimethylhydrazine, 1,2-
Dimethylvinylchloride
Dioxane, 1,4
Epichlorohydrin
Epoxybutane, 1,2-
Ethoxyethanol Acetate, 2-
Ethoxyethanol, 2-
Ethylacetate
Ethyl Acrylate
Ethy Chloride (Chloroethane)
Ethylbenzene
Ethylene oxide
Ethylmethacrylate
Ethyleneimine
Formaldehyde
Formic Acid
Furfural
Glycidyl
Heptachlor*
Heptachlor Epoxide*
Hexachlorobenzene*
Heptachlorobiphenyl, 2,3,3',4,4',5,5'- (PCB 189)*
Heptachlorobiphenyl, 2,3,3',4,4',5- (PCB 156)*
Heptachlorobiphenyl, 2,3,3',4,4',5'- (PCB 157)*
Heptachlorobiphenyl, 2,3',4,4',5,5'- (PCB 167)*
Heptachlorobiphenyl, 3,3',4,4',5,5'- (PCB 169)*
Hexachloro-1,3-butadiene*
Hexachlorocyclopentadiene*
Hexachloroethane*
Hexamethylene Diisocyanate, 1,6-
Hexane
Hexanone, 2-
Hydrazine
Hydrogen Chloride
Hydrogen cyanide
Hydrogen fluoride
Hydrogen sulfide
Isopropanol
Mercury (elemental)
Methylacrylonitrile
Methanol
Methoxyethanol Acetate, 2-
Methoxyethanol, 2-
Methyl acrylate
Methyl Hydrazine
Methylene chloride
Methylethylketone (2-butanone)
Methylisobutylketone
Methyl Isocyanate
Methylmethacrylate
Methyl Styrene
Mirex*
MTBE
Naphthalene
Nickel Carbonyl
Nitrobenzene
Nitromethane
2-Nitropropane
Nitrosodimethylamine, N-
N-Nitroso-di-n-butlyamine
Nitrosomethylethylamine, N-
Nonane, n-
Pentachlorobiphenyl, 2,3,3',4,4',- (PCB 105)*
Pentachlorobiphenyl, 2,3,4,4',5- (PCB 114)*
Pentachlorobiphenyl, 2,3',4,4',5- (PCB 118)*
Pentachlorobiphenyl, 2',3,,4,4',5- (PCB 123)*
Pentachlorobiphenyl, 3,3',4,4',5- (PCB 126)*
Pentane, n-
Phosgene
Phosphine
Propionaldehyde
Propy benzene
Propylene
Propylene Glycol Monomethyl Ether
Propylene Oxide
Styrene
TCDD, 2,3,7,8-*
Tetrachlorobiphenyl, 3,4,4',5- (PCB 81)*
1,1,1,2-Tetrachloroethane
1,1,2,2-Tetrachloroethane
Tetrachloroethylene (perchloroethylene)
Tetrafluoroethane, 1,1,1,2-
Tetrahydrofuran
Titanium tetrachloride
Toluene
1,1,2-Trichloro-1,2,2-trifluoroethane
1,2,4-Trichlorobenzene
1,1,2-Trichloroethane
1,1,1-Trichloroethane
Trichloroethylene
Trichlorofluoromethane
1,2,3-Trichloropropane
1,2,3-Trichloropropene
Triethyamine
1,2,4-Trimethylbenzene
1,2,3,-Trimethylbenzene
Vinyl acetate
Vinyl bromide
Vinyl chloride (chloroethene)
Xylene, m
Xylene, o-
Xylene, P-
Xylenes

X7. GENERALIZED GUIDANCE ON VAPOR INTRUSION ASSESSMENT AND MITIGATION ALTERNATIVES

NOTE X7.1—If, after completing a *VES* for the *TP*, the user wishes to conduct additional investigation such as, for example, conducting a vapor intrusion assessment or to conduct mitigation, the user may find helpful the following general guidance on conducting a vapor intrusion assessment and general guidance on alternatives for vapor intrusion mitigation. The *environmental professional* is also directed to Appendix X5 for additional information.

X7.1 Vapor Intrusion Assessment Guidance

X7.1.1 A vapor intrusion assessment investigation may use data based on interior (within or below the building) or exterior testing. Possible reasons for conducting interior testing may include regulatory requirements or a desire to measure directly concentrations at the actual point of exposure. Possible reasons for conducting exterior testing might include lack of legal access to buildings, the property is undeveloped, a desire to keep transaction activities confidential, and/or concerns that interior tests may be adversely affected by background sources of *COC*.

X7.1.2 The scope of services for a vapor intrusion assessment investigation should be established by the *user* and the *environmental professional*. The *user* and *environmental professional* should refer to existing federal or state vapor intrusion assessment regulation, policy, or guidance, if available (see Appendix X5 and Appendix X8). For example, if the *target property* is owned by the U.S. Department of Defense, that agency's vapor intrusion assessment guidance should be reviewed and considered. If the property is privately owned and located in a state with vapor intrusion assessment guidance, that state's guidance should be reviewed and considered. If the privately owned property is located in a state without vapor intrusion assessment guidance, then the *user* and *environmental professional* may have to rely on federal guidance, for example, EPA, or other guidance deemed appropriate by the *environmental professional*, for example, the ITRC guidance (see Appendix X5).

X7.1.3 Because vapor intrusion investigation methods are rapidly evolving, the *user* and *environmental professional* should evaluate the most currently available technical and regulatory guidance as part of the planning and implementation of a vapor intrusion assessment evaluation. However, vapor intrusion assessment evaluations should use the following general process: *(1)* identify the desired endpoint; *(2)* identify applicable regulatory standards, requirements, and models, or other evaluation criteria to be used; *(3)* identify and collect needed data; and *(4)* evaluate data to determine if the potential for vapor intrusion into a structure exists. This general process may be applied in an iterative fashion, as needed, to achieve the selected endpoint in the most cost-effective and timely manner. There typically are three potential endpoints for a vapor intrusion assessment: *(1)* no vapor intrusion problem exists, *(2)* a vapor intrusion problem exists, or *(3)* it is not possible to reach a conclusion on whether or not a vapor intrusion problem exists. In drawing an endpoint conclusion, it is preferable to use a multiple lines of evidence approach.

X7.1.4 The vapor intrusion assessment should be conducted: *(1)* to provide a definitive determination if a vapor intrusion problem exists at the property; or *(2)* to narrow the uncertainty. If the *user* has obtained sufficient information to proceed with the *real estate transaction*, the *user* may choose to terminate the vapor intrusion assessment even if a definitive determination has not been made concerning the presence or absence of a vapor intrusion problem. When proceeding with a vapor intrusion assessment, the endpoint (that is, definitive determination versus reduced uncertainty) should be clearly defined to ensure adequate data collection to support the desired endpoint.

X7.1.5 Currently available regulatory and technical guidance documents for vapor intrusion contain disparate and often conflicting recommendations for data needs, data collection methods, and screening or evaluation criteria. As a result, it is important to identify clearly the regulatory and technical guidance that will be used for the vapor intrusion assessment evaluation. For sites not under the jurisdiction of a regulatory authority with applicable guidance, the *environmental professional* should identify the specific evaluation criteria to be used in the assessment. A list of select regulatory and technical guidance documents are provided in Appendix X5 and Appendix X8. The *environmental professional* should ensure that the most current information is used.

X7.1.6 The specific data needed to complete the vapor intrusion assessment evaluation will depend on the desired endpoint, applicable regulatory requirements, and a variety of other site-specific factors. Key considerations for defining data needs include: media to be characterized, need to define spatial variability, need to define temporal variability, and need for non-VOC measurements (for example, soil characteristics, building pressure gradient, and so forth). The applicable regulatory and technical guidance documents identified by the *environmental professional* may be used to define minimum data requirements to support a definitive determination that a vapor intrusion problem does not exist. To support a vapor intrusion assessment evaluation, data shall be collected in a technically sound manner and in accordance with the applicable regulatory and technical guidance documents identified by the *environmental professional*. Appendix X8 provides a list of common vapor intrusion assessment data types and guidance concerning data collection methods.

X7.1.7 Data should be evaluated in accordance with the applicable regulatory and technical guidance documents identified by the *environmental professional*. If the initial data collection is not sufficient to support the selected vapor intrusion assessment endpoint, then the vapor intrusion assessment process should be continued with additional data collection or modification of the endpoint or both as needed to achieve the desired objective for the property transaction.

X7.1.8 There are a number of alternative approaches to conduct a vapor intrusion investigation.

X7.1.8.1 *Groundwater Sampling and Use of a Site-Specific Model*—Knowledge of contaminant concentrations and location in groundwater, along with contaminant properties, soil properties, and building characteristics can be used to estimate the impact on indoor air using either empirical or other types of models. Knowledge of the indoor air impact can then be used in a health risk assessment to determine if a vapor intrusion problem exists.

X7.1.8.2 *Soil Gas Sampling and Use of a Site-Specific Model*—Knowledge of contaminant concentrations and location in the soil gas, along with contaminant properties, soil properties, and building characteristics can be used to estimate the impact on indoor air using either empirical or other types of models. Knowledge of the indoor air impact can then be used in a health risk assessment to determine if a vapor intrusion problem exists. This approach uses fewer assumptions than the groundwater sampling approach, but soil gas test results typically display a higher degree of variability.

X7.1.8.3 *Subslab Soil Gas Sampling and Use of a Site-Specific Model*—Knowledge of contaminant concentrations and location in the soil gas directly beneath the slab (or in the crawl space), along with contaminant properties and building characteristics can be used to estimate the impact on indoor air using either empirical or other types of models. Knowledge of the indoor air impact can then be used in a health risk assessment to determine if a vapor intrusion problem exists.

X7.1.8.4 *Indoor Air Sampling*—Measured indoor air contaminant concentrations may be directly applied in a health risk assessment of vapor inhalation exposure. If the health risk assessment results are acceptable, vapor intrusion may be eliminated from further consideration. If the health risk assessment results indicate potential concern, a vapor intrusion problem emanating from subsurface contamination is not confirmed as contributors other than subsurface vapor intrusion may be affecting indoor air quality (that is, background contributors), including, but not limited to, activities that may take place within the structure (such as smoking, wood burning, automobile parking, and so forth), products used within the structure (such as paints, solvents, cleaners, and so forth), building materials (such as carpeting, paint, adhesives, and so forth), and outdoor ambient air quality (that may, for example, be impacted by nearby automobile traffic or industrial emissions). If indoor air quality testing can be conducted to provide representative results in the occupied building space and over appropriate averaging time intervals, the indoor air sampling approach has the potential to eliminate conclusively the existence of a vapor intrusion problem. If indoor air testing indicates concentration levels that present or may present an unacceptable health risk to building occupants, a vapor intrusion problem may be indicated. Attribution of the potential contributors to indoor air quality (that is, subsurface vapor intrusion sources versus background contributors) is necessary to confirm the existence of a vapor intrusion problem originating from subsurface contamination.

X7.1.9 For the cases in which structures do not exist on the *target property* such as for a *target property* still to be developed, or in which structures may be substantially rehabilitated such as the case of a former industrial building being completely gutted and converted to residential use, then indoor air sampling may not be possible or useful. In such cases, use of alternative approaches, for example, such as identified in X7.1.8.1 – X7.1.8.3 may provide useful information.

X7.2 Vapor Intrusion Mitigation Alternatives

X7.2.1 If the vapor intrusion pathway is determined to be complete, there are a variety of mitigation alternatives, including intrinsically safe building design, engineering controls (for example, radon-type mitigation systems), institutional controls, and removal or remediation of the contaminated media causing the vapor intrusion.

X7.2.2 Mitigation of subsurface vapors falls generally into one of the following categories: *(1) institutional controls* such as deed restrictions or other mechanisms by which land uses or development of a site can be legally regulated to reduce or eliminate potential exposures; *(2) engineering controls* such as source removal or treatment, or active or passive, temporary or permanent mechanisms to reduce or eliminate potential exposures; or *(3) intrinsically safe* building design. Institutional controls (ICs) are generally legally enforceable conditions placed on a property to reduce the likelihood of exposure to unacceptable levels of contaminants, in this case, indoor air vapors. ICs do not directly address the source of contamination or the migration of vapors into enclosed spaces, but such controls are often a key feature of mitigation measures for vapor intrusion sites. ICs can take many forms, including restrictive covenants, zoning and land use restrictions, excavation prohibitions, and groundwater advisories. ICs might also include mechanisms to require the installation of vapor intrusion mitigation systems, such as vapor barriers or passive collection systems in new construction. Although possibly less expensive than engineering controls, ICs can be difficult to implement and maintain where state or local governments do not have sufficient legal enforcement authority. Also, to ensure their long-term effectiveness, ICs may require periodic inspections and monitoring.

X7.2.3 Engineering controls (ECs) are physical mechanisms designed to reduce or eliminate vapor migration into an enclosed space. There are four general forms of ECs: *(1) source removal or treatment*; *(2) barriers and venting* that block the migration of vapors from the subsurface into a building, including sealing, modification, and/or repair of preferential pathways/conduits; *(3) pressurization* of building interiors to direct vapors away from enclosed spaces; or *(4) indoor air treatment systems*.

X7.2.4 Removal or treatment of the source of subsurface vapors may be effective for reducing or preventing vapor migration into buildings. Such approaches may also eliminate the need for incorporating other vapor mitigation measures into existing or new construction. Treatment technologies might, for example, include contaminated soil excavation and removal, soil vapor extraction, in-situ chemical oxidation, and groundwater pump and treat.

X7.2.5 Physical barriers and vapor collection systems can effectively prevent vapor migration into buildings in certain situations, although passive barriers (and venting systems) are

generally not as effective as active systems. Barriers are most appropriate for new construction; however, barriers may be placed in earthen floors in crawl spaces and basements of existing structures.

X7.2.6 Vapor barriers are materials or structures installed between a building foundation and sub-foundation material or soil to physically block the migration of vapors into an enclosed space. Barriers are considered to be passive when installed without active sub-slab depressurization systems to remove vapors that might otherwise accumulate below the barrier. Passive barriers are intended to cause vapors to migrate laterally beyond the building footprint by diffusion gradients. Most passive barriers consist of an essentially impermeable high-density polyethylene (HDPE) sheet or a rubberized-asphalt emulsion applied as a liquid that then hardens to form a barrier. In new structures, barriers are placed beneath the floor slab to prevent sub-slab vapors from entering the structure through cracks or construction joints in the slab. In existing structures, membranes can be used to retard the intrusion of vapors in crawl spaces or over dirt floors. Vapors may also be physically blocked by sealing or repairing cracks in the foundation or elimination of preferential pathways.

X7.2.7 Advantages of vapor barriers include:

X7.2.7.1 Relatively low to moderate capital cost,

X7.2.7.2 Relatively low operation and maintenance cost,

X7.2.7.3 If breached during renovation activities, can be repaired, and

X7.2.7.4 If used in conjunction with a vapor collection system, can be very effective for mitigating vapors in new construction.

X7.2.8 Disadvantages of vapor barriers include:

X7.2.8.1 May require installation in combination with an active vapor collection/venting system to enhance performance,

X7.2.8.2 Even small cracks or tears in the barrier may significantly reduce effectiveness, and

X7.2.8.3 Generally not appropriate for existing structures except in crawl spaces and over earthen floors.

X7.2.9 A passive vapor collection or venting system offers a means of drawing subsurface vapors laterally (parallel to a foundation slab) through porous subgrade material (for example, sand or gravel), with or without perforated conveyance pipe and emitting the vapors to outdoor air before the vapors can migrate into an overlying structure. Passive venting systems are generally installed below passive barriers to enhance the lateral movement of vapors below the barrier. In addition to diffusion gradients, pressure gradients created by wind blowing over exhaust pipes or thermal gradients may enhance vapor movement. Wind-driven fans mounted on exhaust pipes may increase venting rates. Passive vents are generally not as effective as active venting systems.

X7.2.10 Advantages of passive vapor collection systems include:

X7.2.10.1 Can be used for new construction (limited use in existing buildings),

X7.2.10.2 Generally will not require permitting to emit vapors to ambient air,

X7.2.10.3 Low operating and maintenance costs,

X7.2.10.4 May be converted to an active system if desired, and

X7.2.10.5 If used in conjunction with a vapor barrier, can effectively reduce vapor intrusion.

X7.2.11 Disadvantages of passive vapor collection systems include:

X7.2.11.1 Difficult to install in existing buildings,

X7.2.11.2 Not effective without adequate vapor barrier,

X7.2.11.3 Ambient air temperatures or barometric pressure may direct vapors back into the system, and

X7.2.11.4 Will not work if the venting layer becomes saturated because of high water tables or flooding.

X7.2.12 An active vapor collection system is essentially identical to a passive venting system except that vapors are drawn into the pipe collection and exhaust system from the subslab space (de-pressurization) by means of a blower or fan. For crawl space applications, an impermeable membrane is installed over the dirt floor and the active vapor collection system then draws vapors from between the dirt floor and the membrane.

X7.2.13 Advantages of active vapor collection systems include:

X7.2.13.1 Documented effectiveness for reducing vapor intrusion,

X7.2.13.2 Can be installed in existing and new construction,

X7.2.13.3 Low installation cost,

X7.2.13.4 Fluctuations in air temperature or barometric pressure do not influence system effectiveness, and

X7.2.13.5 Pressure gauges and alarms can be installed with the system to assess operation.

X7.2.14 Disadvantages of active vapor collection systems include:

X7.2.14.1 May require an air permit to emit vapors through the exhaust system,

X7.2.14.2 Higher operation and maintenance costs compared to passive systems,

X7.2.14.3 Physical or legal access limitations at existing structures may preclude installation, and

X7.2.14.4 Subslab systems do not work well in wet or otherwise low-permeability soil that retards vapor movement unless combined with a dry venting layer in new structures or earthen floors in existing structures.

X7.2.15 Vapor intrusion can be significantly reduced by pressurizing the building interior relative to the subslab pressure; however, to achieve this uniformly throughout a building at all times, it may be difficult and not practical. To achieve this condition, a building's existing heating, ventilation, and air conditioning (HVAC) system can be operated at such an air change rate to create a positive indoor air pressure. Such a condition shall be maintained reliably wherever there are human occupants to prevent unacceptable human exposure. In general, only small increases in indoor air pressure are necessary to prevent vapor intrusion. Pressurization is generally applicable to both new and existing structures, although not all existing HVAC systems or building configurations are amenable to pressurization.

X7.2.16 Advantages of building pressurization include:

X7.2.16.1 No or limited additional capital cost if the existing HVAC system is capable of pressurization,

X7.2.16.2 May be easier to implement in existing structures (particularly large and multi-story buildings) than subslab depressurization systems,

X7.2.16.3 Can be implemented in buildings with wet or very low-permeability soils that prevent subslab depressurization, and

X7.2.16.4 Current Universal Building Codes (UBC) for HVAC systems, by default, result in slightly overpressurizing building interiors to maintain the indoor environment better.

X7.2.17 Disadvantages of building pressurization include:

X7.2.17.1 HVAC systems generally do not operate during the time the building is not occupied, nights, or weekend hours;

X7.2.17.2 Increased energy costs; and

X7.2.17.3 Regular maintenance and attention required to ensure that positive pressure is maintained reliably wherever there are human occupants to prevent unacceptable human exposure.

X7.2.18 In specialized cases, indoor air may be treated by a system that can remove contaminants. Such systems may, for example, include an activated carbon filter installed in the ventilation system. This approach may be necessary for existing structures that are difficult to cost effectively pressurize (for example, many residential dwellings) and where subslab depressurization is not feasible as a result of wet or low-permeability soil conditions. While this approach may be used in new buildings, other alternatives are generally more effective.

X7.2.19 New buildings may also be designed intrinsically safe to reduce significantly or eliminate potential vapor intrusion concerns. An example of an intrinsically safe building design is open air first-floor parking below residential living space.

X7.2.20 The number of mitigation alternatives for new buildings are typically greater than for existing buildings. In addition, the installation of a vapor intrusion mitigation system at the time of building construction is typically more cost effective. Therefore, it is preferable for mitigation to occur at the time a building is constructed, rather than afterwards.

X7.2.21 Once installed, mitigation systems should be operated properly and appropriately maintained to insure that the system is operating at all times the way it was designed to operate.

X7.2.22 The *user* in consultation with a qualified professional should determine the most appropriate mitigation approach.

X8. DATA COLLECTION GUIDANCE DOCUMENTS FOR VAPOR INTRUSION ASSESSMENT (REFER TO APPENDIX X7)

NOTE X8.1—Applicable federal and state vapor intrusion guidance (refer to Appendix X5) should be reviewed as acceptable data collection methodologies are often identified.

X8.1 To conduct a vapor intrusion assessment (refer to Appendix X7), data shall be collected in a technically sound manner and in accordance with applicable regulatory policy/regulation/guidance. This appendix lists common data types and relevant guidance on methods and procedures to collect these data. Data collection in support of vapor intrusion modeling pertains to more than the techniques and procedures for measuring soil gas concentrations. Parameters describing soil characteristics, flux pathway dynamics, and building particulars are important to the process of modeling or otherwise estimating vapor intrusion impact. Soil gas sampling and vapor intrusion measurement protocols already available through other ASTM standards, state and federal guidance, and peer-reviewed publications have not been reproduced. However, identification of procedures to measure the basic parameters to support modeling and evaluation of vapor intrusion is useful. Table X8.1 lists select data required for direct assessment of the vapor intrusion pathway, as well as parameters expected to be incorporated into a modeling assessment of the vapor intrusion pathway, such as can be conducted using the U.S. EPA spreadsheet (http://www.epa.gov/oswer/riskassessment /airmodel/johnson_ettinger.htm) for the Johnson and Ettinger model (1991).

X8.2 In addition to the specific references, there are sources of information (EPA, "Uncertainty and the Johnson-Ettinger Model for Vapor Intrusion Calculations," EPA/600/R-05/110, Weaver, J. W., and Tillman, F. D., National Exposure Research Laboratory, Athens, GA, September 2005; Johnson, P. C., "Identification of Critical Parameters for the Johnson and Ettinger (1991) Vapor Intrusion Model," Bulletin No. 17, American Petroleum Institute, May 2002) about the relative sensitivity of the parameters to the evaluation result for vapor intrusion. If there is question about procedures for measuring individual parameters, knowledge of the relative importance of parameters on the final result may be helpful in focusing effort. It may be prudent to accept the default value for certain parameters while focusing more attention on the more sensitive parameters.

X8.3 Degradation of soil gas concentrations is not included in the U.S. EPA spreadsheet for the Johnson and Ettinger model nor is it addressed in Table X8.1. However, a process for evaluating the natural attenuation of hydrocarbons in soil gas has been published (Roggemans, S., Bruce, C. L., Johnson, P. C., and Johnson, R. L., "Vadose Zone Natural Attenuation of Hydrocarbon Vapors: An Empirical Assessment of Soil Gas Vertical Profile Data," Bulletin No. 15, American Petroleum Institute, December 2001).

TABLE X8.1 Data Collection Guidance for a Direct Vapor Intrusion Assessment of the Vapor Intrusion Pathway

Direct Evaluation of Vapor Intrusion Pathway		
Parameter	Key Issues	Select Guidance
VOCs in Groundwater[A]	General guidance	ITRC 2007; NJDEP 2013; EPA 2002b
	Sample depth below water table	ITRC 2007; NJDEP 2013
VOCs in Soil Gas[A]	General guidance	CA-EPA 2003; API 2004; API 2005; ISO/CD10381-7
	Sample point location	ITRC 2007; NYSDOHS, 2006
	Sample point installation	ITRC 2007; Hartman 2006; DiGiulio 2006
	Purge/sample volume and rate	EPA 2007; ITRC 2007; CA-EPA 2003; Hartman 2006
	Analysis methods	EPA 2007; ITRC 2007; Hartman 2006;
	Target analytes	ITRC 2007
	Leak tracer gas	EPA 2007; ITRC 2007; Hartman 2006; CA-EPA 2003
	Flux chambers	Hartman 2003; Eklund and Schmidt 1990; EPA 1986;
	Passive sampling methods	EPA 2007; ITRC 2007; EPA 1998;
VOCs in Sub-slab Gas[A]	General guidance	ITRC 2007
	Sample point installation	ITRC 2007; DiGiulio 2006
	Purge/sample volume and rate	ITRC 2007; DiGiulio 2006
	Analysis methods	EPA 2007; ITRC 2007; Hartman 2006
	Target analytes	ITRC 2007
	Leak tracer gas	EPA 2007; ITRC 2007; Hartman 2006; CA-EPA 2003
	Sampling method selection: for example, active or passive	EPA 2007; ITRC 2007; EPA 1998
VOCs in Indoor Air[A]	General guidance	ITRC 2007; NJDEP 2013; NYDOHS 2005; CA-EPA 2005; MADEP 2002; EPRI, 2005; EPA 2002c
	Indoor background	McHugh, Connor et al, 2004; McHugh, DeBlanc et al, 2006
	Ambient background	ASTM D6196
	Sampling rate/duration	ITRC 2007; NJDEP 2013; MADEP 2002
	Analysis methods	ITRC 2007; MA-DEP 2002
	Target analytes	ITRC 2007
	Source Removal	ASTM E2121
	Passive Sampling	ASTM D6303
	Building operating conditions	http://resourcecenter.pnl.gov/cocoon/morf/ResourceCenter/article/1307
Radon in Sub-slab Gas and Indoor Air	General guidance	USEPA 1992; McHugh 2007
Cross Foundation Pressure Gradient	General guidance	USEPA 2015
Meteorological data	General guidance	http://www.ncdc.noaa.gov/oa/wdc/index.php
	Specific data needs and sources	Meteorological office of local airport
Building Inspection	General guidance	CA-EPA 2005; NJDEP 2013; ITRC 2007
	Indoor sources	CA-EPA 2005; NYSDOH 2006
	HVAC system	ASHRAE Standards 62.2 and 90.1 (Chapter 6) 2004
	Building foundation	CA-EPA 2005; NJDEP 2013
	Preferential pathways: sumps, dry wells, utility conduits, and so forth	CA-EPA 2005; NJDEP 2013
Measurements in Support of Analytical or Numerical Modeling		
Parameter	Key Issues	Select Guidance
Depth to Water Table	General guidance	
Depth to Base of Building Foundation	General guidance	USEPA 2015
Foundation Thickness	General guidance	ACI 360R April 2010, Guide to Design of Slab on Ground (http://www.techstreet.com/products/1683646#jumps)
Foundation Crack Fraction	General guidance	USEPA 2015
Building Floor Area	General guidance	ASTM E1836
Building Mixing Height	General guidance	USEPA 2015
Building Air Exchange Rate	General guidance	ASTM D6306; ASTM E741
Volumetric Air Flow Through Foundation (Qsoil)	General guidance	USEPA 2015
	Estimation methods	CA-EPA 2005
Vadose Zone Soil Thickness	General guidance	ASTM D5314
SCS or USCS Soil Type	General guidance	ASTM D2487
Total Porosity	Estimation methods	CA-EPA 2005; ASTM F1815; ASTM D5126
Water-Filled Porosity	Measurement methods	ASTM D2216
Soil Dry Bulk Density	General guidance	ISO-11272
	Measurement methods	ASTM D2937
Fraction of Organic Carbon Content	General guidance	ASTM E1195
	Measurement methods	Nelson and Sommers 1982

[A] Check applicable State guidance; see Appendix X5.

X8.4 *References for* Table X8.1 *are provided below:*

API (American Petroleum Institute) 2004, "Collecting and Interpreting Soil Gas Samples from the Vadose Zone: A Practical Strategy for Assessing the Subsurface-Vapor-to-Indoor-Air Migration Pathway at Petroleum Hydrocarbon Sites," Final Draft.

ASHRAE 62.2 and 90.1 (Chapter 6) Heating and Ventilating Systems, American Society of Heating, Refrigerating, and Air-Conditioning, 2004.

ASTM E2121 Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings.

ASTM D2216 Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.

ASTM D2497, Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)

ASTM D2937 Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method.

ASTM D2487 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).

ASTM D5126 Standard Guide for Comparison of Field Methods for Determining Hydraulic Conductivity in the Vadose Zone.

ASTM D5314 Standard Guide for Soil Gas Monitoring in the Vadose Zone.

ASTM D6306 Standard Guide for Placement and Use of Diffusion Controlled Passive Monitors for Gaseous Pollutants in Indoor Air.

ASTM E1836 Standard Classification for Building Floor Area Measurements for Facility Management

ASTM F1815 Standard Test Methods for Saturated Hydraulic Conductivity, Water Retention, Porosity, and Bulk Density of Putting Green and Sports Turf Root Zones.

CA EPA, 2005 Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air, http://www.dtsc.ca.gov/AssessingRisk/upload/HERD_POL_Eval_Subsurface_Vapor_Intrusion_interim_final.pdf.

CA EPA Department of Toxic Substances Control, Glendale, California and California Regional Water Quality Control Board, Los Angeles Region, 2003, Advisory—Active Soil Gas Investigations, January 28, http://www.swrcb.ca.gov/rwqcb4/html/programs/ust/03_0210_Schools_Advisory_Active_Soil_Gas_Investigations.pdf.

CA Los Angeles Regional Water Quality Control Board (RWQCB), 1997, Interim Guidance for Active Soil Gas Investigation, February 25, http://www.swrcb.ca.gov/rwqcb4/html/programs/ust/03_0210_Interim%20Guidance%20for%20Active%20Soil%20Gas%20Investigations.pdf.

DiGiulio, D., Paul, C., et al (2006). Assessment of Vapor Intrusion in Homes Near the Raymark Superfund Site Using Basement and Sub-Slab Air Samples, U.S. EPA Office of Research and Development.

Eklund, B. and Schmidt, C. (1990), Estimation of Baseline Air Emissions at Superfund Sites, Air/Superfund National Technical Guidance Study Series, Vol II, August 1990, EPA-450/1-89- 002a.

EPRI, 2005 Reference Handbook for Site-Specific Assessment of Subsurface Vapor Intrusion to Indoor Air, Report 1008492, Electric Power Research Institute, Palo Alto, CA.

Hartman, B. (2006), "How to Collect Reliable Soil Gas Data for Risk Based Application—Specifically Vapor Intrusion, Part 4: Updates, on Soil Gas Collection and Analytical Procedures," LUSTLine #53, published by the New England Interstate Water Pollution Control Commission, Lowell, MA, newsletter reporting on Federal and State Programs to control leaking underground storage tanks, October 2006.

Hartman, B. (2003). How to Collect Reliable Soil Gas Data for Risk Based Applications, Part 2: Flux Chamber Method, LUSTLine #44, August 2003.

http://www.epa.gov/superfund/programs/risk/airmodel/johnson_ ettinger.htm.

ISO-11272 Soil Quality—Determination of Dry Bulk Density, 1998.

ISO/CD10381-7, Soil Quality-Sampling—Part 7: Guidance on Sampling Soil Gas, International Standards Organization (ISO), 2005.

ITRC, 2014. Petroleum Vapor Intrusion, Fundamentals of Screening, Investigation, and Management.

MA DEP, 2002 Indoor Air Sampling and Evaluating Guide.

McHugh, T. et al, 2007. Use of Radon Measurements for Evaluation of VOC Vapor Intrusion: Method and Application.

Nelson, D. W. and Sommers, L. E., 1982. Total Carbon, Organic Carbon, and Organic Matter, In: Page, A. L. et al, (Editors), Methods of Soil Analysis: Part 2 Chemical and Microbiological Properties, ASA [American Society of Agronomy, Inc.] Monograph Number, pp. 539-579.

NYS DOH. 2006. Guidance for Evaluating Soil Vapor Intrusion in the State of New York, Final. Troy, NY: Center for Environmental Health, Bureau of Environmental Exposure Investigation, http://www.health.state.ny.us/nysdoh/gas/svi_guidance/.

NJ DEP 2013, New Jersey Department of Environmental Protection Vapor Intrusion Guidance. Site Remediation and Waste Management Program. www.nj.gov/dep/srp/guidance/vaporintrusion.

U.S. EPA, 1986, Measurement of Gaseous Emission Rates from Land Surfaces Using an Emission Isolation Flux Chamber, User's Guide, by M. R. Kienbusch, Radian Corporation, P.O. Box 9948, Austin, TX 78766, EPA Contract No. 68-02-3889, Work Assignment 18, Exposure Assessment Division, Environmental Monitoring Systems Laboratory, Las Vegas, NV 89114, February.

U.S. EPA 1992. Indoor Radon and Radon Decay Product Measurement Device Protocols. EPA 402-R-92-004, July 1992 (revised).

U.S. EPA, 2015. Technical Guidance for Assessing and Mitigating the Vapor Intrusion Pathway Evaluating Vapor Intrusion to from Subsurface Vapor Sources to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance), EPA530-D-02-004 Publication 9200.2-154, June 2015 (accessible at www.epa.gov/correctiveaction/eis/vapor.htmhttp://www2.epa.gov/sites/production/files/2015-09/documents/oswer-vapor-intrusion-technical-guide-final.pdf). Also, Techncial Guide for Addressing Petroleum

Vapor Intrusion at Leaking Underground Storage Tank Sites, EPA 510-R-15-001, June 2015 (accessible at http://www2.epa.gov/sites/production/files/2015-06/documents/pvi-guide-final-6-10-15.pdf)

U.S. EPA, 2002b. Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers: Ground Water Forum Issue Paper. Office of Solid Waste and Emergency Response, Document No. 542/S-02/001. May 2002.

U.S. EPA, 2002c, "User's Guide for the Johnson and Ettinger (1991) Model for Subsurface Vapor Intrusion Into Buildings (Revised)," Office of Emergency and Remedial Response, Washington, DC 20460, December. http://www.epa.gov/oswer/riskassessment/airmodel/johnson_ etting-er.htm.

U.S. EPA, 2003, User's Guide for Evaluating Subsurface Vapor Intrusion into Buildings, Office of Emergency and Remedial Response, Washington, DC 20460, June 19.

U.S. EPA 2007. Proceedings from the Soil Gas Methods Workshop, AEHS Conference, San Diego, CA, 3-2007.

X9. SUPPLEMENTAL BIBLIOGRAPHY

X9.1 *ASTM Standards:*

D5157 Guide for Statistical Evaluation of Indoor Air Quality Models

D5314 Guide for Soil Gas Monitoring in the Vadose Zone

D5466 Test Method for Determination of Volatile Organic Chemicals in Atmospheres (Canister Sampling Methodology)

D5791 Guide for Using Probability Sampling Methods in Studies of Indoor Air Quality in Buildings

D6196 Practice for Selection of Sorbents, Sampling, and Thermal Desorption Analysis Procedures for Volatile Organic Compounds in Air

D6245 Guide for Using Indoor Carbon Dioxide Concentrations to Evaluate Indoor Air Quality and Ventilation

D6246 Practice for Evaluating the Performance of Diffusive Samplers

D6306 Guide for Placement and Use of Diffusion Controlled Passive Monitors for Gaseous Pollutants in Indoor Air

D6345 Guide for Selection of Methods for Active, Integrative Sampling of Volatile Organic Compounds in Air

D7297 Practice for Evaluating Residential Indoor Air Quality Concerns

E741 Test Method for Determining Air Change in a Single Zone by Means of Tracer Gas Dilution

E1528 Guide for Environmental Site Assessments: Transaction Screen Process

E1739 Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites

E1903 Guide for Environmental Site Assessments: Phase II Environmental Site Assessment Process

E2435 Guide for Application of Engineering Controls to Facilitate Use or Redevelopment of Chemical-Affected Properties

E2531 Guide for Development of Conceptual Site Models and Remediation Strategies for Light Nonaqueous-Phase Liquids Released to the Subsurface

X9.2 *U.S. EPA Documents:*

U.S. EPA/OSWER Interim Final Report, Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual (Part A), December 1989 (accessible at www.epa.gov/oswer/riskassessment/ragsa/index.htm).

U.S. EPA/OSWER Expedited Site Assessment Tools for Underground Storage Tanks: A Guide for Regulators (Chapter IV: Soil Gas Surveys), EPA 510-B-97-001, March 1997.

U.S. EPA On-line Tools for Site Assessment Calculation: Estimated Henry's Law Constants, Washington, DC, 2004 (accessible at www.epa.gov/ATHENS/learn2model/part-two/onsite/esthenry.htm)

U.S. EPA (1998). Environmental Technology Verification Report, Soil Gas Sampling Technology, W. L. Gore & Associates, Inc. GORE-SORBER Screening Survey, USEPA Office of Research and Development.

U.S. EPA (1998). Environmental Technology Verification Report, Soil Gas Sampling Technology, Quadrel Services, Inc., EMFLUX Soil Gas Investigation System, U.S. EPA Office of Research and Development. EPA Report No. 600/R-98/096.

U.S. EPA (1999). Compendium Method TO-15, Determination of VOCs in Air Collected in Specially-Prepared Canisters and Analyzed by GC/MS. U.S. EPA Office of Research and Development. EPA Report No. 625/R-96/010b (accessible at http://www.epa.gov/ttnamti1/files/ambient/airtox/to-15r.pdf).

U.S. EPA (1999). Compendium Method TO-17, Determination of VOCs in Ambient Air Using Active Sampling onto Sorbent Tubes. USEPA Office of Research and Development. EPA Report No. 625/R-96/010b (accessible at http://www.epa.gov/ttnamti1/files/ambient/airtox/to-17r.pdf).

U.S. EPA (1992). Assessing Potential Indoor Air Impacts for Superfund Sites. EPA Office of Air Quality Planning and Standards, Research Triangle Park, NC, contract No. 68D00124, Work Assignment 1-76, September.

U.S. EPA (2003). Urban Air Toxics Monitoring Program, Final Report, EPA-454/R-04-003, July.

U.S. EPA (1998). Environmental Technology Verification Report, Soil Gas Sampling Technology, Quadrel Services, Inc.

X9.3 *Other Federal Agency Documents (Also refer to Appendix X5):*

U.S. Army Interim Vapor Intrusion Policy for Environmental Response Actions, October 31, 2006.

U.S. Air Force Institute for Operational Health, Guide for the Assessment of the Vapor Intrusion Pathway, Cox, D. N., Howard, W. B., and Smith, M. A., NTIS: ADA449121, 64 pp, February 2006.

X9.4 *Other State Agency Documents (Also refer to Appendix X5):*

Alaska Department of Environmental Conservation (ADEC), 2002. Inhalation of Diesel Vapor in Indoor Air. Technical Memorandum-01-001. ADEC Division of Spill Prevention and Response, Contaminated Sites Remediation Program, 1 December.

California Environmental Protection Agency [Cal-EPA], 2003, Advisory—Active Soil Gas Investigations, Joint Publication of the Department of Toxic Substances Control, Glendale, CA, and the California Regional Water Quality Control Board Los Angeles Region 4, January 28.

Connecticut Department of Environmental Protection (CTDEP), 2005. Significant Environmental Hazard Condition Notification Threshold Concentrations, Reference Table A – Volatile Organic Substances. December.

Hawaii DOH, "Screening for Environmental Concerns at Sites with Contaminated Soil and Groundwater," November 2006.

Idaho DEQ, "Idaho Risk Evaluation Manual," July 2004.

Indiana Department of Environmental Management (IDEM), Office of Land Quality, 2012. Remediation Closure Guide, July.

Louisiana Department of Environmental Quality (LDEQ), 2003. Risk Evaluation/Corrective Action Program (RECAP), Corrective Action Group, October 20.

Massachusetts Department of Environmental Protection (MassDEP), 2002, Indoor Air Sampling and Evaluation Guide, WSC Policy #02-430, April, http://mass.gov/dep/images/indair.pdf; Revised Air Guidelines, Memorandum, Dec. 6, 1995, http://mass.gov/dep/air/aallist.pdf.

Minnesota Pollution Control Agency (MPCA), 2005. Vapor Intrusion Assessments Performed During Site Investigations, Petroleum Remediation Program, April.

New Jersey Department of Environmental Protection (NJDEP), 2013. Vapor Intrusion Guidance, March and Vapor Intrusion Screening Levels dated March 2015.

New Jersey Department of Environmental Protection (NJDEP), 2005. Field Sampling Procedures Manual: Chapter 9—Soil Gas Surveys, August (accessible at http://www.state.nj.us/dep/srp/guidance/fspm/pdf/chapter09.pdf).

New York State Department of Health (NYSDOH), 2005. Indoor Air Sampling and Analysis Guidance. Prepared by Division of Environmental Health Assessment, Center for Environmental Health, February 1.

Oregon Department of Environmental Quality (ORDEQ), 2006. Risk-Based Decision Making for the Remediation of Petroleum-Contaminated Sites, Spreadsheets, September.

Oregon Department of Environmental Quality (ORDEQ), 2004. Screening Model for Volatilization from Soil to Indoor Air at Heating Oil Tank Sites. March 23.

Rhode Island DEM, "Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases," February 2004.

Virginia Department of Environmental Quality (VADEQ), 2006. Voluntary Remediation Program Risk Assessment Guidance, February 16.

Washington State Department of Ecology Model Toxics Control Act (Chapter 173-340 WAC) Cleanup Regulation Chapter 70.105D RCW, October 2005.

X9.5 *Other Documents:*

Abreu, L. D. and Johnson, P. C., "Effect of Vapor Source—Building Separation and Building Construction on Soil Vapor Intrusion as Studied with a Three-Dimensional Numerical Model," *Environmental Science and Technology*, 2005, 39, pp. 4550–4561.

ASHRAE 62.1–2007. Ventilation for Acceptable Indoor Air Quality, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

API (American Petroleum Institute), Bulletin No. 8, Characteristics of Dissolved Petroleum Hydrocarbon Plumes: Results from Four Studies, C. J. Newell and J. A. Connor, December 1998.

API, Bulletin No. 17, Identification of Critical Parameters for the Johnson and Ettinger (1991) Vapor Intrusion Model, P. Johnson, May 2002.

API, Publication No. 4674, Assessing the Significance of Subsurface Contaminant Vapor Migration to Enclosed Spaces, December 1998.

API, Publication No. 4741, Collecting and Interpreting Soil Gas Samples from the Vadose Zone, A Practical Strategy for Assessing the Subsurface Vapor-to Indoor Air Migration Pathway at Petroleum Hydrocarbon Sites, L. H. Wilson, P. C. Johnson, et al, 2005.

Buonicore, A.J., Methodology for Identifying the Area of Concern Around a Property Potentially Impacted by Vapor Migration from Nearby Contaminated Sources, Paper #2011-A-301, Proc. AWMA 104th Annual Conference, Orlando, FL, June 2011.

Davis, R., "Vapor Attenuation in the Subsurface from Petroleum Hydrocarbon Sources," LUSTLine Bulletin 52: pp. 22-25, May 2006.

DiGiulio, D., Paul, C., et al (2006). Assessment of Vapor Intrusion in Homes Near the Raymark Superfund Site Using Basement and Sub-Slab Air Samples, U.S. EPA Office of Research and Development.

Eklund, B., Folkes, D., Kabel, J., and Farnum, R., An Overview of State Approaches to Vapor Intrusion, Environmental Manager, Air & Waste Association, February 2007.

Electric Power Research Institute (EPRI, 2005), Reference Handbook for Site-Specific Assessment of Subsurface Vapor Intrusion to Indoor Air, Report 1008492, EPRI, Palo Alto, CA.

Hartman, B., "How to Collect Reliable Soil-Gas Data for Risk-Based Applications, Part 1: Active Soil-Gas Method," LUSTLine Bulletin 42: pp. 17-22, published by the New England Interstate Water Pollution Control Commission, Lowell, MA, newsletter reporting on Federal and State Programs to control leaking underground storage tanks, pp. 17-22, 2002.

Hartman, B. (2003). "How to Collect Reliable Soil-Gas Data for Upward Risk Assessments, Part 2: Surface Flux-Chamber Method," LUSTLine Bulletin 44: pp. 14-34.

Hartman, B. (2006). "How to Collect Reliable Soil-Gas Data for Risk-Based Applications—Specifically Vapor Intrusion, Part 4: Updates on Soil Gas Collection and Analytical Procedures," LUSTLine Bulletin 53: pp. 14-19.

Hodgson, A. T., et al (1995). Use of Volatile Tracers to Determine the Contribution of Environmental Tobacco Smoke

to Concentrations of Volatile Organic Compounds in Smoking Environments. Lawrence Berkeley National Laboratory, Berkeley, CA. Report No. LBL-37376, December.

Hodgson, A. T. and Levin, H. (2003). Volatile Organic Compounds in Indoor Air: A Review of Concentrations Measured in North America Since 1990. Lawrence Berkeley National Laboratory, Berkeley, CA. Report No. LBNL-51715, April 12.

Kurtz, J. P. and Folkes, D. J., "Background Concentrations of Selected Chlorinated Hydrocarbons in residential Indoor Air," Proceedings of the International Conference on Indoor Air Quality and Climate, International Academy of Indoor Air Sciences, Monterey, CA, June 30-July 5, 2002 (available at www.envirogroup.com).

Lowell, P. and Eklund, B., VOC Emission Fluxes as a Function of Lateral Distance from the Source, Environmental Progress, Vol. 23, No. 1, pp. 52-58, April 2004.

McHugh, T. E., Connor, J. A., et al (2004). "An Empirical Analysis of the Groundwater-to-Indoor-Air Exposure Pathway: The Role of Background Concentrations in Indoor Air," Environmental Forensics 5: pp. 33-44.

McHugh, T. E., DeBlanc, P. C., et al (2006). "Indoor Air as a Source of VOC Contamination in Shallow Soils Below Buildings," Soil and Sediment Contamination 15(1): pp. 103-122.

Shah, J. J. and Singh, H. B., (1988). Distribution of Volatile Organic Chemicals in Outdoor and Indoor Air. Environmental Science & Technology, Volume 22, No. 12, December.