Conceptual Site Model (CSM) Development: Sampling

3.1 Introduction

Indiana Code (IC) 13-12-3-2 and IC 13-25-5-8.5(c) provides statutory authority for characterizing the nature (Sections 2.8 and 3.9) and extent (Section 3.7) of contamination with respect to remediation objectives (Section 1.3). Sampling is vital to development of an adequate CSM. It is the only way to know whether contamination exists as the result of a release, whether receptors may be affected and the pathways by which contamination reaches receptors.

In some cases, limited sampling may qualify sites for closure without further investigation. Other sites may require elaborate multi-stage investigations that span several media. Specific objectives may vary by project and include (for example) adequate characterization of the potential risks of contamination present on or emanating from sites, information needed for remedy selection and design, or demonstration of attainment of remediation objectives.

This section includes guidance on collection of samples in various media under typical circumstances. It also includes guidance on sample handling, analysis, and reporting, as well as data evaluation. It is not a complete compendium of acceptable procedures.

Note that **preferential pathways** (e.g., drain tiles, karst features, utility conduits, sand lenses) may facilitate rapid contaminant migration, sometimes in unexpected directions. Preferential pathways merit special attention and may require different investigative and sampling methods. The most appropriate approach will ultimately depend on site-specific factors.[25] Alternative proposals that meet investigation and data quality objectives are certainly acceptable; the Indiana Department of Environmental Management (IDEM) will evaluate them on their merits.

Note that IDEM may conduct field audits during any sampling event. The scope of audits may vary by program and may include split sampling. For this reason, program areas and project managers may request advance notice of proposed field activities.

[25] Investigation procedures differ for petroleum releases regulated by Underground Storage Tank (UST) or Leaking Underground Storage Tank (LUST) rules. See the *Remediation Program Guide* for more information on LUST sites.

3.2 Sampling Soils

There are many possible reasons for sampling soil. Examples include: assessing potential for direct contact exposure, evaluating subsurface soil chemicals as a potential source of ground water contamination or vapor intrusion, or guiding remedy design, selection and implementation.

3.2.1 Sampling Surface Soil

Surface and near surface soil sample collection usually occurs whenever it is necessary to evaluate the potential for direct contact to chemicals. The *Remediation Closure Guide* (RCG) defines soil direct contact exposure as including dermal soil contact, soil ingestion, inhalation of soil particles and inhalation of vapors arising from soil. Where potential soil contamination is likely confined to the subsurface (e.g., following a release from an underground storage tank), surface soil samples may not be necessary.

The RCG does not define a specific depth interval for surface soil. Soil that is at or near the existing surface that has the potential to result in direct exposure under current or likely future land use should be evaluated for direct contact exposure. At some sites, surface soils lie underneath concrete, asphalt, or other barriers. Where future exposure to surface soil is a concern and access is feasible, sampling beneath the barrier may be necessary if surface contamination is suspected. Doing so will document the degree of potential contamination within surface soil and allow evaluation of the necessity of (for example) maintaining a cap or other cover to limit direct contact exposure.

See Section 3.2.4 for special procedures that apply when sampling soils for volatile organic compounds (VOCs).

3.2.2 Sampling Excavation Walls and Bottoms

IDEM’s underground storage tank programs have specific guidance for collecting soil samples along excavation walls and across excavation bottoms. Similar procedures are usually appropriate at other sites. However, IDEM will evaluate alternative procedures on their merits.

3.2.3 Sampling Subsurface Soil

There are many reasons to collect and analyze subsurface soil samples. If it is likely that excavation activities will bring soil to the surface, or that excavation or utility work may expose workers to subsurface soil, then it is important to evaluate future direct contact with subsurface soil. Residential, commercial/industrial, or recreational direct contact remediation objectives apply when evaluating soils that are likely to remain on the surface following excavation.

If chemicals from a release are present in soil but ground water is not impacted, then it is important to assess the potential for the chemicals in the soil to leach to ground water. Applicable lines of evidence (LOEs) when assessing this potential may include: the mass and physical characteristics of the chemicals, time since the release, chemical concentrations in the soil, soil synthetic precipitation leaching procedure (SPLP) data, soil pH, or ground water monitoring data.

When evaluating the leaching potential of subsurface soils, collect soil samples from intervals that are above the water table at the time of sampling. If ground water elevations subsequently rise, analytical results from soil samples previously collected below the new ground water elevation may no longer be appropriate for comparison against migration to ground water remediation objectives. Migration to ground water remediation objectives may be irrelevant in areas with very shallow ground water.

If ground water is already contaminated, evaluation of leaching *potential* usually becomes irrelevant. Evaluate ground water contaminant concentrations directly, using an appropriate monitoring well network. The observed presence of ground water contamination is a better indicator of whether contaminated soils are a source of ground water contamination than is a theoretical fate and transport model.

If contaminated ground water is present, then subsurface soil data may be collected for other reasons, such as:

- Evaluating direct contact risk, as described above.
- Effectively designing and monitoring performance of remediation systems.
- Developing an understanding of contaminant distribution necessary for CSM development and risk evaluation.
- Ensuring proper placement of monitoring well screens.
- Determining whether contamination extends into deeper water-bearing units.
- Meeting the requirements of program-specific rules that specify soil samples from certain locations (e.g., excavation bottoms).

The following conditions may identify one or more subsurface soil locations suitable for sampling, whatever the purpose of the sampling:

- Locations that elicit the highest field screening result.
- Stained, discolored, oily, shiny, or visibly altered soil.
- Soil in strata likely to be contaminated based on chemical characteristics and soil type. For example, potential accumulation of metals in clay or silt, accumulation on the top of clay strata or at the bottom of sand strata, or other locations *based on the expected behavior of the potential contaminant in the environment.*

Important characteristics when evaluating and describing soil cores include the following: texture, lithological description, color, soil structure, sedimentary features, consistency, moisture content (qualitative determination), boundary or contact, and zones of secondary porosity. Munsell soil charts, or a suitable alternative, are useful when evaluating and describing soil color.

In the absence of positive screening results or visual cues, the samples from borings submitted for laboratory analysis should be from a material within the core interval displaying the greatest apparent effective porosity. Other options include analyzing a sample from each **stratum**, or from each two-foot interval.[26]

As with surface soils, special procedures apply when sampling subsurface soils for VOCs (see Section 3.2.4). *See Section 8.3 for additional information about soil sampling.*

3.2.4 Sampling VOCs in Soils

As their name suggests, VOCs evaporate readily. This property can lead to significant VOC losses during sample collection and handling, and result in biased analytical data. Therefore, special precautions and procedures are appropriate when sampling VOCs in soils, particularly when VOC concentrations may be below residential remediation objectives.

Use U.S. EPA SW-846 Method 5035A (as updated) to minimize VOC loss, especially when collecting soil *closure* samples for VOC analysis. Appendix A of Method 5035A describes several options for the collection, preservation, and storage of samples for VOC analysis. The use of specialized containers and preservation techniques as described in Method 5035A may be unnecessary for samples collected within areas of known or suspected contamination, as long as the sampling method meets project objectives.

SW-846 Method 5035A, Appendix A, Section 7.1 states:

"After a fresh surface of the solid material is exposed to the atmosphere, the subsample collection process should be completed in the least amount of time in order to minimize the loss of VOCs due to volatilization. Removing a subsample from a material should be done with the least amount of disruption (disaggregation) as possible. Additionally, rough trimming of the sampling location's surface layers should be considered if the material may have already lost VOCs (been exposed for more than a couple of minutes) or if it may be contaminated by other waste, different soil strata or vegetation. Removal of surface layers can be accomplished by scraping the surface using a clean spatula, scoop, knife or shovel".

Screening instrument results, professional judgment, and knowledge of the source area and site soils should determine which samples are sent to the laboratory. Collect subsamples from the soil core as quickly as possible, taking special care to limit exposure and disaggregation of the soil's physical structure. This is necessary to minimize loss of VOCs (IDEM, 2008). Any samples not sent to the lab can be discarded. The field record should clearly document reasons for choosing particular samples for lab analysis.

[26] Section 9.7 describes procedures for calculating length-weighted subsurface soil chemical concentrations *within* borings.

Planning and careful preparation are critical for a successful sampling event. When sampling under this procedure:

- Allow sufficient time between subsurface soil core retrievals to avoid sampling backlogs
- Protect soil cores from direct sunlight, rain, wind, etc.
- Collect subsamples soon after the soil core has been removed from the borehole. It is not appropriate to collect subsamples from previously iced material, or to wait five or more minutes for a standard headspace analysis before deciding whether or not to collect subsamples from soil left in the core barrel liner (or similar device) or soil screening container.

IDEM will consider alternatives to the procedures and equipment described in Method 5035A and supplemental IDEM guidance on a site-specific basis.

Photoionization detectors (PIDs) detect most VOCs and are probably the most commonly used VOC field screening instrument. PIDs are suitable for chemicals with an ionization energy less than the PID's lamp voltage – typically 10.6 electron volts. Higher voltage PID lamps exist and can somewhat extend the range of detected chemicals. PIDs see extensive use in investigation of gasoline and chlorinated solvent releases.

A flame ionization detector (FID) may be a suitable alternative when working with unknown investigative chemicals, or when the chemicals have higher ionization potentials than the PID lamp. FIDs may prove especially useful when screening for diesel fuel, and weathered or heavy petroleum products.

All field instruments have advantages and limitations. The sampling and analysis plan should describe the field instrumentation and its use as appropriate for potential contaminants. The discussion should also include any limitations that could affect the use of an instrument (e.g., chemicals not detected, moisture, cold weather, etc.).

IDEM's Office of Land Quality Chemistry Services Section web page[27] contains additional information on sampling soils for VOCs.

3.3 Sampling Ground Water

Short-term ground water sampling may employ any appropriate technology; it need not involve the installation of monitoring wells. However, when collecting and comparing ground water samples over time, use properly constructed monitoring wells that meet the requirements of 312 IAC 13-8-3. IDEM (2009b) contains guidance on implementing this rule.

Appropriate ground water sampling procedures and equipment will vary depending on site-specific conditions and individual program requirements. U.S. EPA (2002b) provides general guidance on preparing for and performing ground water sampling. U.S. EPA (2005b) addresses sampling ground water from direct-push wells.

Turbidity in ground water samples can cause problems. For example, sampling-induced turbidity may result in samples that are not representative of the **aquifer** under evaluation. Turbidity in water samples can also interfere with analysis and cause inaccurate results. In many cases, low-flow, nonpurge, or passive sampling techniques can minimize induced sample turbidity.

[27] http://www.in.gov/idem/4673.htm

Low-flow (also called "micro-purge" or "minimal drawdown") sampling procedures often improve ground water sample quality. Puls and Barcelona (1996) is the primary U.S. EPA guidance on this procedure. A nonpurge sampling option may be suitable in some very specific cases; IDEM (2009c and 2009d) contain low-flow and nonpurge sampling guidance. Polyethylene diffusion bag samplers and other types of passive sampling devices *may* also be acceptable for long-term ground water monitoring at sites that meet a strict set of criteria (ITRC 2004, 2007a). IDEM (2005) contains a discussion of filtration and other issues related to sample turbidity.

Ground water sampling equipment should be capable of meeting the project's data quality objectives. Bailers, peristaltic pumps, high-speed submersible pumps, and inertial lift pumps may cause excessive agitation of ground water samples, and IDEM does not recommend their use when collecting samples for VOC analysis (ASTM 2006; Nielsen 2005; U.S. EPA 2002b, 2005b). The Federal Remediation Technologies Roundtable website[28] includes descriptions of many types of sampling equipment and a matrix that compares the advantages and disadvantages of different types of sampling equipment. ASTM (2006) also contains guidance on selecting appropriate sampling devices.

The project quality assurance project plan (QAPP) should describe proper disposal of contaminated purge water or other investigation-derived wastes. IDEM (2002) may apply to some waste materials.

3.4 Sampling Vapor

Section 5 addresses vapor sampling.

3.5 Sampling Fill

In the context of the RCG, fill is material used to modify land topography. Fill comprised of waste deposited onto the land as a means of disposal may be subject to solid or hazardous waste regulations and requires a site-specific approach that is beyond the scope of this guidance.

Fill areas can complicate development of a CSM. Fill alters hydrogeologic conditions at a site, and may contain chemicals in common with those from a release. Sometimes it is difficult to distinguish fill from waste fill that is subject to regulation. These challenges make it especially important to have a clear understanding of sampling objectives when sampling fill or in fill areas. Sometimes the objective may be to characterize a release in a fill area. In other cases, the objective may be to characterize the fill itself as a potential source of contamination.

With sufficient knowledge of the fill material(s) and their location(s) in the study area, standard or slightly modified standard methods for sampling surface or subsurface soil may be suitable for collecting fill samples. However, it may be difficult to collect a representative sample of fill material, especially if the material is too heterogeneous, or there is little or no information on the source of the material.

U.S. EPA (2009h) contains guidance on developing a sampling plan for fill material. In some cases, adequate characterization of fill material may cost more than removing it.

3.6 Sampling Other Media

The RCG does not provide detailed guidance on sampling surface water or sediment. Investigation of those media requires site-specific approaches. USGS (2009) includes surface

[28] http://www.frtr.gov/

water sampling guidance. U.S. EPA (2001b) contains sediment sampling guidance. U.S. EPA (2003a) and Davis *et al*. (2005) provide guidance on choosing appropriate sediment sampling equipment.

3.7 Extent of Investigation

Investigations should be sufficient to allow evaluation of the risks, if any, posed by contamination, and the effectiveness of any proposed remedy. Unfortunately, it is rarely possible to know in advance how much work will be necessary to support an adequate evaluation. Any investigation may reveal the need for further investigation.

3.7.1 Delineation

Delineation is an iterative process of determining the horizontal and vertical extents of contamination. Understanding the distribution of contaminants is important for identifying receptors and evaluating potential exposure.

In most cases, IDEM expects a ground water investigation *in conjunction* with a soil investigation. Soil should be evaluated for direct contact exposure (ingestion, dermal contact, and inhalation of vapors and soil particles) and, if necessary, its potential to effect ground water. Ground water should be evaluated for direct contact (inhalation and ingestion), and its potential to act as a source for vapor intrusion.

Delineation criteria differ with media type and potential receptor. In general, IDEM expects delineation of contamination to the extent necessary to evaluate all potential exposure pathways. This typically entails defining the on-site vertical and horizontal extents of contamination to land-use specific remediation objectives (commercial/industrial, residential, and/or recreational, where applicable) based on potential exposure scenarios and migration pathways identified in the CSM, *and* a demonstration showing that contamination doesn't leave the **exposure control area**[29] at concentrations exceeding residential remediation objectives. There may be circumstances where defining contamination to land-use specific levels (on-site and off-site) is impractical or unnecessary, and IDEM is willing to consider demonstrations that involve sampling and/or an evaluation of various LOEs, such as:

- Distance and/or time of travel from the delineated area to the boundary of the exposure control area
- Current and likely future use of the property, including ground water
- Extent of the area in which the release(s) occurred
- Possible preferential pathways
- Contaminant characteristics (e.g., mobility, toxicity, volatility, persistence)
- Potential for changes in ground water flow direction (e.g., start up or shut down of existing or planned production wells)
- Magnitude of contaminant concentrations relative to remediation objectives
- Presence of residential and/or ecological receptors in the vicinity

[29] An exposure control area is an area over which a remedy reduces exposure to an acceptable level. An exposure control area can be, but often is not, the same as the area of property control; it may involve multiple properties and multiple owners.

Demonstrations based on LOEs are inherently site-specific, and will rely on the technical judgment of all involved. IDEM will evaluate such demonstrations on their merits.

If contamination at concentrations greater than residential remediation objectives extends outside the exposure control area, IDEM expects delineation to residential remediation objectives *or* a demonstration employing LOEs to show why this is not necessary.

Horizontal delineation typically begins at or near the origin of a release and expands laterally; delineation of ground water contamination most often proceeds in the direction of ground water flow. However, it is also possible to start by sampling at or near receptors or the boundary of the exposure control area and then work back toward the origin. This approach may reveal potential problems more quickly at sites with significant potential risk to receptors.

When investigating a surface release, it may be necessary to begin soil sampling at the ground surface, proceeding downward until direct contact exposure is adequately understood. This may involve collecting more than one surface or near surface sample. If contamination extends into the subsurface, additional samples may be necessary to understand the contaminated zone. In most cases, sampling below 15 feet to evaluate direct contact isn't necessary because exposure to soil below that depth is unlikely.

Horizontal delineation efforts may employ a step-out procedure, as illustrated in Figure 3-A. In this figure, each box represents a sample location, and the numbers within the boxes correspond to sampling round, so that a box containing a "1" marks the location of a sample collected during the first sampling round, and a box containing a "3" marks the location of a sample collected during the third sampling round. Shaded boxes represent sample results that significantly exceed the remediation objective.

The step-out procedure investigates each significant unbounded exceedance of the remediation objectives by collecting additional samples in unsampled cardinal directions (i.e., north, east, south, and west). Step-out distances can vary as suggested by site characteristics. The process is iterative, with step-outs surrounding each successive exceedance until the horizontal extent of contamination is delineated.

In some cases, it may be advisable to employ a step-in procedure, as illustrated in the second example of Figure 3-A. In this example, a bounded exceedance is more tightly bounded using a second set of samples placed closer to the initial exceedance. Step-in procedures may be especially useful when attempting to reduce the size of an area proposed for active remediation or institutional controls (ICs).

Vertical delineation of soil should proceed as far as necessary for development of the CSM and evaluation of exposure scenarios, and to provide any information needed for other purposes, such as remedial design. Vertical delineation of ground water contamination below the first water bearing unit may or may not be necessary, depending on potential contaminant and site characteristics.[30] Clay units and other deposits often thought of as confining may be fractured or discontinuous, allowing contamination to migrate between water-bearing zones. *Therefore, the existence of low-permeability clay units is, by itself, insufficient evidence to demonstrate that deeper aquifers or water-bearing units are not contaminated*.

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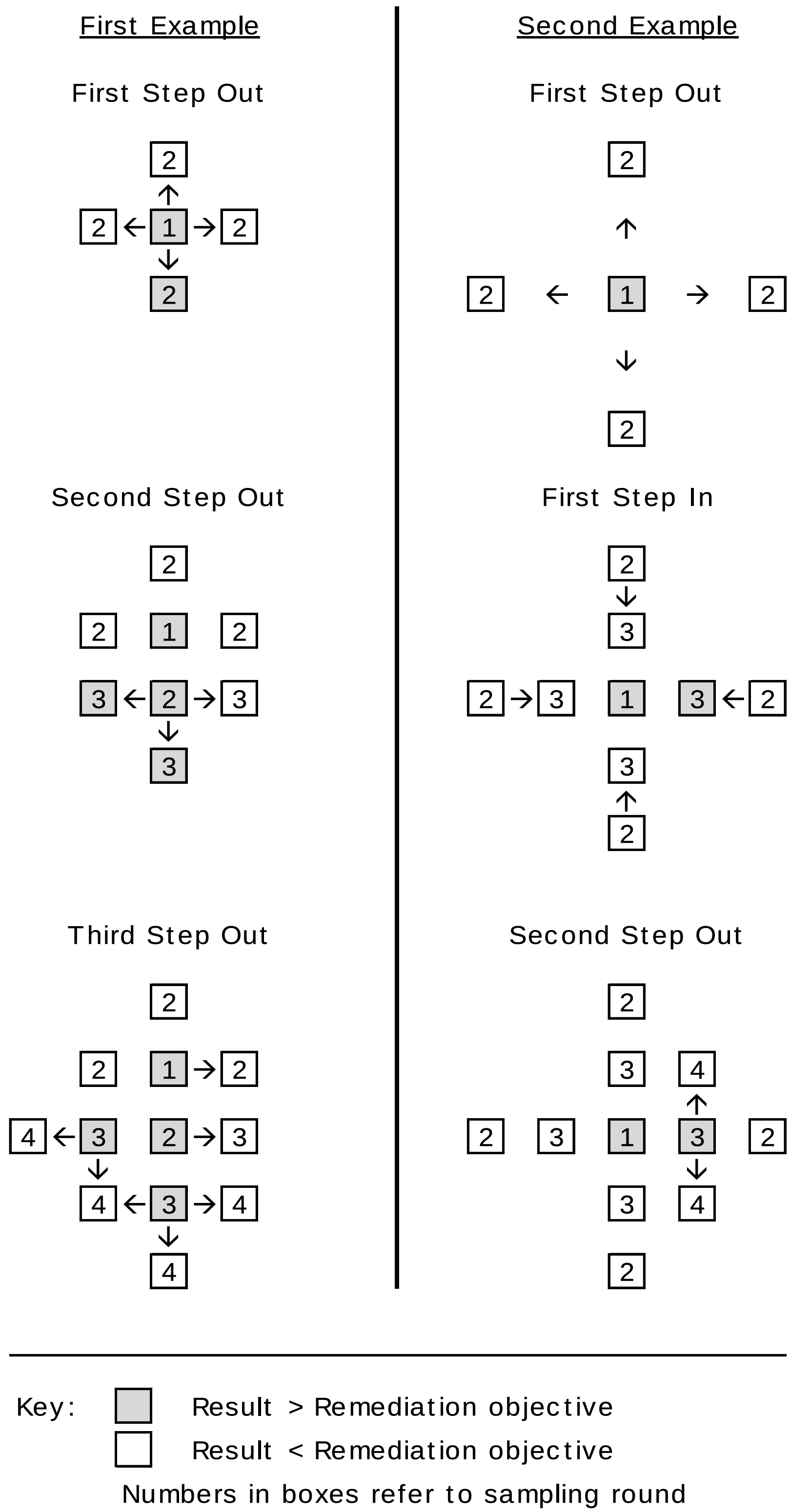
[30] Breaching a confining unit at the base of a water-bearing unit creates a pathway for potential contaminant migration. To minimize communication between aquifers, use dual-wall casing of wells installed in lower units; otherwise, plug the boring immediately upon completion (312 IAC 13-10).

Figure 3-A: Stepping Out (or In)



3.8 Sample Handling

Standard procedures for handling and documenting field samples are important to ensure high-quality, representative samples. A site-specific sampling and analysis plan (SAP) or similar sampling document should describe sample handling and field documentation procedures. IDEM's Office of Land Quality (OLQ) does not currently offer a general guidance document for sample handling, and OLQ does not typically require specific field documentation forms.

IDEM OLQ staff use standard forms to document their field sampling activities. IDEM does not require outside parties to use these forms, though they may prove useful in illustrating the documentation that IDEM expects. IDEM (1999) contains copies of these forms, and describes standard field documentation and sample preservation procedures.

It is important to deliver samples to the laboratory as soon as possible after collection or within a set time frame if the method requires it (U.S. EPA, 2009h). Samplers should maintain and document custody of the samples from collection until delivery.

Some samples require physical and/or chemical preservation in order to maintain sample integrity from time of collection until delivery to the laboratory. Laboratories can provide information on appropriate sample preservation methods. U.S. EPA (2009h, Chapter 2) contains summary tables showing preservation methods and holding times for SW-846 analytical methods. A more general table appears in IDEM (1999, Part III).

3.9 Sample Analysis and Reporting

It is important to choose sample analysis methods that can meet the project's data quality objectives (DQOs). The QAPP, SAP, or other relevant project-specific sampling document should list sample analysis methods and any variations from these methods. Reference to standard published methods is typically acceptable as long as the laboratory performs the analysis exactly as stated in the method. Sources for standard analytical methods include ASTM (2009), NIOSH (2009), SMO (2009), and U.S. EPA (2009h, 2009c, 2009b, 2009a).

Some key considerations regarding sample analysis include:

- Analytical methods capable of delivering reporting limits at least as low as the relevant remediation objectives
- The laboratory's ability to provide data that meet project DQOs. Unlike some states, Indiana does not currently certify laboratories for remediation work.
- When analyzing solid samples (e.g., soils, sediments, and solid waste) for VOCs, IDEM recommends collecting and extracting them using US U.S. EPA SW-846 Method 5035A. IDEM (2008) contains additional guidance on this topic.

Analytical documentation necessary to evaluate data will depend on the intended use(s) of the data. In general, reporting limits and detection limits, along with actual sample results and associated qualifiers, are essential to data interpretation. Section 3.9.1 contains additional information on analytical documentation. See IDEM (1999, 2003, and 2009a) for additional guidance.

3.9.1 Quality Assurance / Quality Control Elements

Data quality is meaningful only as it relates to the intended use of the data (i.e., the DQOs). A quality assurance/quality control (QA/QC) program is the means of judging whether or not the data meet DQOs. QA/QC programs incorporate several elements, including information from sampling, laboratory operations, and method-specific procedures.

Table 3-A includes elements that IDEM has determined are necessary to support two types of DQOs. For example, every element in Table 3-A is, where appropriate to the particular type(s) of analysis, necessary to support DQOs for a final nature and extent investigation, closure evaluation, or stand-alone assessment of the vapor intrusion pathway. Other investigations can support DQOs using the elements indicated in the minimum data documentation requirements (MDDR) column.

In addition to the elements in Table 3-A, the following *sampling-related items* should support every investigation:

- Completed chain of custody with sample date, time, and identification
- Map or diagram of sample locations
- Sample field sheets that document sample identifiers, locations, date and time, sampling methods and equipment, samplers, calibration methods, and any notable observations (color, clarity, texture, reactions with preservatives, etc.)
- Blanks – trip, field, or equipment rinsate blanks, as appropriate
- Identity of field duplicates – typically at least one per twenty samples per matrix for each method
- Adequate sample volume

The following *laboratory-related items* should support every investigation:

- Completed chain of custody with date and time of receipt
- Condition of samples on receipt
- Sample identification – site identification and lab identification
- Sample preparation logs with extraction, cleanup or digestion details
- Certificates of analysis with method, analysis date, results, method detection limits, reporting limits, and any dilution factors
- Case narrative detailing any deviations, problems, and corrective actions

If the purpose of sampling is a stand-alone assessment of the vapor intrusion pathway, IDEM recommends U.S. EPA Methods TO-14A, TO-15, or TO-15 SIM (all canister-based methods)[31] and use of a fixed laboratory when analyzing air, soil gas, or subslab gas samples. The following sampling-related items should support every vapor intrusion investigation:

- Field records of the initial and final canister pressures, start and stop times for canister filling, and approximate fill rates
- Field measurement records (ambient temperature and pressure, screening results)
- Records of any leak tests performed
- Documentation of canister cleaning (batch or individual certification)
- Copy of a completed Indoor Air Building Survey Checklist (as applicable)[32]

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[31] Subject to a demonstration that use of an alternative sampling device or analytical procedure can provide results of comparable quality to results using summa-type canisters and Method TO-15 or similar, IDEM will consider approving the use of such devices and techniques on a site-specific basis. Due to the variety of site-specific conditions and objectives typical of vapor intrusion investigations, generic approval of a particular sampling device or analytical technique is unlikely at this time.

[32] http://www.in.gov/idem/files/la-073-gg.pdf

Table 3-A: Elements for MDDR and Full QA/QC DQOs

Element	Method Type	MDDR	Full QA/QC
Sample introduction method (e.g., direct injection, purge-and-trap)	Specific gas chromatography (GC) detector method	✓	✓
Tuning criteria and results	Gas chromatography/mass spectroscopy (GC/MS)		✓
Initial calibration (IC) and IC verification	All		✓
Continuing calibration(s)	All		✓
Blank results (e.g., field, prep, method)	All	✓	✓
Laboratory control sample	All	✓	✓
Internal standard summary	GC/MS, GC	✓	✓
Surrogate recoveries	GC/MS, GC	✓	✓
Matrix spike/matrix spike duplicate recoveries	All (except TO-14A, TO-15, and TO-15 SIM)	✓*	✓
Interference check sample	Inductively coupled plasma (ICP) methods		✓
Serial dilutions	ICP methods		✓
Method of standard additions (if applicable)	ICP methods		✓
Raw data (instrument printouts, chromatograms, and/or mass spectra as applicable)	All		✓
Confirmation on second column (or GC/MS)	Pesticides, polychlorinated biphenyls (PCBs), benzene, toluene, ethylbenzene and xylenes (BTEX) and other VOCs by GC		✓

*Only necessary during initial and final sampling.

The IDEM OLQ Chemistry Services Section web page[33] contains additional information on QA/QC elements.

[33] http://www.in.gov/idem/4673.htm

3.10 Data Evaluation

There are three major components of the data evaluation process: verification, validation, and comparison against user requirements. The data evaluation process assesses whether the sample results fulfill project objectives. It verifies that sample collection, documentation, and delivery occurred as planned. It validates results for the end user against predetermined quality criteria. It compares those results against user requirements. Finally, it incorporates any new information into the CSM.

3.10.1 Verification

Verification assesses whether sample collection and analysis occurred as planned. Examples of deviations include sample relocation due to access issues, low soil recovery from a boring, dry wells, or analytical error. In some cases, the verification process may reveal the presence of data gaps.

3.10.2 Validation

Validation is an analyte specific and method specific process that compares data quality (i.e., accuracy and precision) against quality criteria predetermined during the planning phase (Section 2.7). Validation demonstrates whether the data are reliable enough to meet project objectives. For example, inaccurate reported concentrations close to a decision level may lead to an incorrect decision. Another example occurs when high levels of one chemical mask the presence of other, perhaps just as important, chemicals. Validation documents any effects on the results, thus allowing the end user to reach an informed conclusion. See U.S. EPA (1999d, 2001c, 2002e, 2004d, 2005d) for additional detail on the data validation process.

3.10.3 Comparison with User Requirements

The final component of the data evaluation process includes a comparison against project objectives. Ideally, the data should enable project-related decisions. However, sometimes new data do not meet project objectives, or they indicate a need for change in the original project objectives. As always, incorporate new information into the CSM and use the updated CSM to plan any necessary further activities.

3.11 CSM Documentation

Materials needed to support a CSM and aid IDEM evaluation of project reports will vary from site to site. Coordination with IDEM staff will help ensure efficient development of a CSM that is consistent with industry best practices. Supporting materials include, but are not limited to:

Land Use Documentation

- Summary of site location, size, ownership history and years of operation
- Summary of contaminant or potential contaminant types, sources, and locations
- Phase I and/or Phase II report(s)
- Previous investigative reports
- Scaled plan view map(s) showing structures, property boundaries, exposure control areas, adjacent properties and *specific* land uses, subsurface utilities, potential release origins, and other relevant site information
- Records of interviews with current or past owners and employees, local officials, and/or site neighbors
- Historic aerial photographs, where available
- Site records – current and past historical processes, chemical use, and waste storage and disposal practices
- Property tax records
- Municipal utility maps
- Identification of sampling area access restrictions
- Fire insurance maps

Geological Setting Documentation

- Scaled site map showing sample locations and descriptions
- Soil boring and monitoring well stratigraphic logs
- Geologic cross-section diagrams that include analytical results, borings, wells (with screened areas and water levels), subsurface utilities, excavated areas, tanks, and any types of piping or drains
- Potentiometric surface maps
- Indiana Department of Natural Resources Water Well Records for wells within one mile of the release, and high capacity wells within two miles
- Topographic maps and/or elevation surveys
- Soil survey maps
- Utility (water, sewer, electric, gas, etc.) location maps, including known pipe invert locations
- Hydrogeologic and geotechnical data (e.g., site-specific slug/pumping test results or other relevant local hydrologic data, test results, grain size analysis, fraction of organic carbon, mineralogy, soil chemistry)
- Monitoring well construction diagrams
- Maps showing the vertical and horizontal extents of contamination delineated to appropriate levels in each affected medium
- Narrative summarizing investigative findings discussing the inter-relationship of the identified main geologic units, aquifers, ground water flow characteristics, and preferred contaminant pathways

Susceptible Areas Documentation

- Ecologically susceptible area evaluation
- Geologically susceptible area evaluation
- Wellhead protection area evaluation
- Preferential pathway analysis (naturally occurring and anthropogenic)
- Evaluation of potential exposure scenarios

Data Analysis Documentation

- SAP
- QAPP
- Analytical results for all samples in tabular format, including comparisons to relevant remediation objectives, and appropriate supporting documentation.
- Methods employed in placing, collecting, screening, and handling samples
- Real world coordinates for each sample location based on *IDEM Office of Land Quality Spatial Data Collection Standards*[34] (IDEM, 2008b).
- Digital copy of all sampling results formatted according to OLQ *Electronic Data File Submittal Guidelines*[35]
- Analysis of temporal trends
- Calculations for site-specific remediation objectives

[34] http://www.in.gov/idem/files/olq_spatial_data_collection_standards.pdf
[35] http://www.in.gov/idem/5384.htm