Steps in Conducting Structural Vapor Intrusion Potential Evaluations Under the Inactive Hazardous Sites Branch 13 February 2017

This document provides the steps for conducting structural vapor intrusion evaluations under the Inactive Hazardous Sites Program and should be used as a supplement to the North Carolina Division of Waste Management's Vapor Intrusion Guidance found at http://deq.nc.gov/about/divisions/waste-management/waste-management-permit-guidance/inactive-hazardous-sites-guidance-documents. The Division's risk calculator or vapor screening tables should be used to screen sample data at each step. These are also available through the same web link. In addition to these guidance documents and tables, the Inactive Hazardous Sites Branch's "Guidelines for Addressing Pre-Regulatory Landfills and Dumps," also available on the Branch web page, should be used to determine sample locations, methods and procedures for the evaluation of vapors generated from buried waste at Pre-Regulatory Landfill sites.

The science of vapor intrusion evaluations continues to evolve. Look for periodic updates to this and the Division's guidance.

Contents

Structural Vapor Intrusion Potential Evaluation Steps

AVOID CONDUCTING INDOOR AIR SAMPLING AS THE FIRST STEP due to the large variety of contaminants found commonly in household and commercial products used in those spaces. Follow the steps below.

I. Delineate contamination in groundwater and soils to unrestricted use standards.

II. Identify areas where volatile contaminants are present within 100 feet of an existing or future structure (500 feet if a Pre-Regulatory Landfill).

Note: All hazardous substances with a Henry's Law Constant of greater than 10^{-5} atm m^3/mol must be evaluated if present at the source site. Contaminants of concern may include not only the typical analytes on a volatile organic scan, but also mercury, hydrogen sulfide, ammonia and some semivolatile compounds.

III. At the properties identified in II, evaluate the potential for structural vapor intrusion as described in A and B below.

Note: All child-occupied spaces such as schools and day care facilities should be screened using the residential screening values.

A. Compare groundwater concentrations to DWM groundwater vapor screening values using the calculator or the tables. If groundwater contamination exceeds the vapor screening values within 100 feet of the structure (500 for PRLF) and

1. **is less than 5 feet below ground surface, proceed to step V for crawlspace/sub-slab vapor testing.**

2. **is greater than 5 feet below ground surface, proceed to step IV for soil gas testing.**

B. If soil contaminants exceed 10 ppm or the unrestricted use direct contact remediation goals and

1. **are located under a building, proceed to step V for crawlspace/sub-slab vapor testing.**

2. extend over a large area less than 100 feet from a current of future structure proceed to step IV for soil gas testing.

IV. Conduct soil gas testing in accordance with steps A-C below.

A. To evaluate vapors from groundwater contamination, collect soil gas samples:

1. in the area of highest groundwater contaminant concentrations at the source site property just above the water table or

2. near the hydraulically upgradient perimeter of the structure(s) at a depth between 5 feet to 10 feet below ground surface.

Note: Each and every lot or structure does not require soil gas testing. If collecting in an area away from the source area, an understanding of the intervening geology and the location of utility corridors that may be preferential gas migration pathways is essential. Structures in line with preferential pathways may equally be at risk depending on these pathways. The selection of properties for sampling should also take into account variations in construction (slab vs crawl space) and uses of the buildings (less frequent opening of building entry ways associated with certain uses reduces fresh air exchange).

B. To evaluate vapors from contaminated soil not currently located beneath structures:

1. if the highest soil contaminant concentrations are at a depth of more than five feet, collect soil gas samples in the area of highest soil contaminant concentrations and at a depth of five feet below ground surface.

2. if the highest soil contaminant concentrations are at depths of less than five feet, other methods such as installing passive samplers within the contaminated soil horizon may be needed.

C. Compare the soil gas sample results from A and B above to vapor screening values for soil gas. For those soil gas samples that exceed screening values, proceed to step VI for crawlspace/sub-slab vapor testing.

Note: Where soil gas testing fails to meet soil gas screening levels at a vacant lot, groundwater contamination must be reduced to a point that soil gas and/or groundwater screening levels can be met. Alternatively, if a risk-based remedy is being implemented, land use restrictions would need to be secured at the property to prevent exposure via vapor intrusion into future structures.

V. Conduct crawlspace*/sub-slab vapor testing in accordance with steps A and B below.

A. Subslab: Compare concentrations to soil gas screening values. If exceed, go to step VI for indoor air testing. Note that if a homeowner objects to subslab cuts, proceed to indoor air testing.

B. Crawlspace: Compare concentrations to indoor air screening values. If exceed, go to step VI for indoor air testing.

VI. Conduct indoor air testing*

Note: Sample results that exceed the indoor air screening levels should always be confirmed as soon as possible. The IHSB should be notified within 24 hours of indoor air sample events exceeding screening levels.

* – Refer to notes for crawlspace and indoor air testing that follow.

Notes on Crawlspace and Indoor Air Testing

Time of Sampling: Ideally samples should be collected during the time of year the structure is most prone to vapor intrusion. However, high concentrations may call for immediate testing with another sample to be collected during the time of year structures would be more likely to have vapor intrusion effects. Those times would include:

Cold weather: When the exterior of the building is colder than the interior, the heating of the indoor space can produce a chimney effect and cause air below the structure to rise into the structure. Cold weather sample collection should occur when the high temperature for the day will be less than 60 degrees (Fahrenheit). Generally, that means mid-November through mid-March for the mountains and upper piedmont and mid-December through mid-February for the lower piedmont and coastal plain.

During seasonal high water table: For areas with shallow water tables, sampling during the time of the seasonal high water table should also be conducted.

Note that during the fair weather periods of the year, an HVAC system may not cycle or will cycle less. This would produce less exterior draw from outside and under the house. If windows remain closed, the structure may not be under positive pressure conditions, allowing vapors to enter from the subsurface. However, if windows are opened, there will be more fresh air exchange. Thus for structures with positive pressure HVAC systems, periods of milder weather may allow more vapor intrusion if the windows remain closed than during the summer and winter when the system is running more frequently.

Pre-Sampling Preparation: A critical step is preparing for sampling in crawlspaces and inside structures. Refer to the section in the Division's Vapor Intrusion Guidance for inspecting these spaces and removing chemicals prior to testing. Make sure the forms in Appendix B *Indoor Air Building Survey and Sampling Form* and Appendix E *Instructions for Occupants – Indoor Air Sampling are completed* and necessary clearing of chemicals from these areas is conducted. Photos should be collected on a pre-sampling inspection of any items stored in crawlspaces and provided to the project manager prior to testing. Photos of the sampling equipment in place should be collected during the sampling as well.

Background Sampling: An exterior upwind background sample should be collected when collecting crawlspace and indoor air samples. Detections of the same chemical in the background sample will be evaluated along with other lines of evidence when determining whether crawlspace/indoor air detections are the result of site-related contamination or from background sources. Upwind background samples should be initiated one hour prior to the collection of indoor air samples unless estimates of building exchange rates indicate a shorter or longer delay is appropriate. The time lag between the collection of the background and the test sample should allow for one exchange volume to have occurred.

Additional Sampling Events: Continued periodic testing should be performed if groundwater contamination is increasing toward a structure. Additional testing for some period should also be conducted with new construction in the area of concern to allow for settlement effects and for confirmation of effectiveness of any vapor abatement measures installed.

Supplemental Specifics on Sampling and Analytical Procedures

Read and follow the instructions in the Division's Vapor Intrusion Guidance. The following provides more detail on sampling and analytical procedures that should be followed.

- A detailed description of sampling equipment and collection procedures should be provided in a work plan. A summary of proposed procedures to prevent introduction of particulates into the sample canister and to ensure no leaks should be included. Sampler should specify leak check compounds. Best not to use isopropanol. Laboratory-grade helium is generally recommended unless a lower grade can be justified based on the contaminants of concern.

- Summa canisters should be used for all volatile organic compound (VOC) testing. Summa canisters should have pressure gauges. Summa canister and flowmeter can be *either* "individual certified" or "batch certified." Samples from indoor spaces should carry individual certification. Sampler should obtain tubing and connections from laboratory supplying flowmeter and canister. Specify only Swagelok-type fittings or connections with Teflon tape. Confirm the canister has not been idle on the shelf in the lab for longer than a month post-certification. Make sure the canister certification does not show site-related contaminants in concentrations higher than two orders of magnitude below the screening/indoor air levels.

- Sampler should record vacuum readings on the canister before and after sample collection. If any problems are encountered, the problem and the solution implemented should be provided in the sample report. Empty or improperly filled canisters should not be submitted for laboratory analysis. Always leave a partial vacuum on the container post sample collection.

- Field notes should be recorded and provided and should include at a minimum: weather conditions, leak check gas employed and leak check readings, volume of air purged from tubing prior to sample collection including calculations to determine adequate purge volume, start and end times of test and start and end vacuum readings, canister and regulator identification numbers and any other relevant information.

- VOCs should be analyzed by TO-15. The sampler should direct the laboratory to test for the contaminants detected in soil and groundwater within 100 feet of the structure. If only a limited site assessment has been conducted at the time of a vapor intrusion potential evaluation, a broad VOC analytical scan should be performed. TO-15 SIM should be used if the TO-15 detection limits are not lower than the ***Indoor Air Screening Levels*** (for indoor air and crawlspace samples) or the ***Soil Gas Screening Levels*** (for soil gas samples) for the chemicals of concern on the Division vapor intrusion tables. For semivolatile compounds of concern, additional sample containers/analytical methods should be specified. The remediator should contact qualified laboratories prior to submitting samples to verify that the laboratory will be able to achieve detection limits at or below Division screening levels/indoor air levels.

- The laboratory conducting the analyses should have National Environmental Laboratory Accreditation Program (NELAP) certification and be qualified to conduct air testing. Field analysis should only be employed when the mobile laboratory is certified to conduct the analyses and the contractor demonstrates the laboratory technicians are qualified to perform the analyses.

- While soil gas, crawlspace air or indoor air samples should only be tested for contaminants detected in groundwater and soil at the site, the laboratory may report results for other contaminants. Non-site related contaminants are routinely detected from household sources such as paints, furniture, carpets, cleaning agents and other chemicals used or stored in the home. Only those attributable to the site need to be evaluated for risk. However, a Division toxicologist may provide additional information on the risk posed by non-site related contaminants to the homeowner as a courtesy.

- If reusing tubing, should collect an equipment blank between samples. However, it is best to dispose of tubing between samples. Use inert tubing such as nylon. All other equipment should be decontaminated.

- The laboratory should also provide method blank and laboratory control sample data.

- Passive sampling devices that collect samples over several days to weeks may be a useful supplement to summa canister testing by providing concentration data over a longer period of time. The applicability and limitations of these devices should be evaluated prior to their use.

- Sampling plan should specify how soil gas sampling equipment for soil gas will be installed to prevent introduction of air from the surface or near surface. The sampling equipment should be sealed at the surface. Tracer gases should be used to ensure no significant leakage at probe seal (for example >20% tracer, data is unreliable).

- Refer to Appendix D, sections D.4.1-D.4.8 of "Vapor Intrusion Pathway: A Practical Guideline," January 2007, ITRC (or most current version) for additional information regarding gas probe installation and leak testing. The Division vapor intrusion guidance and other USEPA guidance may also provide proper installation procedures.

- Sampling plan should specify sample collection rate. Rapid collection could create short circuiting of air from the surface or other non-intended areas. <200ml/min is generally recommended.

- The 1 liter summa canisters (smaller size) are preferred for soil gas testing. Larger draws may induce air flow from clean areas or the surface.