Photo courtesy of *Eagle Synergistics*. Photo taken while conducting a HRSC investigation in Navajo nation.

# *Implementing Direct Sensing High Resolution Site Characterization at EPA UST Release Sites in Indian Country*

U.S. Environmental Protection Agency
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## 1.0. Introduction.

In 2023, the United States Environmental Protection Agency's Office of Underground Storage Tanks commissioned a study[1] on the applicability, benefits, and costs of high resolution site characterization at underground storage tank release sites, also known as leaking UST sites. The study included interviews of state, federal, private industry experts, and practitioners. The study concluded that HRSC provides:

- A better understanding of geology and contaminant distribution.
- Increased confidence in making corrective action decision.
- Typically reduced overall project costs and duration.

EPA prepared this document to provide guidance to EPA project managers in Indian country on implementing HRSC to realize the benefits described by the study. In addition, it will assist them in requesting and interpreting results of direct sensing HRSC investigations. This guidance draws heavily on information provided by specialist contractors and equipment manufacturers, states, regional EPA experience, and information provided by the Interstate Technology and Regulatory Council in *Implementing Advanced Site Characterization Tools*. This guidance provides project planning tools to help EPA project managers implement HRSC investigations, including:

- A tool selection table based on project objectives and data needs.
- How to include existing data in developing the preliminary Conceptual Site Model.
- Information on working with stakeholders to develop the final investigation scope.
- What to provide to contractors in a Performance Work Statement that will allow them to develop an adequate project Scope of Work.
- What to look for in the contractor's Scope of Work.

[1] High Resolution Site Characterization at Petroleum Underground Storage Tank Release Sites: Applicability, Benefits and Costs IEc April 2023.

The guidance describes field work activities, how to review field data, and how to use results, including suggestions about:

- How to engage stakeholders.
- How to adapt the investigation based on results.
- How to understand field data and quality control measures.
- Quality Assurance documentation and Standard Operating Procedures.
- The process for making on-site decisions.
- How to review the data received.
- How to incorporate HRSC data in adapting CSMs.
- Communicating HRSC data and engaging stakeholders in case decisions.

The guidance then presents case studies that help describe how HRSC projects were planned and implemented at a selection of sites.

## 1.1. HRSC Benefits, Tools, and Considerations.

### 1.1.1. HRSC Site Characterization Benefits.

HRSC uses adaptive work planning, multiple technologies, and dynamic work execution to reduce uncertainties, optimize the selection of remedial alternatives, and reduce the cost of long-term management of contaminated land. HRSC allows investigations to be completed at a scale and data density appropriate to resolving the data gaps in the project conceptual site model. HRSC helps to:

- Characterize subsurface conditions at a scale and resolution that conventional investigation methods are unable to attain.
- Identify and delineate the contaminant mass phase(s) that are present (i.e., non-aqueous phase liquid, dissolved, sorbed, and vapor).
- Assess whether contaminant mass is in a permeable zone (mobile porosity) or a low-permeability zone (immobile porosity or essentially “storage”).
- Enable more accurate estimation of contaminant mass and volume through more precise identification and delineation.

- Optimize the selection and design of viable remedy alternatives following the guidance ITRC LNAPL-3.
- Reduce the cost and improve performance of remedy monitoring by optimizing well placement (including injection, recovery, and performance monitoring wells).[2]

### 1.1.2. HRSC Tools and Techniques.

Direct sensing probes use physical properties of subsurface materials to infer lithology, water content, contaminant content and hydraulic conductivity. Blending this information can be used to infer soil type and likely properties in storing and transmitting water and contaminants.

Where the geology permits, direct sensing tools are advanced into soils and unconsolidated formations to measure physical properties or to detect the presence of selected chemical contaminants. Data from sensors on these tools are plotted versus depth and are commonly called "logs." The logs are viewed onscreen in real-time as the probes are advanced and the log data are saved in digital files for later review and presentation. Some of these sensors may be combined into one probe to maximize data collection and to reduce time and cost.

[2] From Clu-in HRSC Intro.

# Direct Sensing HRSC Tools

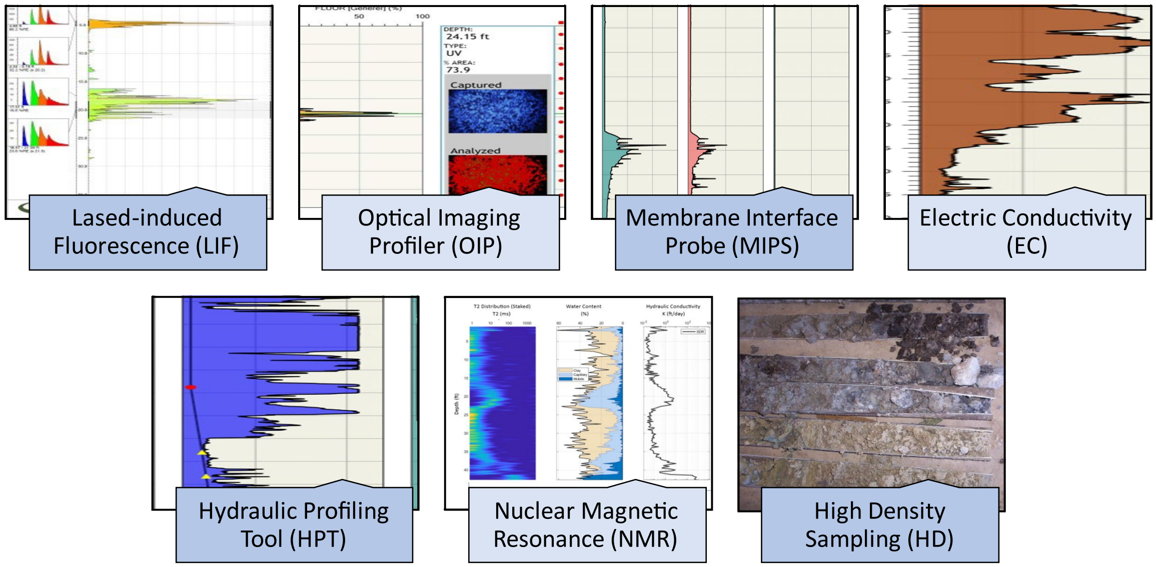



*Figure 1.1.2. Representation of direct sensing HRSC technologies and data they provide.*

**Direct Sensing HRSC Tools**

The most common tools used in direct sensing HRSC investigation at UST release sites are below.

- Laser Induced Fluorescence ultraviolet optical screening technology identifies separate-phase hydrocarbons present in the soil-pore space and can differentiate LNAPL types when used by skilled practitioners.
- Optical Image Profiler -- identifies separate-phase hydrocarbons present in the soil-pore space.
- Membrane Interface Probe with photoionization detector and flame ionization detector -- detects elevated dissolved-phase and residual petroleum contamination at concentrations below reliable response with LIF or OIP. MIP detection of VOCs also can provide screening for petroleum vapor in the vadose zone[3].

[3] MIP systems equipped with halogen detectors (e.g., halogen-specific or an electron capture detector used in chlorinated solvent direct sensing) may be useful at used oil UST release sites or where leaded-fuel releases have left residual 1,2-dichloroethane. At most UST release sites, however, the concentrations of chlorinated hydrocarbons will be extremely low and may not typically be detected using these sensors. Where these contaminants may be present it is better to define the general area of the petroleum plume and the likely geologic strata where contaminant migration is likely to occur using direct sensing HRSC methods and then collect samples for precise laboratory analysis using traditional soil or groundwater sampling techniques.

- Electrical conductivity -- helps differentiate fine- and coarse-grained soil layers or to identify conducting fluids (e.g., saline water or landfill leachate). EC is commonly combined with the MIP, OIP and LIF probes.
- Hydraulic Profiling Tool -- evaluates lithology, permeability, and estimates hydraulic conductivity in the subsurface soil layers to identify potential storage and transport zones for residual LNAPL and possible pathways for dissolved-phase contamination.
- Nuclear magnetic resonance -- estimates porosity and water content and infer soil type and hydraulic conductivity. NMR is not used in combination with other tools due to the development of strong magnetic fields and potential interference.
- High density soil sampling and groundwater profiling confirms results and compare laboratory-measured concentrations (e.g. TPH, BTEX, and naphthalene) to the direct-sensing measurements.

Examples of the use of many of these tools are provided in the case studies in Chapter Six.

**Other HRSC Techniques**

While direct sensing HRSC tools are the subject of this guidance, there are other HRSC techniques, such as geophysics and multilevel sampling that can differentiate preferential geologic pathways or storage zones where direct sensing is not practicable.

HRSC can also be completed by collecting discrete, high-density samples or using NMR in existing wells. Passive sub-surface sorbent air sampling can be used as a preliminary HRSC technique before using direct-sensing tools. This technique can achieve high quality, compound specific screening at part per billion resolution and the sampler can be installed using hand tools. This technique provides a way to delineate sites that are inaccessible to drill rigs.

## 1.2. UST Release Sites where High Resolution Site Characterization may be Useful.

The 2023 study identified situations where HRSC:

- Is typically recommended.
- May be considered.
- May not be appropriate or necessary.

Criteria and factors for consideration are summarized below. HRSC may be appropriate to use in other scenarios not described here. Project managers should consider the corrective action needs and the likely overall cost and time savings when deciding if HRSC is appropriate.

**UST release sites where HRSC is generally recommended.**
If any of the following apply at your site, the EPA Office of Underground Storage Tanks recommends that the project manager conduct an HRSC investigation[4].

- A large release has occurred and a quick determination of the LNAPL extent and dissolved phase contamination is needed.
- Rapid movement of contaminants to receptors is suspected.
- Cleanup costs >$100,000 are being contemplated.
- Large release (> 1,000 gallons) has occurred.
- Determining placement of monitoring well screens placement in complex soils.
- A 3rd round of investigation to define the extent of contamination may be needed.
- The Conceptual Site Model does not explain LNAPL movement or persistent or recurring LNAPL.
- In situ treatments will be injected into the ground.

**UST release sites where HRSC should be considered.**
The EPA OUST recommends that the project manager consider conducting an HRSC when:

- Differentiating between new and old releases.
- Monitoring wells with persistent or recurring levels of contaminants of concern are preventing case resolution.
- Considering a new remedial approach after a remediation method has failed.
- Presenting a graphical display of the CSM that shows the relationship between groundwater elevations, the source area(s), soil layers, migration pathways, and the extent of contaminated groundwater.
- The CSM did not adequately quantify the LNAPL volume or define the groundwater flow pathways when considering using MNA or NSZD.
- Active remediation has been conducted for over 10 years.

[4] Experts and practitioners that participated in the 2023 study were in near unanimous agreement that HRSC will improve decision making and may save time and money in the situations described. Each of the boxes presented summarize the expert opinions on when and when not to use HRSC.

**UST release sites where HRSC is not appropriate.**

HRSC is generally not appropriate when:

- The geologic conditions are not suitable for the available technology (e.g., groundwater is too deep, or rock or dense gravel prevent the use of direct-push tools).
- The contaminated zone is small enough, and the geologic profile is simple enough that the site can be fully characterized with traditional techniques in a single phase of investigation over a few days.
- Sufficient data already exist to make conclusive case decisions.
- Excessive mobilization cost or delayed deployment time of HRSC compared to conventional boring and monitoring well investigation techniques would result in greater overall costs or a longer duration for the corrective action.

## 2.0. Project Planning.

Careful project planning is essential when using HRSC techniques. This requires planning flexibility and stating clearly defined project objectives so that HRSC tools are rapidly applied as new data is obtained.

Many aspects of HRSC projects can be managed much like "conventional" borehole and monitoring well investigations. As part of deciding whether to use HRSC and how to use HRSC, consider the specific and important factors below when using HRSC.

- Use site information and other existing data sources to create a preliminary CSM (as described in 2.1) and use the CSM to define data collection objectives, site remediation goals, and implementing agency data requirements.
- Decide how newly generated data will be shared, stored, and integrated with previous site assessment data and used to adapt the preliminary CSM.
- Adapt the investigation decision-making process and scope of work to reflect real-time data as the investigation proceeds. This can greatly facilitate the decision-making process and reduce project costs.
- Ensure Tribal authorities are integrated into the planning process and Tribal knowledge is incorporated as appropriate into the data objectives. Identify local stakeholders who may have information to share and will be interested in the data gathered. Real time and adaptive information gathering is inherent to direct sensing HRSC. It informs interested stakeholders about the investigation design, implementation, and reporting. This helps all parties gain comfort in the decision making that will follow the investigation.
- Estimate what is required to meet the data gathering objectives (e.g., the level of effort, technologies).
- Determine how to evaluate data obtained from detector responses to develop a targeted remediation plan.
- Design a visual representation of the data throughout the investigation.

## 2.1. The Preliminary Conceptual Site Model and Developing Project Objectives.

In all cases, develop a preliminary CSM that clearly describes project objectives and data needs. At a minimum, describe:

- ✓ Hydrogeology.
- ✓ Expected source of contamination.
- ✓ Contaminant movement pathways.
- ✓ Exposure points that are being investigated.
- ✓ Source-pathway-receptor relationship data gaps that cannot be adequately defined using existing information.

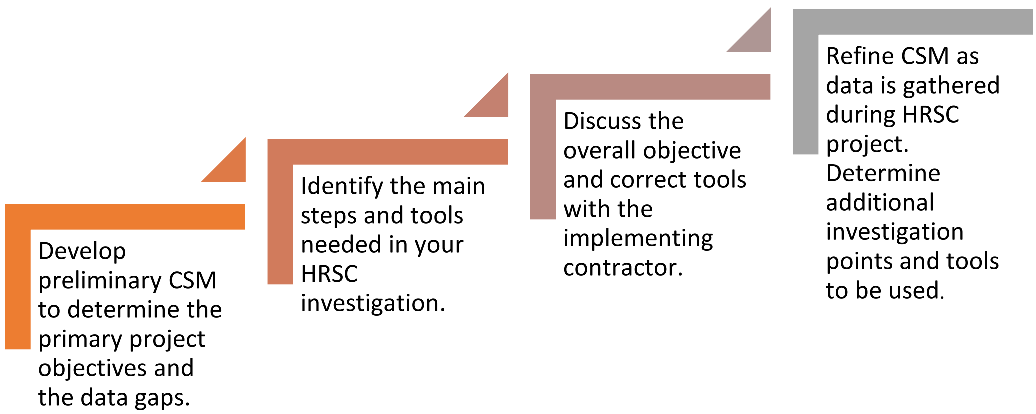



*Figure 2.1 Developing CSM and HRSC Project Objectives.*

Table 2.1 provides examples of typical project objectives derived from the 2023 EPA HRSC study and describes the associated data needs and resulting key HRSC tools. Use the preliminary CSM to determine the primary project objectives and the data gaps that an HRSC investigation can help resolve. Understanding the objectives and data needs will help you identify the main steps and tools needed in your HRSC investigation. Then you can discuss the overall objective and correct tools with the implementing contractor. Additional guidance on identifying and selecting tools is available in the ITRC ASCT tools and documents. The preliminary CSM will be adapted as data is gathered during the HRSC project and help decide which additional investigation points need to be completed and what tools used.

*Table 2.1. Project Objectives, Data needs and appropriate HRSC Tools for Petroleum UST Release Sites.*

| | **Data Need** | | | |
|---|---|---|---|---|
| | Locate non-aqueous phase liquid (NAPL).[5] | Identify dissolved-phase or low level sorbed concentrations. | Identify geologic variability, particularly high vs low permeability strata. | Estimate contaminant mass relative to clean and contaminated soil. |
| **Project Objective** | **Recommended HRSC Tool(s)** | | | |
| Where is the subsurface source: LNAPL delineation? | UVOST® or OIP<br>MIP<br>HD | MIP | | |
| How far have contaminants travelled: plume extent? | UVOST® or OIP<br>MIP | MIP | | |
| LNAPL residual, mobile or migrating. | UVOST® or OIP<br>HD<br>NMR may identify LNAPL heavy oils but has not reliably detected gasoline or diesel. | | HPT and EC to accurately locate wells and screen to allow representative transmissivity tests (if required).<br>Soil cores for contaminant concentrations. | |
| Are there preferential geologic pathways? | UVOST® or OIP | MIP<br>Discrete GW samples | HPT and EC<br>NMR may help identify water-bearing units. | |
| Are there confining layers creating perched contaminant layers? | UVOST® or OIP | MIP | HPT and EC<br>NMR | |
| Need to know where to inject chemicals, absorbents or nutrients. | UVOST® or OIP<br>HD | MIP | HPT and EC<br>NMR | UVOST or OIP<br>MIP<br>HPT HD |
| Need to differentiate between new and old releases or different sources. | UVOST®<br>OIP can locate different sources but not type of LNAPL<br>HD with appropriate analyses. | MIP helps map dissolved-phase plume that may help differentiate sources.<br>Compositional analysis of soil and groundwater samples.<br>Microbiological assays. | HPT and EC - understanding geologic pathways helps understand potential sources. | |
| Understand why monitoring wells have persistent or recurring contaminants or LNAPL. | UVOST® or OIP | MIP | HPT and EC | |
| Is there a PVI risk based on EPA screening criteria? | UVOST® or OIP | MIP<br>Vapor sampling | HPT and EC | |
| A sentinel well network needs to be installed to detect movement to receptors. | UVOST® or OIP: If dissolved phase only, UVOST® or OIP may not be necessary. | MIP | HPT and EC | |

## 2.2. Involving Stakeholders in Project Planning.

Stakeholder engagement is a vital part of designing the HRSC objectives in a way that meets both CSM development needs and stakeholder information needs. Plan dialogue and information

[5] OIP and UVOST may not effectively detect aviation gasoline NAPL as it is typically **not** fluorescent.

exchange with key stakeholders on the data that is being gathered, how that data will be used and shared with stakeholders during and after field work. Invite local stakeholders to view the HRSC investigation and the real-time data. This will provide an opportunity for stakeholders to express concerns and needs. The case studies in Chapter Six provide examples of how stakeholders were involved in HRSC investigations. The selected contractor should be able to describe the work they will do in plain language and to explain the results to interested stakeholders from a range of non-technical backgrounds.

## 2.3. Developing the HRSC Contract.

The HRSC performance work statement is developed after project objectives and data needs have been agreed upon, and the appropriate technologies selected. The PWS is the basis for the request for proposals and the scope of work shared with the contractor. The PWS provides a relatively concise statement of the HRSC work, usually including an overall project objective and a list of the steps and tools the project manager considers the most useful. Be sure to describe your reporting and analysis expectations in the PWS. Attachment One – Example Performance Work Statement contains a sample HRSC PWS modifiable to the tools selected and the specific site conditions. Based on the PWS, the contractor develops a project work plan that guides decision making during the investigation. HRSC contractor capabilities vary on data analysis and presentation, so it is important that the PWS clearly identifies the skills expected from the HRSC subcontractor. The PWS should be clearly written and clearly describe specific project requirements and outcomes.

Typically, EPA personnel and the contractor discuss the contractor's work plan to ensure it meets the project needs. Section 2.4 describes the information that you should provide the contractor that will help them create an effective work plan. Section 2.6 highlights areas of the work plan to review to ensure the work plan has information to help guide discussions with the contractor and ensure project expectations are met.

General LUST remediation contractors typically do not have the necessary expertise to perform HSRC activities and will need to subcontract this work out to another company. There are numerous contracting companies with HRSC direct sensing capabilities at locations across the U.S. Some operate just the sensing equipment and subcontract the drilling operation, while some carry out both tasks. Both sensing and drilling equipment is highly mobile and can be transported in the back of a pick-up truck or van. The sensing equipment can be easily shipped by plane, helicopter, or boat to access remote locations. Many smaller direct-push rigs are available that can be transported on a trailer or pick-up truck or mounted on a barge. Some direct-push rigs can be dismantled for transport by air.

*Geoprobe Systems*® and *Dakota Technologies, Inc*. provide information on specialist contractors who can provide OIP, MIP and UVOST® direct-sensing services across the U.S. In most cases, there is at least one provider located in, or adjacent to, any state. *Geoprobe Systems*® provides technical training to operate its direct-sensing tools and provides training for contractors, consultants, and regulators on interpreting logs.

## 2.4. Performance Work Statement: Developing the Work Plan with the Specialist Contractor.

To develop a comprehensive work plan based on the PWS and to ensure the most appropriate equipment is used for the project, the contractor will need detailed site information. The following tables describe general items, detailed information, and reporting elements the contractor may need to develop a comprehensive work plan that will achieve desired outcomes.

*Table 2.4a. Description of General Items needed for PWS.*

| PWS General Items | Description |
|---|---|
| **Project Scope.** | Describe in broad terms the site and the overall purpose of the assessment (e.g. locate LNAPL in order to apply the EPA PVI screening protocol to assess whether a site can be safely redeveloped for a particular use). |
| **Data gaps.** | List what EPA has identified as the primary data gaps and which HRSC tools EPA thinks can most easily provide the required information. |
| **Communication Plan.** | Identify key contacts at EPA and the Tribe and list responsibilities for identifying and communicating with stakeholders. Describe how the HRSC contractor is expected to provide information and communicate with EPA, Tribes, and stakeholders. This may include emails, online meetings, community meetings, and explaining the HRSC tools to interested parties during actual field work. |
| **Site permits and access clearance.** | List who (EPA, Tribe, contractor) has responsibility to obtain permits for site work, including well installation permits, resolving access, and paying any fees. |
| **On site decision making.** | Specify whether EPA or Tribal staff will be involved in decision making during dynamic work planning or whether field decisions will be left entirely to the contractor. |
| **Daily communication.** | List expectations for information exchange during field work. This should include online distribution of each log as completed and daily updates on work completed and recommended work for the next day. If offsite personnel will be involved in decision making, schedule an online daily meeting to review each day's data and the plan for the next day. |
| **Quality control.** | Reference the required quality control procedures for the HRSC techniques requested. Quality control and standard operating procedures from Dakota and Geoprobe Systems® are provided in the Attachment Three – Standard Operating Procedures for Certain HRSC Technologies of this document. ASTM standard practices are available for MIP (D7352) and HPT (D8037) logging and an OIP standard practice is being developed. |

*Table 2.4b. Description of Detailed Information needed for PWS.*

| PWS Detailed Information | Description |
|---|---|
| **UST facility description and history.** | Site buildings, UST locations, dispenser layout, history of UST removals and excavation. |
| **Site maps, photos, utility drawings.** | Provide available information and make available to contractor to allow them to plan necessary field work and to evaluate whether they have sufficient information to develop a basic structure for a CSM visualization.<br><br>At all sites, for safety reasons, the contractor will need to complete an appropriate utility survey before any subsurface field work is completed. |
| **Site Paving Conditions.** | The contractor will need to know surface conditions to plan how and when to "clear" locations ahead of the HRSC. Surface cover can be a significant impediment to rapid completion of the HRSC if, for example, concrete needs to be removed before field work or other obstructions.<br><br>Clearance methods may include manual excavation, concrete coring, air knifing or vacuum clearance and this work may be done ahead of the HRSC contract or on a "day ahead" basis as each day's work is planned. In some cases, a specialist contractor may do this work. |
| **Other site conditions.** | Describe conditions that might require particular equipment, or that limits access such as narrow pathways or steep slopes. Note any overgrown vegetation, wetlands, and slopes. |
| **Available soil and groundwater investigation or UST closure reports.** | • **Borehole logs:** depth to bedrock, blow counts per 6 inches, if available. The direct push contractor needs this information to assess what equipment is needed and where direct sensing tools can be used. Typically, blow counts greater than 40 indicate where probe refusal may occur. If known ahead of time, it may be possible to plan to auger through intermittent hard layers to allow the probe to progress.<br>• Chemistry, contaminants of concern, age of contaminants under investigation, existing analytical data.<br>• Water table elevations, LNAPL measurements in monitoring wells, contaminant concentrations over time.<br>• Current contaminant maps.<br>• Any LNAPL locations, known or suspected.<br>• Current CSM.<br>• Any history of remediation performance. |

| PWS Detailed Information (cont'd.) | Description |
|---|---|
| **LNAPL.** | If LNAPL is present in monitoring wells and can be sampled, the HRSC contractor should use it as a site reference sample for LIF-UVOST® or OIP work, either before mobilization or at the beginning of site work. This helps validate the sensor's capability and identifies LNAPL properties that may affect the sensor in the field and help avoid false negatives.<br><br>Specify whether a sample will be provided to the contractor ahead of the field work or if the contractor should collect an LNAPL sample for validation after mobilization to the site but before field work starts.<br><br>Describe potential NAPLs involved (important if they are types that MIP, OIP or UVOST® don't perform well on [aviation gasoline for OIP and UVOST®, for instance]). |
| **Estimated area of LNAPL and contaminated groundwater to be investigated.** | This governs the number and selection of locations, and how the locations will be decided and modified during site work. |
| **Monitoring wells or boring locations or areas of observed contamination (e.g. seeps into a stream) of particular interest.** | These locations can be compared to the HRSC data (e.g., wells with LNAPL). Describe well depth, diameter, and screened depth and other depth or location information, if known. This information helps calibrate the HRSC data and the HRSC data can aid understanding of how groundwater or contaminant zones relate to the well construction. |
| **Desired depth of investigation.** | This might be an absolute depth, an elevation or a depth related to groundwater, bedrock, refusal, or a particular stratum. Note that experience dictates that most residual LNAPL mass likely will be present or retained below the range of groundwater elevation. |
| **Acceptable detection limits.** | If there are particular data objectives, such as delineating a dissolved plume to a particular concentration, list those requirements. This will help the contractor advise on the appropriate HRSC tools and the proposed approach. |
| **HRSC tool selection protocols.** | Describe the preferred protocol for selecting tools, for example, when to transition from UVOST® or OIP tools to the MIP probe. In general, it makes most sense to start at the core of the suspected contamination using the least sensitive tools and track the plume outward (e.g., LIF or OIP to define the extent of LNAPL, then MIP to track the groundwater or soil gas plume). The contractor will advise in their work plan which protocols they recommend. |

| PWS Detailed Information (cont'd.) | Description |
|---|---|
| **Confirmatory "conventional" sampling.** | This depends on your data objectives but, in general, it is good practice to complement 10% of HRSC investigation locations (at a minimum of three locations) with groundwater sampling points (which can be completed as temporary or permanent monitoring wells) and continuous soil sampling.<br><br>Confirmatory subsamples should be sent to a laboratory to be analyzed for TPH by EPA Method 8015 (or equivalent) to quantify and characterize the total residual LNAPL mass.<br><br>Additional analysis by GC/MS for BTEX and any other petroleum contaminants of concern should be planned if needed for risk characterization. |
| **Required restoration after subsurface work.** | This could be as simple as backfilling a shallow investigation point to ground level with bentonite chips or might involve bentonite grouting and reinstating finished surfaces. |

*Table 2.4c. Description of Reporting Elements Necessary for PWS.*

| PWS Reporting Elements | Description |
|---|---|
| **Preliminary Conceptual Site Model.** | Specify whether you require the contractor to prepare a preliminary CSM before field work begins that will be used as the baseline to compare field data to as it is received. The preliminary CSM could be 3D visualization or might be a combination of plans and sections using existing geographic and environmental data. It might be as simple as a google earth image with existing and proposed investigation locations marked on it. |
| **Field data files.** | Data files are typically in ASCII, ZIP, or text format. JPEG or PDF images of the data logs should be sufficient for self-processed data. However, request an image that provides data both on an axis that is scaled for the particular log location and an image on an axis that is scaled to allow rapid comparison of all data logs on the same vertical and horizontal axis. |
| **Final Report 2D visualizations.** | Final reports should include a topographic, two-dimensional, view of the results provided at a range of depths relevant to the investigation. Cross sections of logs can quickly define the depth and distribution of contamination.<br>Decide whether you need preexisting data and confirmatory data from this investigation incorporated into the imaging results. This is ideal where adequate previous data exist. |

| PWS Reporting Elements (cont'd.) | Description |
|---|---|
| **Final Report 3D visualizations.** | HRSC contractors can provide results in an interactive model, allowing 3D visualization from different perspectives, typically as an additional cost item. This is a useful tool in public communication and where remediation systems need to be designed.<br><br>If you plan to do your own data manipulation you may need to obtain an appropriate software package. Attachment Five -- 3D Visual Analysis provides information on 3D visual analysis practices and programs to consider when requesting and reviewing 3DVA. |
| **Final Report Quality control.** | The final report should document the Quality Control procedures followed and the results of that Quality Control. |
| **Final Report Descriptive Elements.** | The final report should be a descriptive report of the investigation, integrate new and prior site data, present a revised CSM, and provide conclusions relevant to the project objective. If necessary, the report should identify remaining data gaps and include recommendations for further investigation. |

## 2.5. Preparing an Independent Government Contract Estimate.

When projecting the costs for your Independent Government Contract Estimate, you should include the following in your estimated budget:

- 2D and 3D visualization of existing data to provide the platform for visualizing HRSC data during and after field work.
- Mobilization and demobilization.
- Preparation activities.
    - Public and private utility tracing.
    - Pre-clearance of planned boreholes (hand auguring, soft dig, or air knife).
    - Surveying.
- Daily oversight.
- Direct push rigs to drive the HRSC probes: are there any site restrictions, limited headroom, or no vehicle access, for example, that require particular direct push platforms to be provided?
- HRSC equipment.

- Daily updates and required real time and other reporting data packages.
- Confirmatory sampling.
- Investigation location grouting, backfill and surface restoration.
- Report generation and amount of visual analysis.

Typically, you only need to provide a high level summary of costs for your IGCE, including direct subcontractor costs, other direct costs (ODCs, primarily equipment, shipping costs, etc.) and any anticipated primary contractor oversight costs.

The 2023 EPA study[6] suggests that average costs (including oversight, direct push and HRSC probes and reporting) will be around $7,000 per day and within the range of $4,500 to $12,000 per day. More extensive site preparation activities, confirmation sampling, degree of real time reporting, complexity of visual data analysis, mobilization and demobilization activities will lead to sites being in the higher cost range. Each case study in Chapter Six provides cost information.

For an UST release at a retail gas station with two to four USTs and a couple of dispenser areas, allow for at least three days of HRSC investigation. In most cases no more than five days total will be necessary. The extra two days allow for flexibility in tracing the contamination, completing confirmatory sampling, and installing temporary or permanent monitoring wells. As a guide for budgeting purposes, most direct sensing HRSC techniques can log from 150 to 250 vertical feet per day, depending on the type of technologies deployed, the number of changes of location, extent of residual contamination, the total depths drilled, backfill and restoration requirements, and how much pre drilling clearance is required at each new location. In most cases, a daily rate contract works best, especially if the production rate (direct sensing probe locations completed per day) can be reasonably estimated.

[6] High Resolution Site Characterization at Petroleum Underground Storage Tank Release Sites: Applicability, Benefits and Costs IEc April 2023.

## 2.6. Reviewing the Work Plan.

The workplan details how the contractor will provide data and information to meet the goals of the project and meet the requests made in the PWS. Review the workplan tasks against the PWS for completeness. Consider the following questions as you review the contractor's workplan.

***Are the requested tools listed? If not, are suitable alternatives proposed and justified?*** The work plan needs to demonstrate that the contractor adequately recognizes the project data needs and objectives and will provide the HRSC tools requested or has identified appropriate alternatives. The work plan will include appropriate SOPs and quality control. Make sure the proposed equipment is appropriate for achieving the project data objectives. For example, if a data objective is to differentiate sources of LNAPL, then OIP may not be an acceptable alternative to using LIF-UVOST® techniques without additional confirmatory sampling.

***Is contractor availability adequate?*** Availability can be critical to a proposal responsiveness (e.g., an emergency response to a catastrophic release requires immediate availability). Make sure that the workplan contains clear mobilization times, along with the caveats to achieving that mobilization time (e.g., delays in assigning the project will affect availability).

***How are costs presented?*** HRSC costs are often presented in daily rates, lump sum with a fixed price, or in unit costs. If day or lump sum costs are provided, the proposal must identify the onsite equipment and include allowances for equipment break downs or maintenance. The specialist may indicate daily performance either in feet per day or locations completed. "Reasonable" conservative estimates of average daily performance for most HRSC sensing equipment are in the 150 to 250 ft/day range.

Unit costs require specific information on the tools used and all inclusions. It is important to understand whether the unit costs are additive or inclusive. For example, if an electrical conductivity array or HPT sensor is included with an UVOST® or MIP probe, is the cost of the EC included in the overall MIP, UVOST or OIP cost?

***Are mobilization costs and time factored in?*** Mobilization costs will typically be a function of the distance the contractor has to travel but can be reduced if local drilling contractors can be used to drive HRSC probes rather than have a specialist drive to the site, potentially from out of state. Many HRSC providers have a national presence. If there is flexibility on scheduling site work, they may be able to provide more competitive mobilization rates, particularly if work at more than one site can be combined into the same mobilization.

***Are qualified staff available and identified? Do field staff have appropriate health and safety certifications?*** Using HRSC sensing tools requires in-depth understanding of the sensing technology, petroleum chemistry, and the effects of the subsurface geology on the tools and the sensing results. The HRSC team includes the HRSC sensing tool specialist and an experienced drilling rig operator. The HRSC specialist has general scientific training and experience, a working knowledge of the reference materials and can provide recommendations on the approach and technologies. The drill rig operator should have technical knowledge of and experience with HRSC tools.

***Does the drilling subcontractor have experience?*** If a drilling subcontractor is to be used, rather than a driller from the specialist's team, make sure they have demonstrated experience in driving direct sensing tools or that the HRSC subcontractor has confidence in the drilling subcontractor's ability to operate the system. Also, make sure it is clear who is responsible for costs arising from down time if either subcontractor experiences system breakdowns.

***Does the laboratory subcontractor meet quality standards?*** When confirmation laboratory sampling is needed, be sure to request appropriate state and national certification in the PWS so that the laboratory selected meets appropriate quality standards. In some cases, on site screening level mobile laboratory analyses may provide useful confirmatory data even where full certifications are not in place.

***Does the contractor have positional data through survey or daily GPS data?*** Positional data (latitude and longitude) and elevation allows the CSM to be updated as needed and to identify and adjust elevations of key features. Check to ensure that the workplan requires the HRSC contractor provide this data by using either previously completed survey data or daily GPS data of each boring location.

***Are field quality controls identified and adequately described?*** Field data that is collected should be accurate and complete. Ensure that the proposals specify the type of field quality checks and the frequency that each check will be completed. Some checks are carried out before field work is performed and some between each log location. These are specified in the SOPs included in Attachment Three – Standard Operating Procedures for Certain HRSC Technologies and include visual checks of systems, calibration or "response" checks using pre-prepared samples and line checks to ensure system integrity.

***Does the proposal include contingencies for downtime and repairs?*** It is essential that the proposal includes contingencies for system downtime and tool repairs (i.e., duplicate equipment availability, heated trunk lines for faster purge times when high contaminant zones are found), point timing flexibilities that allow other testing if a particular instrument is under repair, or other work can be completed during sensor repair. The proposal should clearly state that no costs will be incurred while inoperative systems are being repaired.

***Does the proposal describe tools and methods for project planning and stakeholder involvement?*** The selected contractor will be involved in meetings with the EPA, local Tribal authorities, and stakeholders to describe the HRSC investigation techniques and data. The work plan should describe the contractor plans to use emails, on line systems and presentations before and throughout the investigation to communicate with interested parties.

***Does the proposal describe how data will be shared?*** Field data sharing ensures project personnel and other stakeholders, are kept up to date with progress. Field data should be available electronically and quickly. Data may be shared by simply distributing logs by email or could involve a web-based sharing platform. Make sure the proposal describes how data will be shared after completion of each log location and specifies that data will be shared at the end of each day's work.

The plan should identify who the contractor anticipates sharing data with and whether there is any cost implication with adding to the distribution list as other stakeholders become involved with the project. Any such costs must be specified in the work plan.

For more complex sites the contractor should state how they will update the visual analysis of contaminant distribution and geology each day. This ensures that investigation work is based on a real time understanding of the data generated during the investigation.

***Does the proposal include a description of the reports and associated delivery schedules?*** The proposal should describe what the final report will include and how it will be generated and distributed.

The proposal should include a plan and schedule to prepare a preliminary report including field data and initial imaging to ensure that any immediate dependent decisions, like follow up analytical work or groundwater sampling, can be scheduled. Formattable data files should be readily available.

The proposal should include a plan and schedule for providing a final report compiling all analytical data from the field work, field procedures and the results of quality control procedures, follow up work and confirmation laboratory testing and preexisting work.

The ITRC *Implementing Advanced Site Characterization Tools* checklists are included in Attachment Four -- ITRC ASCT Checklists as an additional resource.

## 3.0. Managing the Field Work.

This section describes how EPA, the main contractor, the specialist contractor, Tribal authorities and interested stakeholders work together from before field work is started through completion of the field work to ensure the HRSC investigations include all the required project information in the most effective way. This section describes how to develop a dynamic work plan, what to be aware of when reviewing field data from the specialist, how to understand quality control steps and ways data can be presented during the field work to help the dynamic work plan adapt as results are received.

Before field work starts, complete a virtual pre-mobilization meeting with contractors and interested stakeholders to ensure a clear understanding of the project scope of work and project objectives.

All project personnel and interested stakeholders can meet to review the project objective, SOW, decision making information and daily and location-by-location dynamic decision making once the contractors have mobilized to the site with an approved work plan.

### 3.1. Lines of Responsibility and Stakeholder Involvement.

The specialist contractor works with the overall consultant and the EPA to implement the HRSC. Decisions on safe drilling, preserving equipment, and analytical and quality control reside with the specialist contractor. The specialist contractor works with the overall consultant and the EPA to agree on locations and investigation depths on a location by location and daily basis. This requires that information is shared as it is created.

During the initial site meeting, on-site personnel will review the following topics with Tribal representatives, property owners and operators, and other interested parties:

- On site decision making.
- Access needs (e.g., moving parked cars if access is needed to a particular area).

- Ensuring that the field work has the least possible impact on day-to-day activities at the sites being investigated.
- A project timeline that includes when interim findings are shared.
- The site-specific Health and Safety Plan that includes anticipated hazards, stop-work authority, and daily work objectives.

This meeting is also a good time to discuss plans for stakeholder involvement, including arranging to view an HRSC log location being completed, observing the data being produced in real time, and deciding when to share interim and final 2D and 3DVA.

## 3.2. The Dynamic Work Plan.

HRSC is most effective when it can be used flexibly to gather the data needed to achieve the project objective. Design an overall work plan that lays out the investigation scheme with decision making criteria. The criteria should provide information that aids in deciding where and when to complete the next direct sensing log or sample location.

Describe the investigation strategies in general terms based on the overall objective. Three common strategies include:

1. Mapping a source area by completing a grid of investigation points (see *Figure 3.2.1 Source Area Mapping*).
2. Tracking contaminant movement by working along a transect of points (see *Figure 3.2.2 Plume Area Mapping*).
3. Investigating conditions at a potential point of exposure and working back to the source area (see *Figure 3.2.3 Assessing Points of Exposure*).

In many cases, the dynamic work plan will include components of each of these strategies. In-field decisions can adapt as the CSM develops. The four main types of investigation points are described in the figure below. You should expect to complete all of the primary locations, most of the secondary locations and only those perimeter and infill locations that fill important data gaps.

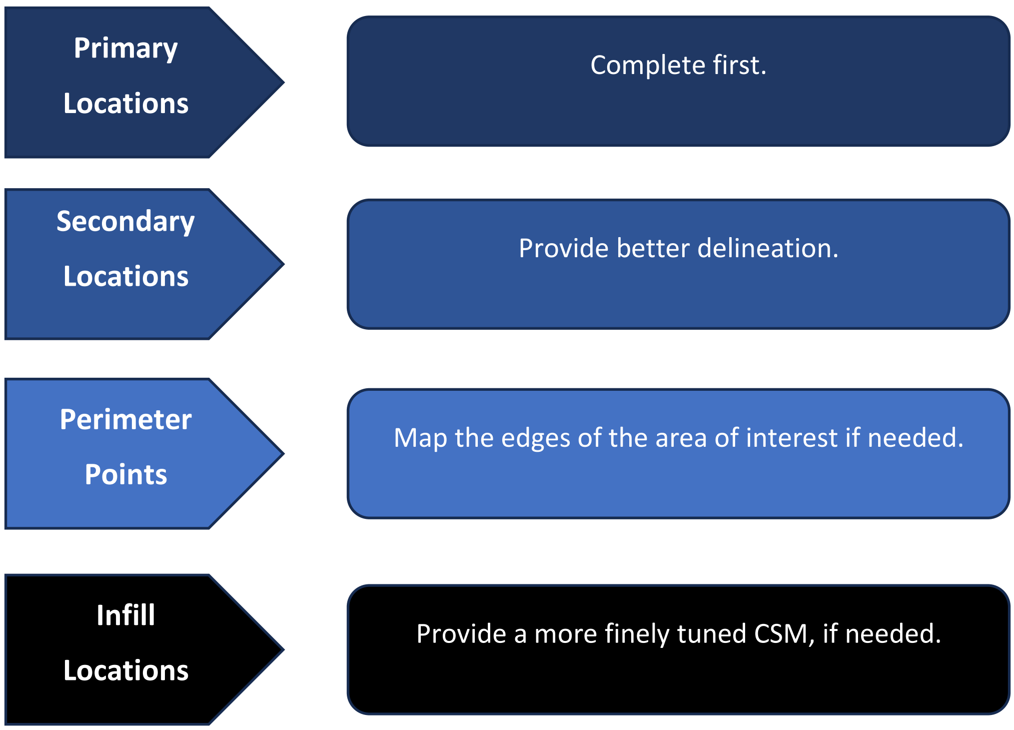



*Figure 3.2. HRSC Investigation Areas.*

While the examples illustrated below use a precise grid, actual site locations will be influenced by factors such as results from previous logs, structures, underground services, and above ground utilities. The likely layouts will need to reflect those barriers to access or drilling.

*Remember that not all, and maybe not even the majority, of the points set out in the preliminary grid will need to be completed. Only those points that provide useful decision making data need to be completed.*

If LNAPL is anticipated, practitioners typically work from the inside of the expected affected area. This means that they will map the LNAPL using OIP or UVOST® before using MIP to delineate the distribution and edges of the dissolved phase plume. In such cases, at least one of the first log locations should be completed next to any existing monitoring well or location with complete boring logs. This "calibrates" the direct sensing data to previous observations.

The denser data and different test methodologies between HRSC and "conventional" investigations means that discrepancies between old boring log data and well sample results and direct sensing log results are to be expected. This is why HRSC investigations are conducted. Such discrepancies may be due to poor sample recovery in old borings or because LNAPL entered a well at a depth some distance below the water table, especially in confined formations. For these reasons, for dissolved phase investigations it is often best for the first log location to be next to a monitoring well of interest to help determine how contaminants are getting into the well screen or missing them. Once the contaminants transport mechanisms are understood then the investigation can be continued upgradient to delineate the source and plume distribution.

### 3.2.1. Identifying a Source Area: Central Grid.

For identifying a source area or mapping the area of the release, a central grid can be most effective. Follow the recommendations below.

- ✓ Outline a grid of potential log locations around the suspected release or monitoring well with elevated dissolved phase or LNAPL to map the extent of the source area (see Figure 3.1).
- ✓ Adjust the grid by allowing for known obstructions (e.g., underground utilities, foundations, and areas without access).
- ✓ Pre-clear more locations than will be drilled to allow flexibility on site.
- ✓ Grid spacing will vary based on the data density needed to meet project objectives, but at most UST release sites the initial grid spacing should be set no more than 25-feet unless existing data already show a larger area of LNAPL is present.

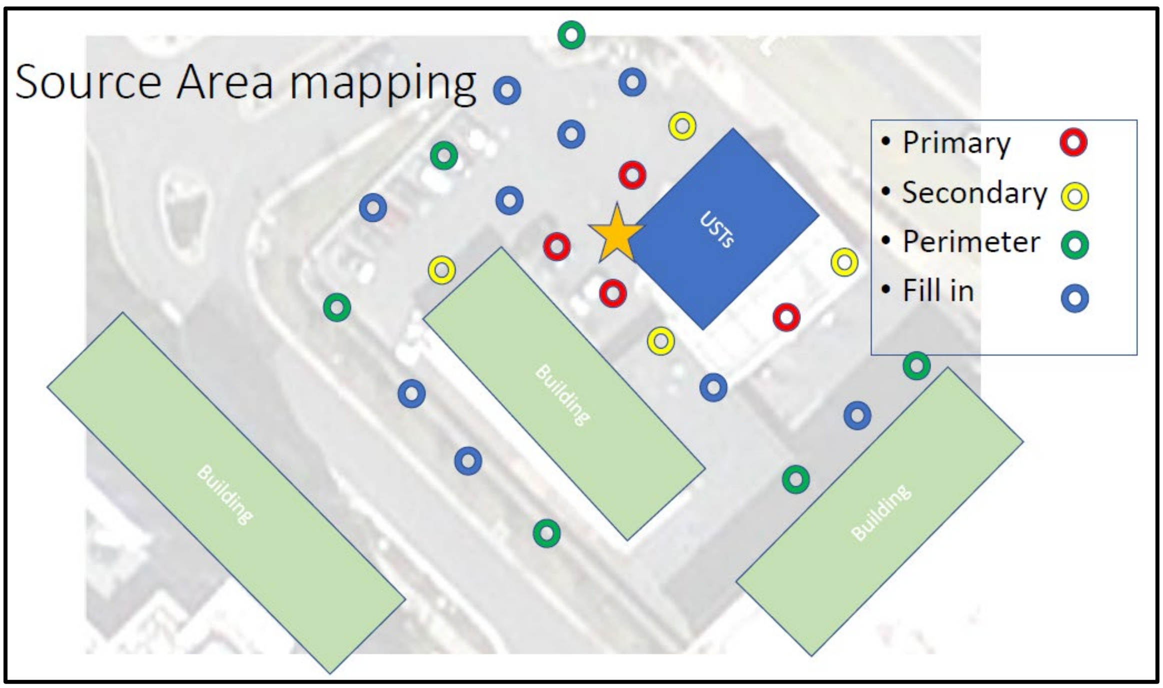



*Figure 3.2.1. Example of a Central Grid Layout to Identify Source Area.*

In this example, the source area is assumed to be around the USTs, but at an actual site the source could easily be from piping or dispensers a significant distance from the USTs.

### 3.2.2. Transverse or Longitudinal Transects: Defining a Plume Area.

Where a plume is suspected, map the extent along its length and map its intensity by completing transverse transects. The direction and spacing of points in the transect depend on hydrogeologic and geologic criteria, as well as contaminant intensity. As discussed above, modify grids for actual sites to account for on-site factors.

For example, it may be appropriate to determine where to put progressive log locations based on previous log results, groundwater gradient, suspected preferential pathways (such as buried alluvial channels or bedding plane orientation), or changes in hydraulic conductivity. LNAPL migration may follow lithologic controls and not move in the same direction as groundwater flow.

Figure 3.2.2 shows a potential layout to map the extent of a potential plume, or the lateral variation based on a particular groundwater flow direction.

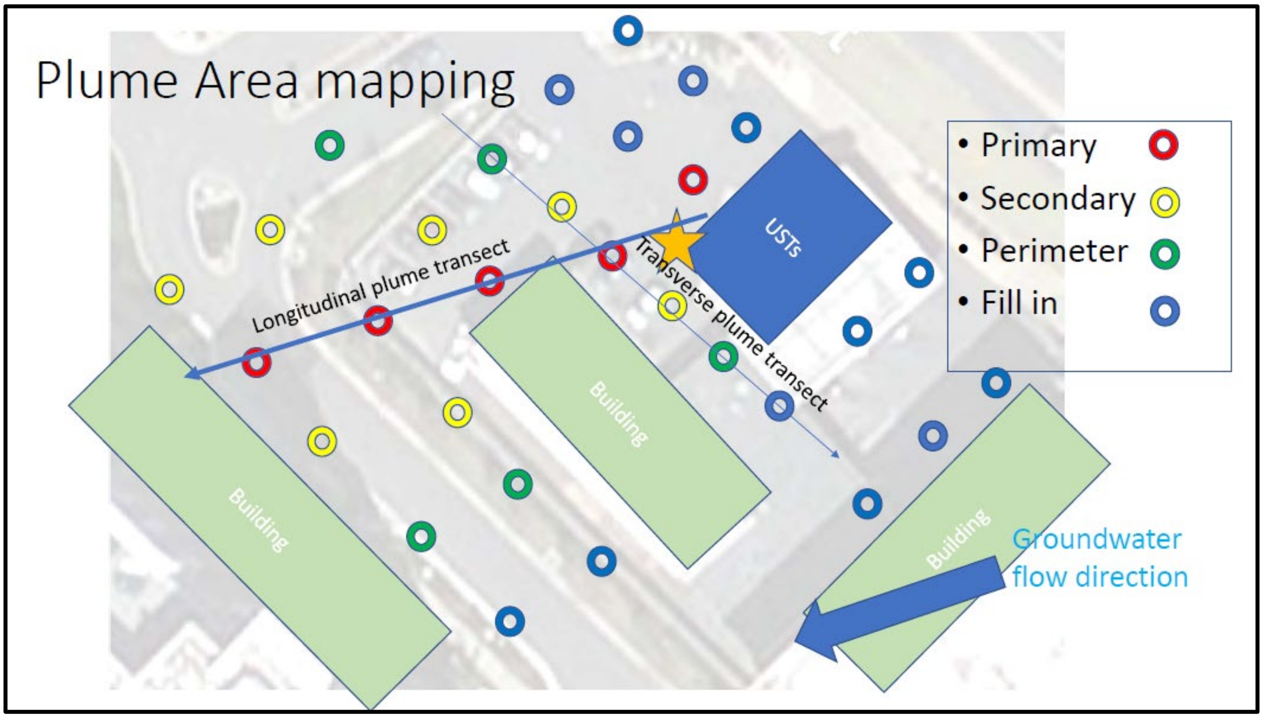



*Figure 3.2.2. Example layout to map the extent of a potential plume or lateral variation based on groundwater flow direction.*

### 3.2.3. Assessing Potential Points of Exposure and tracking back from Known Contamination.

Where there are potential points of exposure (drinking water wells, surface water, utilities, buildings potentially affected by vapor intrusion) it may be appropriate to design the investigation to screen the area to identify which receptors require further investigation. For example, use OIP or UVOST® log locations near building foundations to assess whether the EPA petroleum vapor intrusion screening criteria are met for depth to LNAPL. Depending on the investigation objectives in some cases it may not be necessary to extend the investigation toward the source area. In other cases, the investigation may be designed to start at the known area of contamination (for example, LNAPL in a monitoring well) and then work back to understand both the source area and how the contaminant moved from the source to the location encountered.

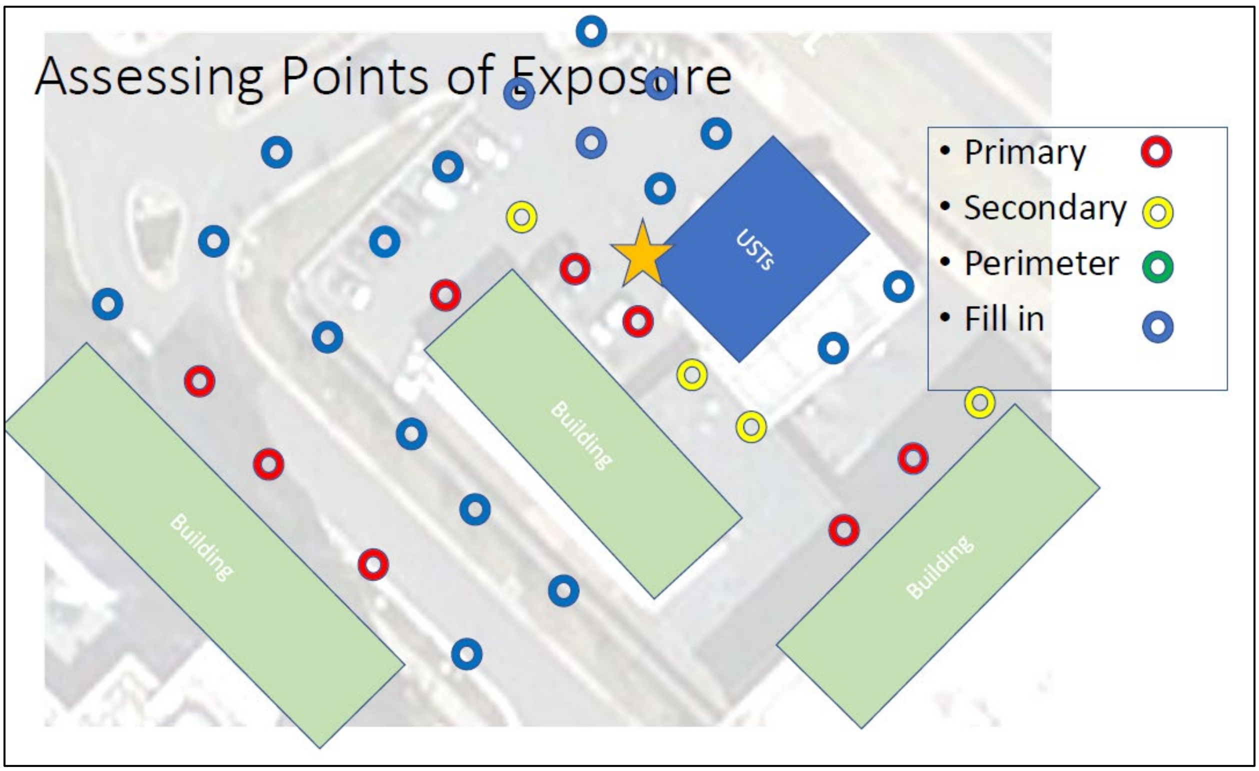



*Figure 3.2.3. Example layout to assess potential points of exposure (in this case buildings potentially affected by vapor intrusion) and track back from area of known contamination.*

### 3.2.4. How Deep should Investigation Locations go?

When deciding how deep to drill each log location, allow for vertical variability. Complete the first couple of locations to considerably greater depths than anticipated for most locations to ensure that the overall geology of the site is understood early in the investigation.

- Extend points at least 10 feet below groundwater, if possible, to ensure that potential contaminant movement at depth is detected. Consider fluctuations of groundwater over time. During dry season or droughts, for example, LNAPL may have migrated deeper and be trapped beneath the "normal" groundwater level after groundwater elevations recover.
- Extend logs 10 feet below the last significant contaminant detection in at least two or three points to confirm no deeper spread. Once the contaminant movement is generally understood it may be sufficient to have 4 to 5 feet (effectively a "rod" length) below the contaminated areas to map the vertical extent.
- If an identified regional barrier to groundwater and contaminant migration exists, like a thick mudstone layer, construct enough locations deep enough to map that formation.

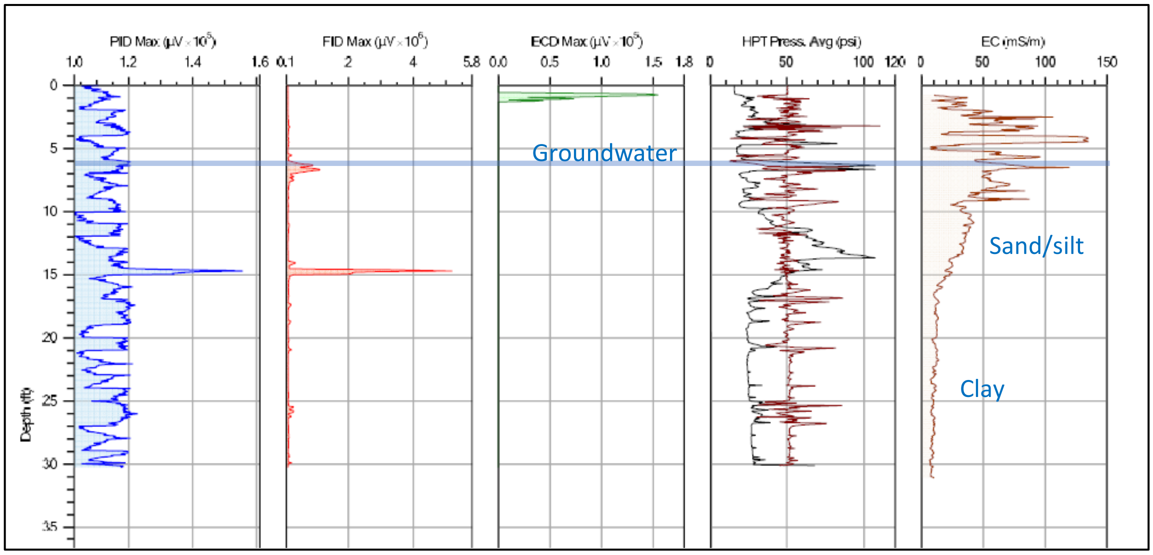



*Figure 3.2.4. MIP/HPT/EC trace showing FID peak below groundwater, above clay base layer.*

## 3.3. Reviewing Data.

As soon as field work starts and data begins to be collected, start making decisions about complete log depths, next data locations, and where to take confirmatory samples.

Direct sensing probes use physical properties of subsurface materials to infer lithology, water content, contaminant content, and hydraulic conductivity. Blending this information can be used to infer soil type and likely properties in storing and transmitting water and contaminants.

ITRC's *Implementing Advanced Site Characterization Tools* and Dakota Technologies, Inc. and Geoprobe Systems® standard operating procedures (included in Attachment Three – Standard Operating Procedures for Certain HRSC Technologies and Attachment Four -- ITRC ASCT Checklists) contain detailed information on system performance and quality control steps.

Table 3.3 highlights decision-making results to consider when updating the live CSM. For more detailed discussion of the use of data provided by direct sensing tools, refer to *Advances in the Characterization and Remediation of sites contaminated with petroleum hydrocarbons*, Chapters 7 and 8.

*Table 3.3. Key information and Key Data Outcomes from HRSC Tools.*

| Sensor | Attribute | Detection | Reading interval | Key decision-making information | Caution |
|---|---|---|---|---|---|
| **Electrical conductivity** | Soil grain size, water quality | Layers as thin as 1-2 cm | 1.5 cm intervals | Identify potential confining layers and permeable zones. | Salinity and other ionic fluids (e.g. injected bioremediation chemicals) can affect measurements. |
| **Hydraulic profiling tool** | Water injection into soil to assess permeability. | 0.03 to 25 m/d: silt to sandy gravel | 1.5 cm intervals | Estimates hydraulic conductivity and identifies permeable and confining layers. Dissipation tests allow water table to be identified. | Unable to quantify low (clays) or very high (gravel) hydraulic conductivity (>30m/day). If data at these extremes needed interpret with EC data or consider NMR. |
| **Nuclear magnetic resonance** | Filled and open porosity, water content | Averages properties over a 30 cm interval. | 5 to 30 cm[7] | Measures porosity and water content. infers low and high level permeability variation and identifies water bearing units. | Currently does not work with other tools on same drive. Can estimate hydraulic conductivity up to 3000 m/day. Limited availability. |
| **Laser induced fluorescence – UVOST®** | Measures induced fluorescence of PAHs within hydrocarbons as a percentage of a reference emitter (%RE). | %RE of 0.5%: Typically, 2% or greater is a potential indicator of LNAPL. Analyze wave form to help identify LNAPL at low %RE, even below 2%. | 1.5 cm | Identifies LNAPL presence. Wave form provides indication of product type and weathering. | While UVOST does not differentiate between residual, mobile or migrating LNAPL, wave intensity and wave form can be used to indicate depths with higher transmissivity and indicate where LNAPL is entrapped or residual[8]. False positives from some forms of calcite (e.g. limestone and caliche) but wave form analysis allows these to be identified. Certain conditions, e.g. heavy oils or tar can mask signal. |
| **Optical Image Profiler** | Measures area of induced fluorescence of PAHs within hydrocarbons as a percentage of the pixels within the optical "frame." | Rule of thumb is to use a fluorescence area >5% as indicative of NAPL. | Image preserved every 1.5 cm. Operator can stop and take high quality "still" images. | Identifies LNAPL presence. Provides photos of LNAPL distribution in soil and provides visible light images of grain size at selected depths. | Cannot differentiate product type or LNAPL state and be aware of false positives from calcite, etc. but these may be filtered out by optical image processing and interpretation. |
| **Membrane Interface Probe** | For petroleum hydrocarbons uses flame ionization and photoionization detectors to measure volatile organic compounds. | Estimated detection limits for normally operating MIP are 0.5 to 5 ppm for BTEX and petroleum hydrocarbons. | MIP takes a VOC reading every 1.5 cm. The most "accurate" reading is taken every 30cm when probe advancement is halted for 45 seconds. | FID measurements near $10^7$ µv indicate the presence of residual LNAPL. Compare FID and PID readings to differentiate petroleum from natural organics, including methane. | After the probe passes through a heavily contaminated zone, a carryover "tail" of contamination can appear to show a greater depth of contamination than is there in reality: avoid using MIP in LNAPL areas. Increase time allowed for the probes to purge and equilibrate or use heated trunk lines. This effect is most significant for the PID. |

[8] Laser-induced fluorescence logging as a high-resolution characterisation tool to assess LNAPL mobility, Science of the Total Environment, 2020, Rincon et al.

## 3.4. Quality Control Review.

In general, steps are taken before each log is run, during each drive or "log acquisition," in reviewing each data file, and at the start of each day's work. The following information on typical quality control can be used as a guide to expectations for the specialist contractor and the EPA regional site manager can use the information to help them assess whether the contractor is using good quality control practices.

For all direct sensing work, the contractor should visually check that rods, connecting threads, and cables are in good condition at the start of each day and between each log location.

Duplicate logs approximately 3 feet apart should be considered:

- At least once during field work or at 5% of investigation points to test the reproducibility of site data.
- Adjacent both to logs with elevated readings and near downgradient logs showing "background" readings.

Note that these duplicate logs are an internal system quality control check and different from confirmatory sampling (discussed in Section 3.6).

The SOPs and QAPPs included in Attachment One – Example Performance Work Statement and Attachment Two -- Example QAPP Crosswalk for Direct Sensing HRSC provide details on Quality Control steps, and they also are summarized in the table below.

*Table 3.4. Checklist of Quality Control activities for HRSC projects. This checklist provides recommended actions to take daily, between points (as applicable), during each log, and during data review for various HRSC sensor types.*

***Electrical Conductivity***

| *Timing* | Quality Control Activity |
|---|---|
| ***Daily*** | ✓ Complete a test measurement using a purpose designed “test jig” for two standard EC values. Results should be within 10% of standard. |
| ***During Each Log*** | ✓ Assess log quality as the probe advances. Flat lines or numerous sharp spikes may indicate electrical problems. |
| ***Data Review*** | ✓ Compare to HPT and NMR data and borehole logs if available. |
| ****Note*** | ✓ EC is affected by salinity in soil and groundwater. It may be used to track brine plumes or ionic remediation injectate in some cases. |

***Hydraulic Profiling Tool***

| *Timing* | Quality Control Activity |
|---|---|
| ***Daily*** | ✓ Check probe and screen for plugging, damage, or water leaks. Complete QA tests prior to each log. Pressure is tested with water flow and without flow through the screen. |
| ***During Each Log*** | ✓ Perform dissipation tests at selected permeable zones in the formation. Monitor penetration rate, HPT and line pressures and flow for consistency. |
| ***Data Review*** | ✓ Compare groundwater depth estimated from on-site boreholes or background information to HPT data. |
| ****Note*** | ✓ Perched water (and potentially LNAPL) may be detected above impermeable layers with targeted dissipation tests. |

***Nuclear Magnetic Resonance***

| *Timing* | Quality Control Activity |
|---|---|
| ***Daily*** | ✓ System is calibrated using process software before mobilization and before each log is run. |
| ***During Each Log*** | ✓ Reference coil used to check for background noise. |
| ***Data Review*** | ✓ Compare to HPT and EC data. Compare to slug tests from nearby wells. |
| ****Note*** | ✓ Be aware of artificial signal generation, such as power cables and heavy traffic. |

*Table 3.4 Checklist of Quality Control activities for HRSC projects (cont'd.).*

***Laser-Induced Fluorescence – UVOST***

| *Timing* | Quality Control Activity |
|---|---|
| ***Daily*** | ✓ Check probe seals, inspect sapphire window for chips, cracks. |
| ***Between points*** | ✓ Measure reference emitter and normalize readings to the %RE. Be aware of potential for fogging inside the window. |
| ***During Each Log*** | ✓ Monitor probe pushing rate to ensure low level detections can be observed. |
| ***Data Review*** | ✓ Review wave forms for false positives (and to identify low level %RE true LNAPL detections). Check background readings are less than 0.5% %RE and no greater than 1%. |
| ****Note*** | ✓ If possible, compare a site LNAPL sample to the reference emitter signal. |

***Optical Imaging Profiler***

| *Timing* | Quality Control Activity |
|---|---|
| ***Daily*** | ✓ Check camera frame rate remains near 30 frames/sec. Is optical window clear and undamaged? Does the camera give a zero response in black box test? Measure performance (% area fluorescence) against gasoline and diesel standards. |
| ***During Each Log*** | ✓ Check images for potential sources of false positives. Verify camera frame rate remains near 30 fps. Verify power level to probe remains within acceptable range. |
| ***Data Review*** | ✓ Compare optical and fluorescence images to verify fluorescence % appear reasonable. |
| ****Note*** | ✓ If possible, use site specific LNAPL sample to verify level of detection with the OIP. |

***Membrane Interface Probe***

| *Timing* | Quality Control Activity |
|---|---|
| ***Daily*** | ✓ Check calibration, heating block and membrane and carrier gas flow rate. Typically, benzene or toluene are used as QA standards before each log for fuel investigations. |
| ***Between points*** | ✓ Check response against a range of quality standards. Verify carrier gas flows are stead. Verify detector responses are reasonable with no long flat lines or abundant sharp spikes. |
| ***During Each Log*** | ✓ Check for signs of carryover, ensure probes and lines are purged between points. Use OIP or LIF log results to avoid LNAPL or very high concentrations. |
| ***Data Review*** | ✓ Compare signal intensity to grain size indicated by EC/HPT. |
| ****Note*** | ✓ In cold weather heated trunklines can help with line purging and preventing moisture influencing measurements. Weathered fuels will provide reduced responses. Can track vadose zone vapors for PVI investigations. |

## 3.5. Updating the CSM during Field Work and Next Steps in the Dynamic Work Plan.

As data are collected and reviewed, decisions can be made about which locations in the work plan to complete next. The overall approach should be to “jump” points when a positive result is obtained for the data being sought, whether that is LNAPL, elevated PID and FID readings, or identifying a potential pathway such as a gravel-filled alluvial channel. This ensures data can be fine-tuned as needed by returning to intervening locations as time and resources permit.

Once the main source area has been identified, the next steps are refining and defining the extent of the plume to the level of precision needed to resolve the project objectives. This is the part of the characterization where iterative investigation locations are needed to identify potentially subtle signals at the edge of the plume, and whether UVOST signals for LNAPL or PID/FID measurements for dissolved phase plumes. Careful analysis of UVOST signals can help identify low level LNAPL at the boundaries of the LNAPL body, even at low signal intensity. At this stage, operator expertise is an important part of making on site decisions to fine tune the CSM.

Locating additional log locations and deciding on depths and investigation tools should be guided by the original CSM. The project objective is also modified by the data obtained at each location. For example, if the original CSM envisioned sand layers with deep groundwater but initial locations identify clay or other lower permeability layers within the sand below the release, it might be appropriate to have more shallow locations near the source area to identify whether a perched contaminated layer exists.

## 3.6. Confirmatory Sampling.

This guidance recommends completing soil and groundwater sampling with associated laboratory analyses adjacent to 10% of direct sensing locations to compare the results (note that confirmatory sampling is in addition to the 5% of duplicate logs that provide an internal quality control check for the sensor systems as described in Section 3.4).

When completing confirmatory sampling, typically using the same direct push rig as used to carry out the direct sensing, remember locations will not be identical because of the variability of contaminant distribution. Confirmation samples should be collected close to log locations and no more than 5 feet away, with sufficient space between locations to avoid driving down the same hole. Even if a soil sampling point is constructed within 5 feet of a log location there is no certainty that an elevated direct sensing reading at a specific depth in one location will be matched by a soil sample at the same depth in the adjacent location due to soil heterogeneity.

*Figure 3.6. Sample of weathered bedrock showing relict fractures and discrete stained layers.*

Consider using the HRSC tool to analyze representative splits of the confirmation soil sample cores for a realistic comparison of the in-situ sensor and the laboratory's results on the same soils.

Careful logging of soil cores, including careful depth measurements and ensuring the amount of soil core recovery versus depth is accurately recorded, helps accurately identify contaminated areas. If practical, consider including photographs of the soil core under ultra-violet light to help detect LNAPL. General suggestions regarding confirmatory soil sampling include:

- As budgets and time allows, core subsamples should be taken at systematic intervals, for example 1-foot intervals from above, through the thickness of the observed LNAPL, to below the LNAPL.
- Consider additional sampling at soil transitions of interest or if noticeable variations in direct sensing signal response indicate a change in product or site conditions.
- Chemical confirmation samples should be submitted for laboratory analysis for the petroleum of concern (e.g., TPH GRO for gasoline releases, TPH DRO for diesel releases).
- Analytical results can guide which samples are selected for other contaminants of concern, when that information is needed (e.g. benzene analysis for risk management purposes).
- TPH analysis results correlate with direct sensing results to provide a rough comparison.
- For LNAPL screening, the recovered soil log is screened with the direct sensing tool to provide a direct correlation between the samples taken and the screening tool. If the correlation works well, use the HRSC spread of data with statistical analysis to provide estimates of contaminant mass, and with HPT data, mass flux.

Dakota Technologies, Inc. provides a LIF frozen core analysis that allows a laboratory grade comparison of the UVOST tool to laboratory chemical analyses[9]. This level of analysis may be appropriate at large release sites but may not be cost effective at "typical" UST release sites. However, it may be considered at any site to yield some site-specific correlation between HRSC results and laboratory data.

Collect confirmatory groundwater samples using driven probes or from monitoring wells constructed at the locations suggested by the direct sensing investigation. Direct push groundwater samples reduce the time and cost of confirming groundwater conditions. If monitoring wells are constructed as part of confirmatory sampling, use the soil property and contaminant data from the direct sensing to design screen intervals that accurately sample the strata of concern and ensure screens do not overlap and connect multiple flow zones.

[9] LIF frozen core analysis (LIFFCA) using UVOST® and TarGost®.

If LNAPL is indicated by the investigation (and a project objective is to identify whether LNAPL is residual, mobile, or migrating), install monitoring wells that are designed to carefully target the LNAPL interval identified by HRSC. Use those monitoring wells for LNAPL transmissivity testing and collecting discrete LNAPL samples, if needed.

The confirmatory sampling is another line of evidence: the data is in addition to, and does not supersede, the data provided by the direct sensing investigation.

## 4.0. Reporting and Communicating Results.

The data dense outputs from HRSC investigations allow visually powerful reports to be generated. These reports can show how contamination is being stored and transmitted in ways that are easily understandable and are accessible to a range of audiences. There are many ways to show the data -- from straightforward two-dimensional pictures to interactive 3D computer generated images. Decide on the reporting objective and how the reporting will help decision making and communicating with decision makers and stakeholders to help you decide how to display the data.

Reports should include individual data logs, data can be compiled into cross sections and plans, or presented on 2D or 3D visualizations. Data files should be provided in a format that can be used as needed to tabulate results. Attachment Five -- 3D Visual Analysis contains more details about 3DVA.

The following sections describe typical reporting formats that an EPA project manager can expect to see. The information provided can be used to guide contractors on EPA expectations.

### 4.1. Presenting data logs.

HRSC data log should be made available by the contractor individually as a visual image, and at a scale selected to maximize the data visibility for each individual log. Also, use a common scale to show the relative results between each log. Present logs as cross sections to show lateral and vertical trends relevant to the project objective. An example is shown below.

This cross section of logs display LNAPL fluorescence in red, plotted over HPT injection pressure in blue. Permeability is generally low across the site with HPT pressure typically exceeding 50psi. In the example below, the third log from the left, outlined in yellow, was run in the former tank pit which had been backfilled with clean sand after the tank was removed. The low HPT pressure down to about 10 feet below grade in this log is a clear indication of high permeability soils, like sand. The low and flat HPT pressure down through the backfill indicates the water level is below the bottom of the old tank pit. In an ideal adaptive investigation, more logs would be obtained in the field from a position "to the left" of the first log to constrain the extent of LNAPL migration in that direction.

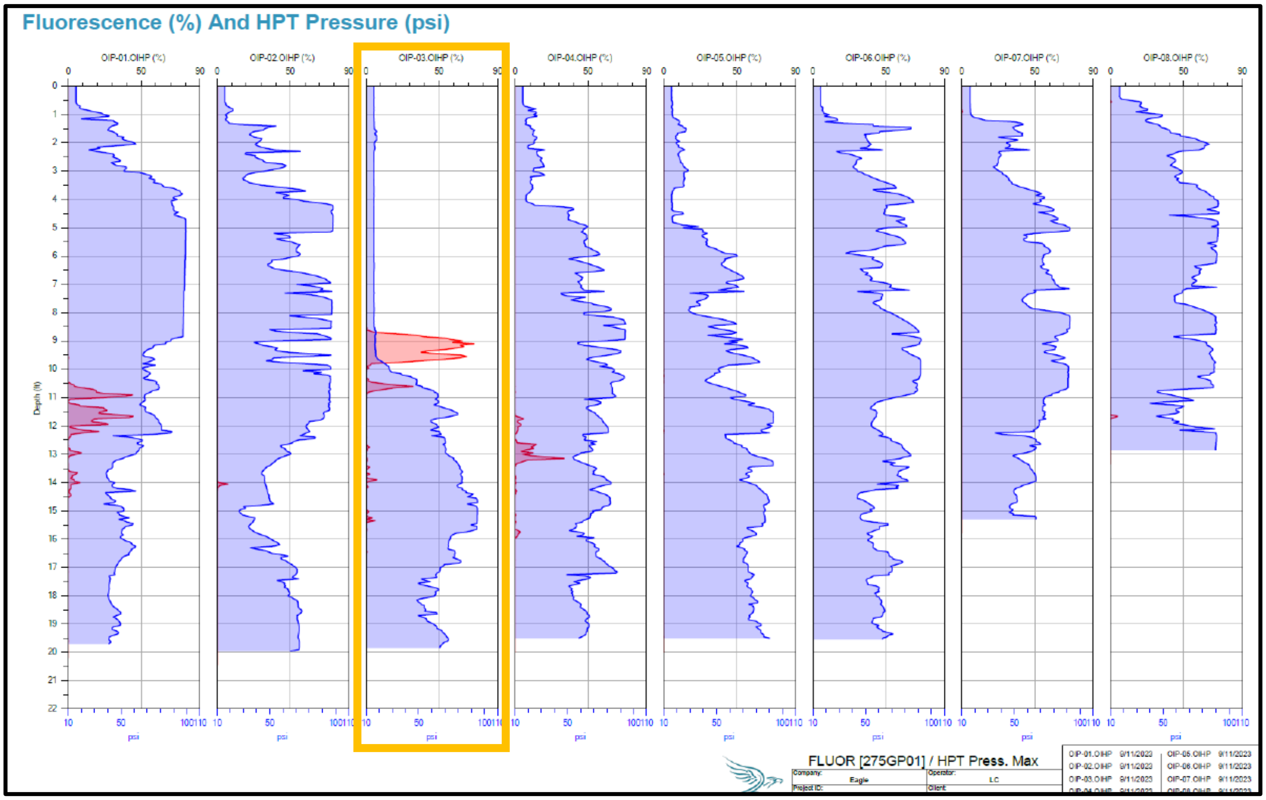



*Figure 4.1 Cross-section of Data Logs. Source: Eagle Synergistics.*

## 4.2. Data Tabulation.

Some log viewing software packages allow entering lab analytical results at the depth where each sample was collected. This provides an easy visual comparison of lab analyses to log results that can be viewed onscreen and printed for reporting. Alternately, log data can be exported to spreadsheets and lab data included in the spreadsheet to allow for plotting of log results beside lab results. Log data, lab data, and lithologic data may be entered into visualization software packages for 2D and 3D visualizations.

## 4.3. Contour Plots.

Contoured HRSC data plots are a useful way to show important features of the CSM -- ranging from peak readings to contours of the top or base elevation of identified contamination. Outlines of the base of permeable or top of low permeability units, represented by HPT or EC data, may also be shown. Lithology can control LNAPL or vapor flow directions instead of groundwater flow directions. Contour plots can be generated based on the total data or can be generated as horizontal “slices” at defined depths to show vertical variation. Make sure the data presentation clearly identifies how the contour plots were generated to ensure the visualizations are comparable. In figure 4.3 below MIP measurements have been used to contour areas of the site where high volatile organic compounds are expected.

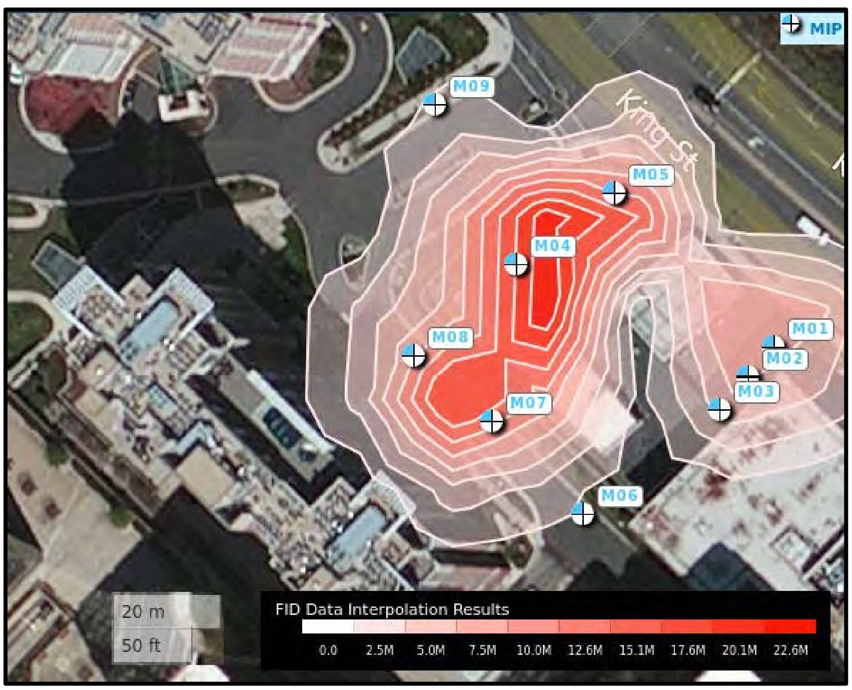



*Figure 4.3. Example of a MIP-generated Total VOC Contour Plot. Source: Columbia Technologies.*

## 4.4. Graphical Representations.

HRSC data can be presented as strip logs, as cross sections, or as compilations of cross sections into fence diagrams. For maximum visual impact of HRSC data, compile the data into a three-dimensional model, incorporating historical data, HRSC data, and confirmatory test results as well as topography and facility infrastructure.

More information on compiling direct sensing HRSC data into 3DVA is presented in Attachment Five -- 3D Visual Analysis.

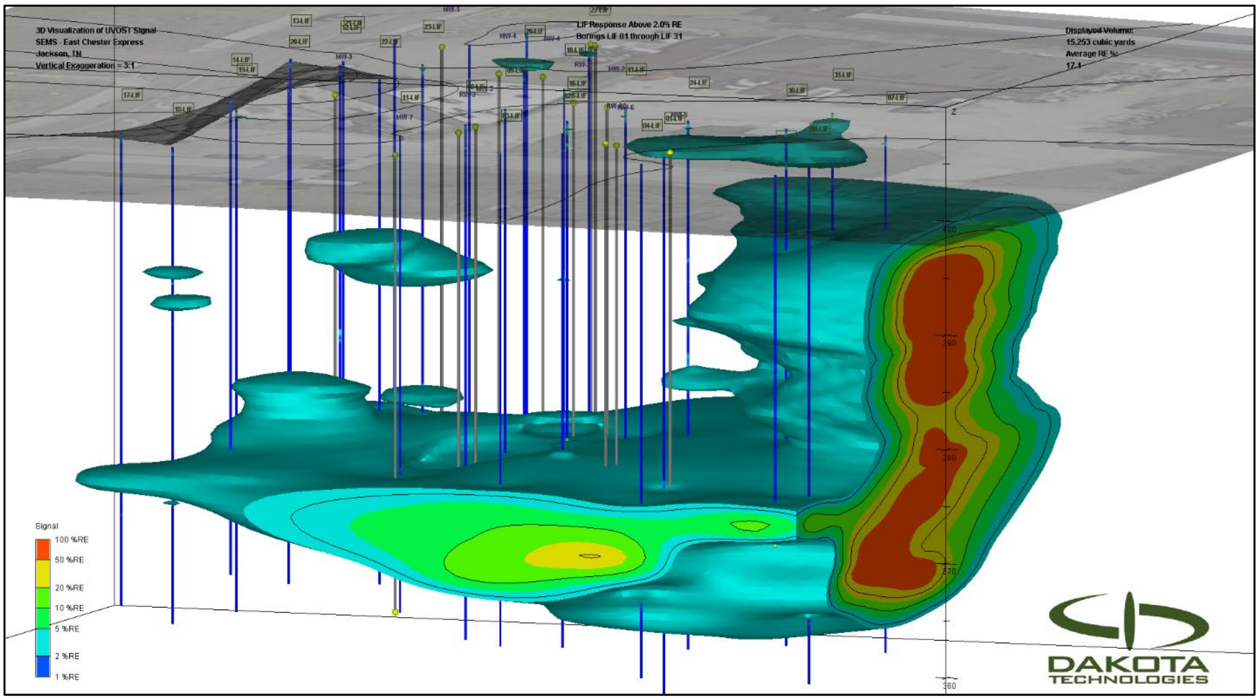



*Figure 4.4a. Still image 3-D Visualization of HRSC Data. Source: Dakota Technologies.*

Data presentations can range from the HRSC "chemical" information, as described in a video prepared for ITRC's ASCT team (as shown in Figure 4.4a) showing the distribution of LNAPL based on UVOST® readings, to more complex representations showing the interaction of geology and chemical data.

Figure 4.4b HPT measurements show the significance of geology in controlling the LNAPL distribution, represented by UVOST® %RE and prepared by Dakota Technologies. While these averaged representations provide a powerful visual way of summarizing the data, they can also provide a misleading impression that the contamination is distributed in balloon-like globules rather than in specific strata.

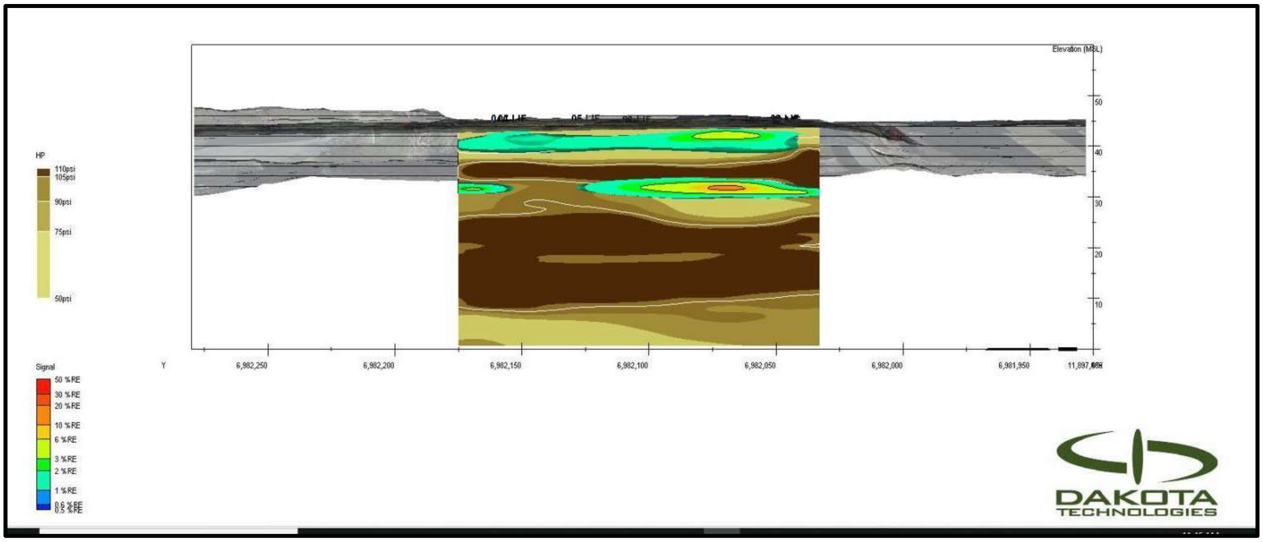



*Figure 4.4b. LNAPL Distribution Visualization. Source: Dakota Technologies.*

A different visual technique presents the individual location measurements to show how geology and contaminant distribution interact. An example of this visualization, prepared by Columbia Technologies, is shown below (Figure 4.4c).

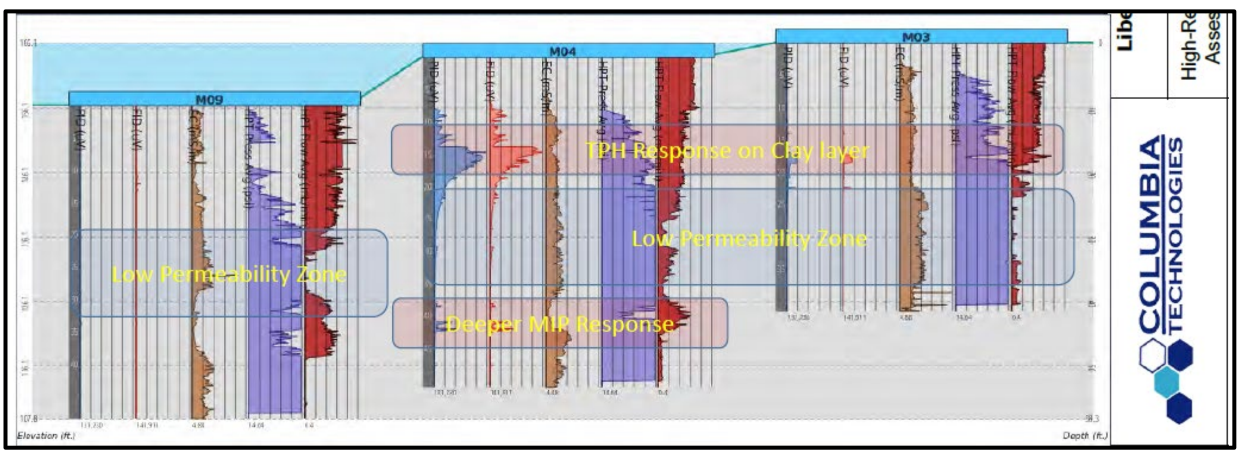



*Figure 4.4c. Geology and Contaminant Distribution Visualization. Source: Columbia Technologies.*

An alternative 3D visualization of HPT and PID data is shown on Figure 4.4d, prepared by Eagle Synergistics. The visualization helps to show areas of contamination contained in the more permeable strata (shown in blue) and perched on lower permeability strata (shown in more purple, red colors).

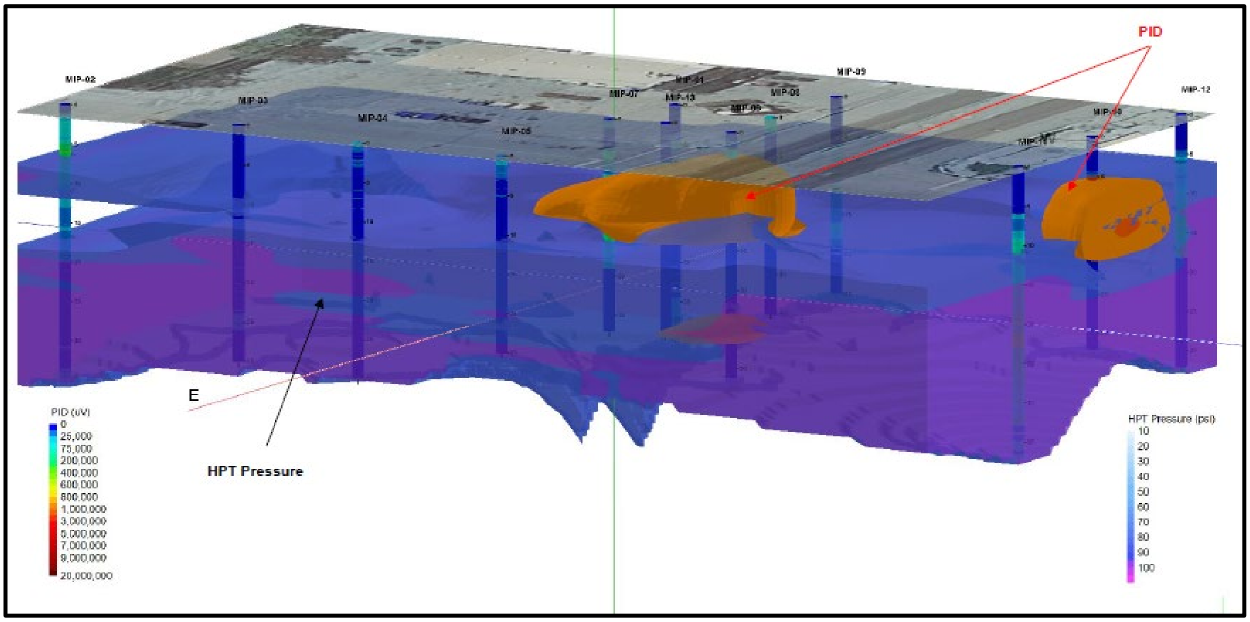



*Figure 4.4d. Areas of Contamination in Different Strata. Source: Eagle Synergistics.*

## 4.5. Historical and Confirmatory Sampling Data and HRSC Data.

Data comparisons can be made in several ways, but all depend on the two data sets being comparable. One way of comparing HRSC data and conventional lab test data is by a comparison and correlation coefficient between the direct sensing data and previously available concentration data and results of confirmatory analyses from the investigation. This can provide useful information on contaminant mass and can be used to estimate mass flux. For example, samples need to be taken from the same geologic strata and in similar locations, vertical and horizontal, to the direct sensing data.

The data can be compared visually, as shown below, or can be compared using tables or graphs.

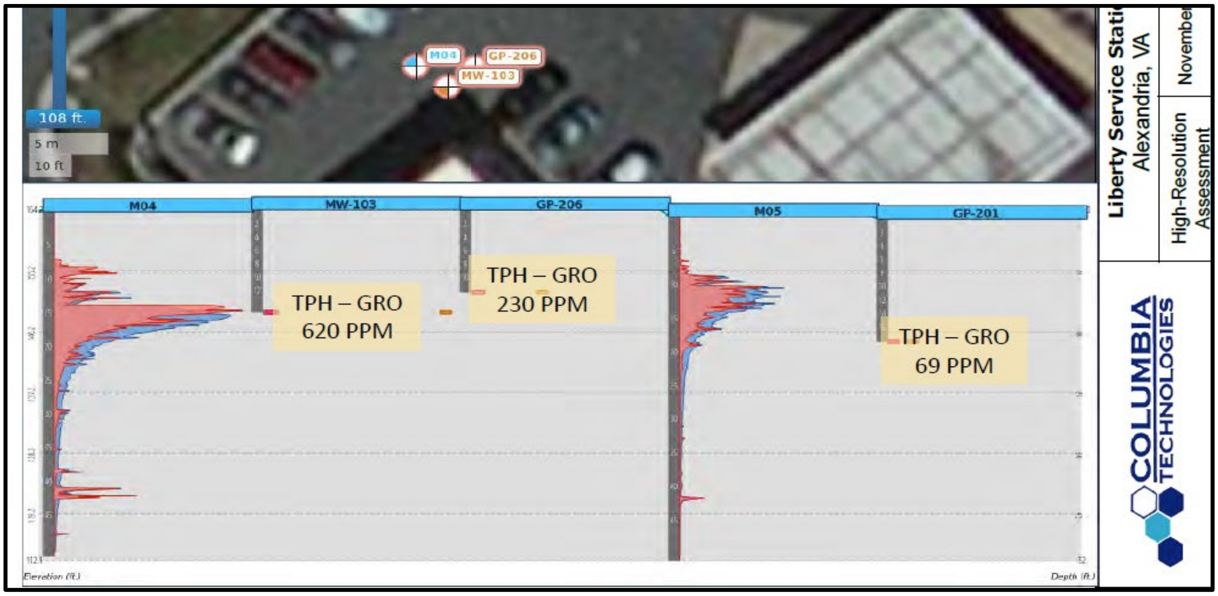



*Figure 4.4e. Visual Data Comparisons. Source: Columbia Technologies.*

Figure 4.4f is an example data log correlating TPH analytical data, field PID measurements and OIP % area fluorescence data[10]. The field-sample PID peaks and troughs broadly match the TPH and OIP readings, but the fine layering of the OIP readings is not reflected in the PID readings, potentially masking the discrete contaminant intervals of concern at 5- and 5.5- feet depths.

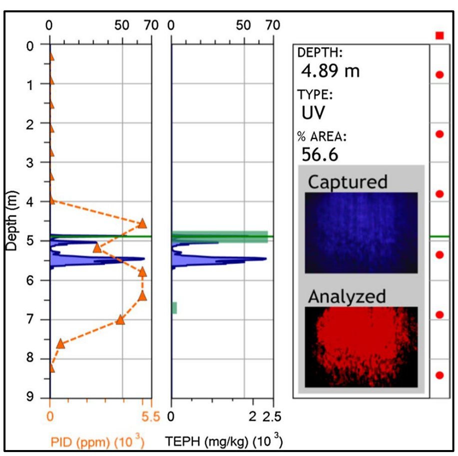



*Figure 4.4f. Data Log correlating TPH Analytical Data, Field PID Measurements and OIP % Area Fluorescence Data. Source: McCall et al. (see footnote).*

Confirmatory sampling can be tabulated against the appropriate HRSC data points, whether compared to UVOST %RE, OIP area % or PID or FID µv, as shown below for a hypothetical LIF-UVOST survey. As noted previously, correlation between results from samples analyzed in the laboratory and results from HRSC are affected by

[10] Evaluation and application of the optical image profiler (OIP) a direct push probe for photo-logging UV-induced fluorescence of petroleum hydrocarbons, McCall et al Environmental Earth Sciences V 77 2018

heterogeneity and reflect different methods. Differences between the data are to be expected so any correlation must be made with caution.

*Table 4.4g. Tabular form of HRSC Data and Confirmatory Sampling Data.*

| | | | | | Contaminant Zone Depths | | | | Analytical Results | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Probe ID | Date | Total Depth | Elevation | Maximum response, %RE | Max response depth | Top response >2%RE | Bottom response >2%RE | Thickness >2%RE | Depth | Analysis | Result |
| 1 | 1/1/2050 | 25 | 100 | 75% | 12 | 8 | 15 | 7 | 12 | TPH-GRO | 1100 |

## 5.0. Incorporating HRSC Data in Decision Making.

EPA site managers can use the multiple lines of evidence collected during the HRSC investigation, confirmatory sampling, screening data (such as soil gas measurements) and preexisting data to help make case decisions consistent with the project objectives. The following table integrates data needs for decision making, data sources, and some indicative values to look for. The HRSC specialist can advise on the significance of site data, interpret the local site conditions, and provide guidance on the overall picture being shown by the HRSC data.

*Table 5.0. Project Data Needs, Data from HRSC, and Confirmatory Results.*

| | HRSC Data | | Confirmatory Results | |
|---|---|---|---|---|
| **Data Needs** | **Chemistry** | **Geology** | **Soil Results mg/kg** | **Groundwater** |
| ***Where is the secondary source in the subsurface?*** | UVOST®>2% and a wave form consistent with petroleum. MIP-FID>$10^7$µv, OIP fluorescence | EC and HPT data can help delineate where contamination might be expected based on stratigraphic predictions. | >100 | >15 mg/l TPH or measured LNAPL |
| ***Is LNAPL residual, mobile or migrating?*** | UVOST®>2% and a wave form consistent with petroleum. MIP-FID>$10^7$µv, OIP florescence Discrete soil samples. | Does EC or HPT data show potential pathways for LNAPL movement? Use EC and HPT data combined with UVOST/OIP to design confirmatory wells. | NA | Measurable LNAPL in confirmatory wells, Collect Transmissivity data, e.g., is T>0.1 $ft^2$/day? |
| ***Is there a PVI risk based on EPA screening criteria?*** | UVOST® petroleum %RE>2%, MIP-FID>$10^7$µv, OIP fluorescence within 15 ft of structure Soil vapor samples | Does EC or HPT data show a barrier to vapor movement? HPT dissipation test groundwater elevation | >100 | >15 mg/l TPH or LNAPL. Groundwater elevation in wells: use HRSC data to confirm elevation is confined or unconfined. |
| ***How far have contaminants travelled: Plume extent?*** | FID and PID data from MIP Groundwater samples. | EC and HPT data showing pathways. | NA | Longitudinal transect of wells located using HRSC log data to define plume extent. |
| ***What is the potential flux?*** | Transects of distribution from MIP-FID, PID. | EC and HPT data define geometry of geology containing the plume. | NA | Transverse transects of wells designed to sample discrete permeable strata used to quantify flux. Calibrated high density data results can be used with HRSC transects of HPT data to estimate mass flux. |
| ***Are there potential pathways?*** | MIP, UVOST® and OIP identify potential movement. | EC and HPT data identify preferential pathways. | NA | NA |
| ***Are there confining layers creating perched contaminant layers?*** | Look for MIP, UVOST® and OIP data with sharp upper or lower boundaries. | High EC data and high HPT pressure, low flow data indicate clay layers. | NA | NA |
| ***Where to inject chemicals, absorbents or nutrients*** | Use MIP results for groundwater plume soil vapor and non LNAPL soil, UVOST® or OIP to define LNAPL contaminant area. | Use EC and HPT data to estimate layers that can accept injectate. | NA | Consider collecting samples for particle size distribution analysis. |
| ***How to differentiate between new and old releases or different sources?*** | Use HRSC data to map plumes. Use UVOST® data to estimate type of product and potential weathering profile that can indicate source. HD data to identify product will be useful. | NA | NA | NA |
| ***Why do monitoring wells have persistent or recurring contaminants or LNAPL?*** | Look for HRSC data indicating contaminants near monitoring wells and in layers potentially not tapped directly by well. | Combining physical and chemical signals and comparing to existing well design will help understand where contaminants are moving into well. | NA | NA |
| ***A sentinel well network needs to be installed to detect movement to receptors.*** | Use HRSC chemical data to map main area of plume. | Use HRSC physical data to identify pathways and groundwater elevation to design vertical and horizontal well and screen placement. | NA | NA |

# 6.0. Case Studies.

The following case studies are derived from EPA regional UST release sites. In two cases these investigations were completed by the EPA regional LUST program, one was completed on behalf of the owner/operator with EPA guidance and one, not in Indian country, was completed under state authority with the EPA involved in funding field work and reviewing the results. The case studies provide examples of how to:

- Determine the amount of soil excavation at a site.
- Assess the potential for petroleum vapor intrusion.
- Determine whether an LNAPL source remained at a site.
- Identify potential pathways for contaminant movement.

The locations range from Washington to Virginia. Refer to the preceding chapters for more information and guidance about technology selection, project planning, and communicating results. Photos and images in the case studies were provided by EPA Region 8 and 10, Virginia Department of Environmental Quality, Dakota Technologies, Columbia Technology, and Eagle Synergistics.

## 6.1. Case Study #1. Pre-excavation Scoping at the Satus Store, Washington.

The EPA investigated Satus Store in Washington state, a closed, abandoned UST system near private drinking water wells. Initial investigations identified petroleum contaminated soil and confirmed that the nearby drinking water wells had not been affected by the release. Residual LNAPL was identified, and the decision was made to remove petroleum contaminated soil to abate the release. HRSC was identified as appropriate given the geology and the data needed.

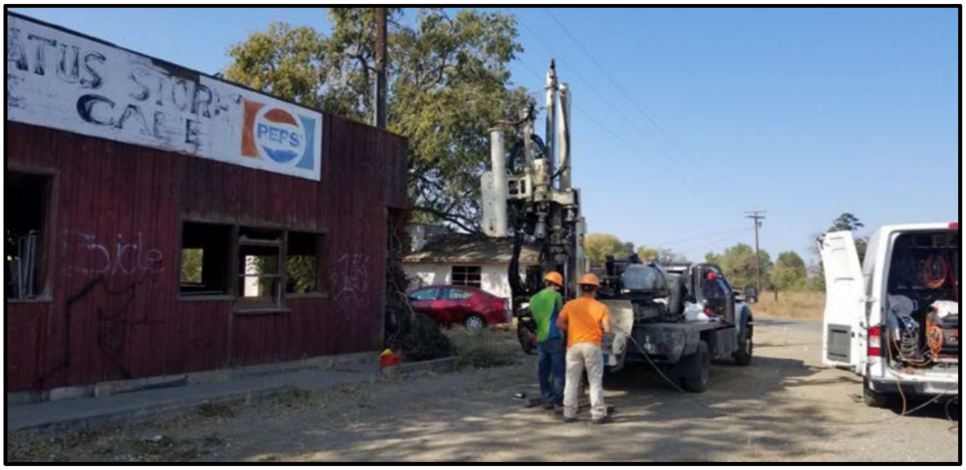


*Figure 6.1. Remediation Activities at Satus Store site in Washington. Source: EPA Region 10.*

### 6.1.1. Objective.

The objectives of the October 2020 HRSC investigation at the Satus Store site were to:

- Determine extent of residual NAPL.
- Approximate volume of PCS that remained on-site at concentrations exceeding cleanup levels (Washington State Model Toxics Control Act Method A cleanup levels for unconditional, clean closures).
- Investigate in the most cost-efficient manner possible.

This data was used to scope the excavation needed to remove petroleum contaminated soil.

### 6.1.2. Scope of Work.

The HRSC portion of the October 2020 site investigation included three days of direct push HRSC borings and collection of four confirmation soil samples to assist in interpretation of the results.

### 6.1.3. Tools Used.

The initial plan was to begin with UVOST® to define the area of residual NAPL, then step out with a MIP/HPT combined tool to characterize lower concentrations of petroleum contamination in the subsurface, and to estimate aquifer conductivity using the hydraulic profiling tool. However, the extent of NAPL and gross levels of petroleum contamination in the subsurface was much greater than expected. Consequently, the entire three days of HRSC was spent using the UVOST.

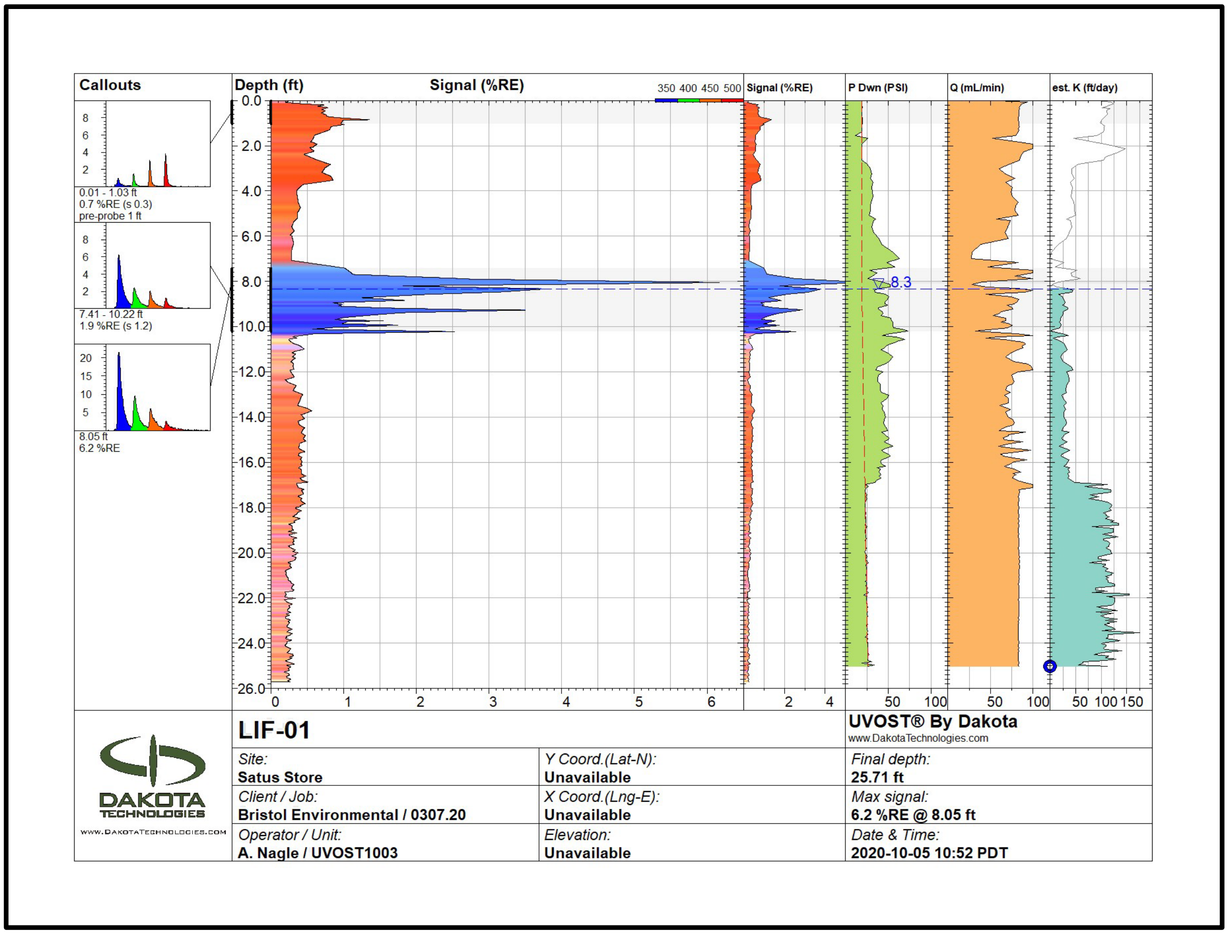



*Figure 6.1.3, UVOST Data from Satus Store HRSC investigation in Washington. Source: Dakota Technologies.*

## 6.1.4. Decision Making Information Obtained.

In the three days of onsite HRSC, a total of 31 UVOST direct push borings were advanced to a typical depth of 20 feet, with a maximum depth of 25 feet, to determine the extent of residual LNAPL. Results of each UVOST boring were obtained in real time which were used to guide further HRSC locations. Twenty-eight out of the 31 UVOST locations showed a significant response in the field. However, final results of the investigation had to wait until confirmation soil sampling results became available and the UVOST response could be calibrated and correlated to lab data.

Of the four confirmation samples collected, two were collected from locations that exhibited a high-response, one from a location with a medium-response, and one from a location with a low-response. The signal on the main UVOST plot (total fluorescence) versus depth is relative to a Reference Emitter. At the Satus site, soils that exceeded MTCA Method A cleanup levels correlated to a %RE greater than 1.5% which was present at 23 of 31 boring locations. The residual LNAPL exceeding this criterion was found between 7 feet and 12 feet deep, confirming excavation was a practical solution and showing where the limits of the excavation would be.

### 6.1.5. Cost and Time.

Total costs for three days of HRSC investigation at Satus were $35,000. This included the drillers who used a Geoprobe Systems® rig, the HRSC subcontractor (Dakota Technologies), and EPA's UST cleanup contractor, Bristol Environmental Services. During the investigation, 31 borings were advanced to depths between 17 and 20 feet through unconsolidated sands and silts, resulting in approximately 200 feet per day. These costs also included a three-dimensional site model prepared by Dakota Technologies by interpolating the UVOST data and generating several 4DIM files to facilitate visualization of the site model. These 4DIM files can be viewed using a free program (Standalone 4DIM Player) available from the C Tech Development Corporation website.

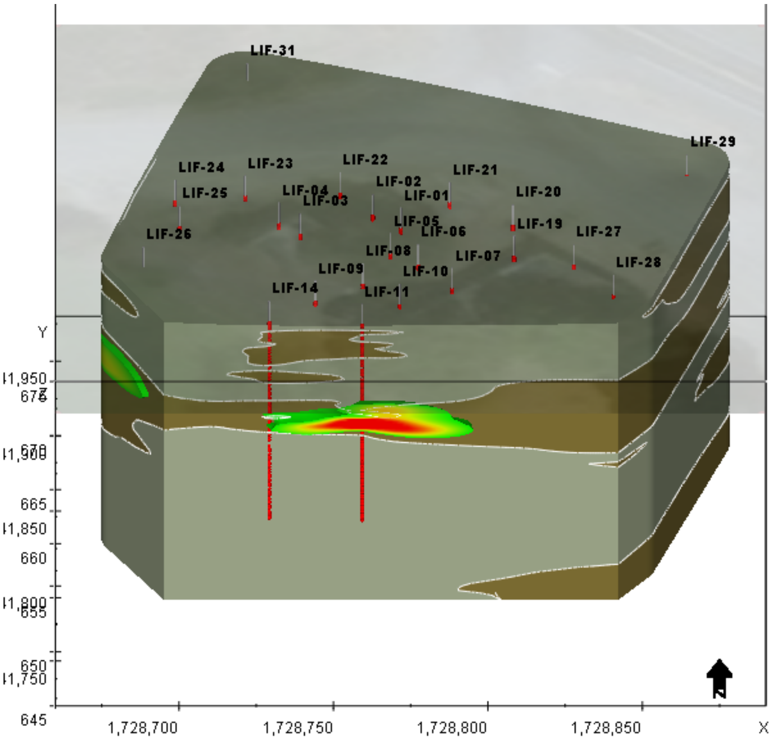



*Figure 6.1.5. 3DVA Satus Store site model from Dakota Technologies.*

### 6.1.6. Communicating Results.

Bristol provided the EPA results of the Satus HRSC investigation as a document with data tables and maps showing the estimated extent of residual LNAPL and PCS present onsite at concentrations exceeding MTCA Method A cleanup levels. Results were shared with the Tribe and no concerns raised. The HRSC investigation helped both to maximize the amount of LNAPL removed during excavation and to provide information showing that the residual LNAPL that could not be excavated was not mobile and posed limited risks to human health and the environment.

Subject to some limited confirmatory monitoring, this site is now a candidate for no further action.

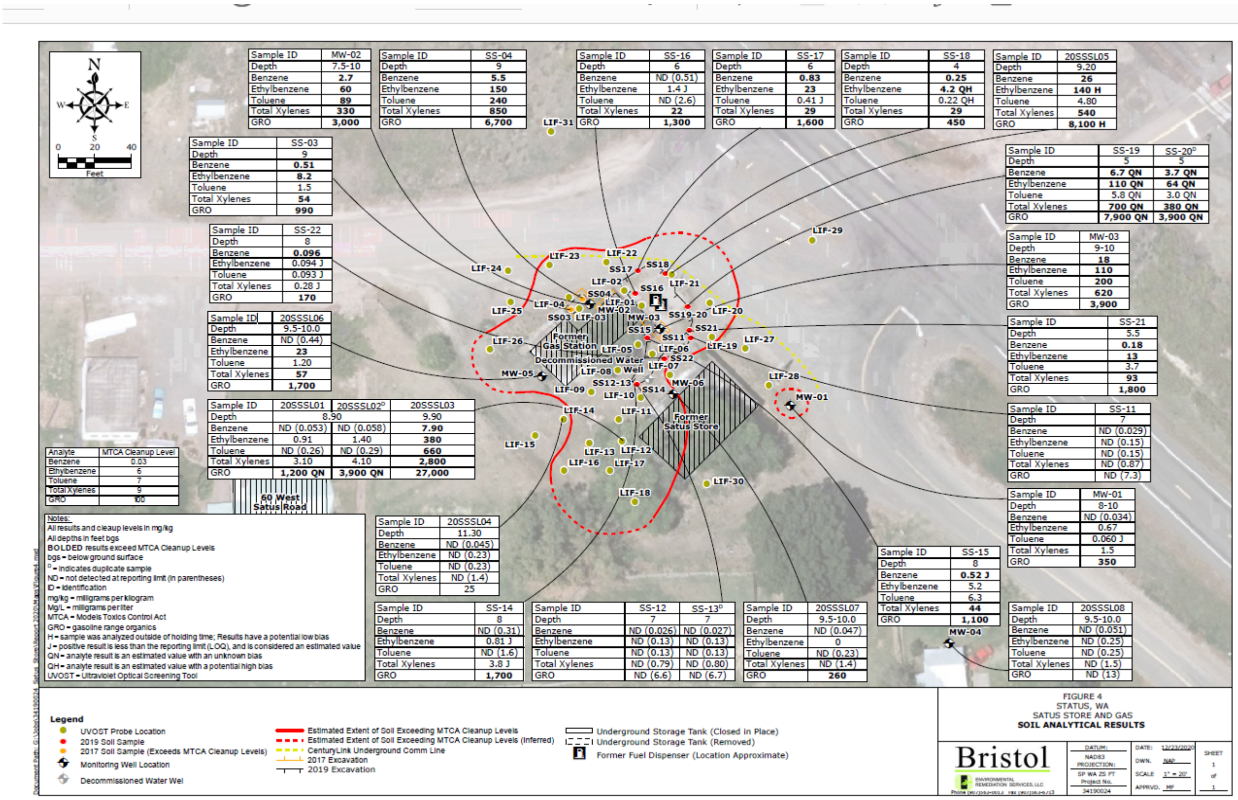



*Figure 6.1.6. Map from Bristol's Deliverable Report from the Satus Store site. Source: EPA Region 10.*

## 6.1.7. Lessons Learned.

While HRSC can be expensive up front at roughly $12,000/day, it can be cost effective overall when compared to more traditional approaches of multiple mobilizations or having a mobile laboratory onsite. It is important for project managers and/or fund managers to consider costs and cost effectiveness comprehensively for a site.

The HRSC investigation at Satus could have benefited from one or two more days in the field to fully characterize the extent of residual NAPL at the site but adding additional days of investigation is not easy under the EPA contract system once the project has begun. Designing the scope and contract to provide for an appropriate amount of flexibility helps maximize the value of HRSC for EPA projects in Indian country. One cost saving is eliminating the 3D site visualization model as a deliverable when not technically necessary and where the information does not need to be presented to the public. Another cost saving measure is having as many tools as possible on the rods to reduce the need for separate drives for different tools. Reducing the number of drives required maximizes the number of sample locations that can be done each day.

*Figure 6.1.7. Photo of Satus Store excavations based on the HRSC effort. Source: EPA Region 10.*

## 6.2. Case Study #2. Understanding Contaminant Pathways at Heflin's Garage.

A release of several thousand gallons of gasoline in the mid to late 1980s from failed piping at Heflin's Garage in Fredericksburg, Virginia, was pulled across a four-lane highway (Warrenton Road) by four bored supply wells through unconsolidated sand, silt, and clay. Connecting the impacted houses to municipal water in 1989/1990 allowed LNAPL and groundwater to stabilize and follow the natural groundwater gradient back across the highway where LNAPL and dissolved phase petroleum discharged to an unnamed tributary to the Rappahannock River. LNAPL recovery via two pump and treat systems on either side of the road was performed for two decades by a state-managed (and EPA-funded) contract with some success. Petroleum vapors reached at least two of the residences across the street and sheens on the stream continued into the $21^{st}$ century.

### 6.2.1. Study Objective.

Two HRSC surveys were performed in 2007 and 2021 to assess the status and boundaries of the LNAPL and dissolved-phase hydrocarbon plumes on both sides of the road and in the woods closest to seeps carrying DPH into the unnamed, offsite stream. The 2021 study was used to formulate a new remediation strategy.

### 6.2.2. Scope of Work.

Working on Warrenton Road was not permitted by Virginia Department of Transportation, so the HRSC survey points for 2007 and 2021 surveys were completed near the source area of the former dispensers, south of the road, and in front yards of residences north of the road. The survey in 2021 sought to delineate LNAPL and DPH plumes into the woods upgradient of the creek.

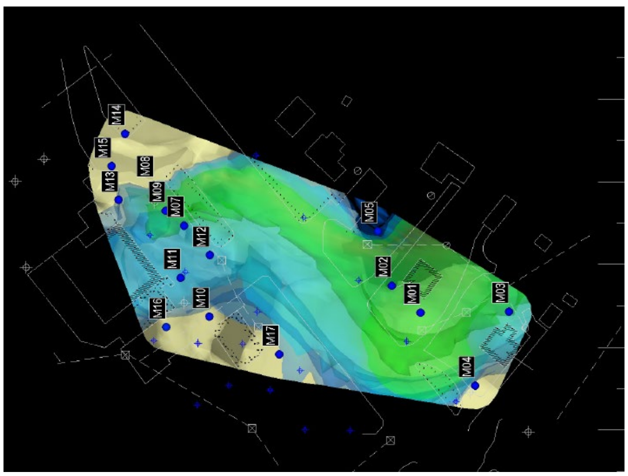
### 6.2.3. Tools Used.

2007 Survey: MIP and EC (or Soil Conductivity); 2021 Survey: MIP, OIP, HPT.

### 6.2.4. Decision making information obtained.

The 2007 data graphically depicted the pathway (in a partial Z-shape) of the original LNAPL and subsequent residual NAPL (or DPH) from the source area to the four impacted residential properties.

The 2021 data was presented in plan and profile view. The profile view included not only the LNAPL in red but areas of higher HPT, or tighter, clayey soils, to show how geologic pathways allowed the LNAPL to migrate back across Warrenton Road and towards the creek. The data from this survey allowed for new monitoring wells to be placed accurately in the wooded area, screened across the appropriate depths to capture the high DPH impacting the creek.



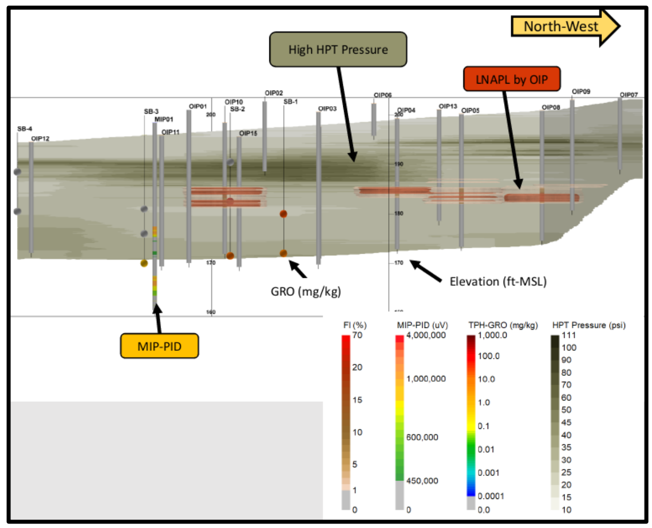



*Figure 6.2.4. Maximum VOC Concentrations and Transect showing the Relative Position of VOCs and Permeable Strata. Source: Columbia Technologies and Virginia DEQ.*

### 6.2.5. Cost and Time.

For the 2021 investigation the total cost including project management, VDOT bonding and permitting for lane closures, traffic control subcontractor, soil sampling from six borings, and report was about $52,000. Of those costs, the OIP/HPT/MIP Lump sum fee was $22,000 and the DPT rig rental with operator for five days was $8,000.

### 6.2.6. Stakeholder Engagement and Communicating Results.

Site access agreements were obtained from impacted residences across the street and from church elders for a wooded creek area their church owned. A summary of the report was shared in a meeting with church elders after work was performed to explain results and discuss their future plans for the church property.

### 6.2.7. Lessons Learned about HRSC.

This project alone has shown the advancement of HRSC technically from 2007 to 2021. From about 2009 through 2018, Laser-Induced Fluorescence was the favored tool to screen for LNAPL at a site, especially during the early site investigation phase when the type of fuel released is not known. For Heflin's Garage where the fuel type is known to be gasoline, the Optical Interface Probe is sufficient for showing the LNAPL. HPT being able to be used with either the OIP or MIP probes has made OIHPT the popular choice as only one direct push drive needs to be made at each location to gather both physical and contaminant subsurface data.

*Site photo. Source: Virginia DEQ.*

For this 35-year project, HRSC helped to visualize the LNAPL migration pathway and to design and appropriately place monitoring wells to accurately monitor the dissolved phase plume. Understanding soil types through HPT and EC allowed a passive remediation barrier system to be implemented and successfully reduce of DPH in the creek.

## 6.3. Case Study #3. LNAPL Identification and Delineation, and Assessment of Petroleum Vapor Intrusion Risk at TJ's Quik Stop, Poplar, Montana.

TJ's Quik Stop in Poplar, Montana, has been used as a gasoline station since the 1950s. In 1985, the owners reported a release of 8,000 gallons of gasoline from piping beneath a dispenser. Localized excavation of contaminated soil was completed. In 1989, complaints of petroleum odors were reported in nearby properties. These odors were attributed to petroleum entering the town sewer system during periods of heavy rainfall. In 1996, underground storage tanks were removed and 1,700 cubic meters of contaminated soil excavated. In 2016, the Montana DEQ determined that groundwater at the site contained petroleum contaminants in excess of state standards. The site was deemed not eligible for the Montana state fund and regulatory responsibility for the site was transferred to the EPA.

*Site photo. Source: EPA Region 08.*

### 6.3.1. Study Objective.

The HRSC investigation was designed to delineate the extent of remaining petroleum contamination and assess the need for further action, particularly in relation to any potential residual petroleum vapor intrusion risks.

### 6.3.2. Scope of Work.

The project SOW was to complete approximately 30 direct sensing locations to a depth of 30 feet, with the option to go as deep as 45 feet to confirm geology and to verify the full depth of contamination. Confirmatory samples were to be taken to compare to the HRSC data and help with regulatory decision making.

### 6.3.3. Tools Used.

The project used nine OIP and 13 MIP locations with EC and HPT to characterize the site. Locations were completed to depths between 21.5 and 45 feet. Duplicate OIP and MIP locations were completed at two locations. Two confirmatory soil samples were taken from each of five boreholes adjacent to MIP and OIP investigation points. No groundwater samples were collected.

### 6.3.4. Decision Making Information obtained.

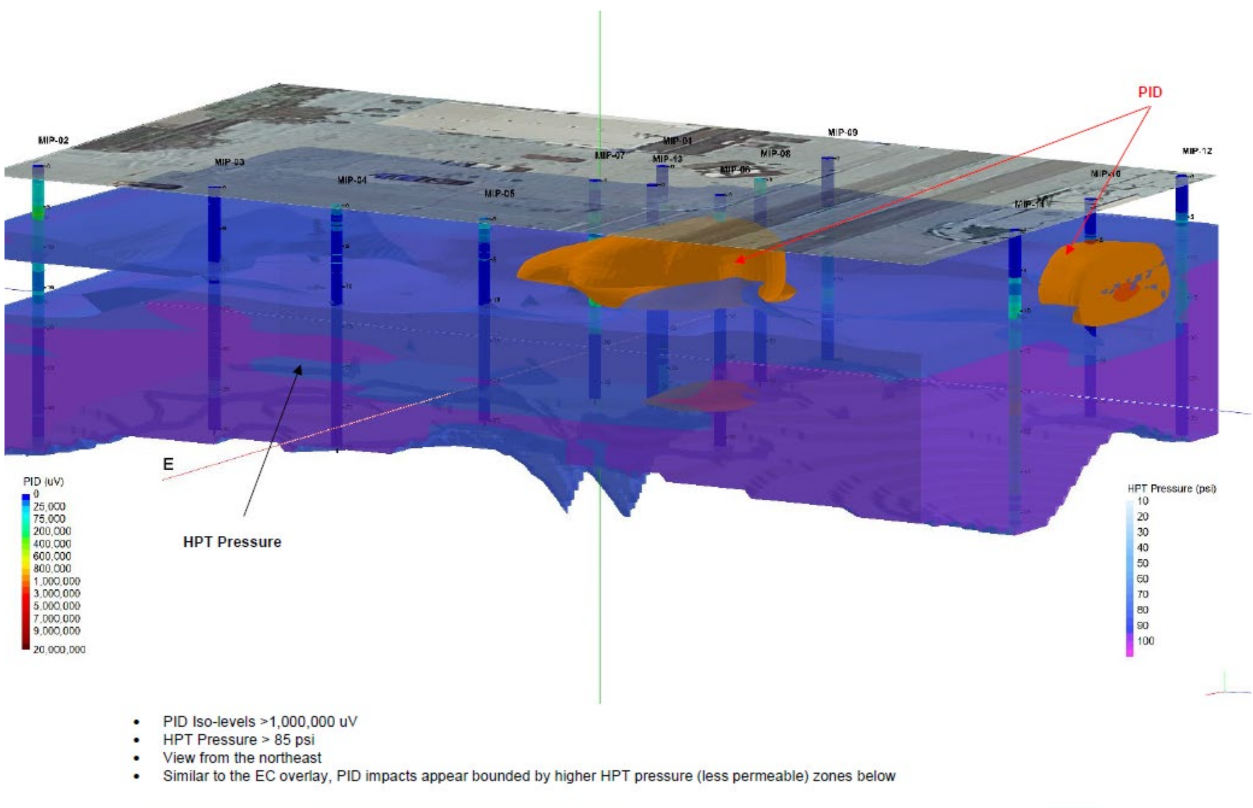



*Figure 6.3.4. Data Visualization. Source: Eagle Synergistics and EPA Region 08.*

The investigation identified no areas of significant LNAPL and identified that residual contamination was limited to a central area of the site between 5 and 10 feet deep and that vertical migration was constrained by low permeability soils. EPA screening distances confirm that PVI was unlikely to be a significant risk to existing structures. A data gap created by the road between the Quik Stop site and the property across the road meant some uncertainty remains on whether contamination on the two sites is related or from separate sources.

### 6.3.5. Cost and Time.

Using an HRSC specialist and direct push rig cost $65,000 and took five days in the field to complete.

### 6.3.6. Stakeholder Engagement and Communicating Results.

The results of the investigation were communicated to the Fort Peck Tribe. The rapid delineation and characterization of the plume was very helpful in communicating to the Tribe that receptors were not currently affected by the release.

### 6.3.7. Lessons Learned.

If possible, plan to sample locations in roadways between potential source areas to avoid significant data gaps.

## List of Acronyms and Abbreviations used in this Document.

| | |
|---|---|
| %RE | percent of reference emitter |
| 2D or 3DVA | two- or three-dimensional visual analysis |
| 4DIM | four dimensional interactive models |
| ASCII | American Standard Code for Information Interchange |
| ASCT | advanced site characterization tools |
| ASTM | ASTM International, formerly known as American Society for Testing and Materials |
| BPA | blanket purchase agreement |
| BTEX | benzene, toluene, ethylbenzene, xylene |
| CSM | conceptual site model |
| DNAPL | dense non-aqueous phase liquid |
| DO | dissolved oxygen |
| DPH | dissolved phase hydrocarbons |
| EC | electrical conductivity |
| ECD | electron capture detector |
| EPA | United States Environmental Protection Agency |
| FID | flame ionization detector |
| GC/MS | Gas chromatograph/mass spectrometer |
| GPS | global positioning system |
| HD | high density sampling |
| HPT | hydraulic profiling tool |
| HRSC | high resolution site characterization |
| IGCE | independent government cost estimate |
| ITRC | Interstate Technology and Regulatory Council |
| JPEG | joint photographic experts' group |
| LIF | laser induced fluorescence |
| LNAPL | light non-aqueous phase liquid |
| LUST | leaking underground storage tank |
| MIP | membrane interface probe |
| MiHPT | Membrane Interface Probe with Hydraulic Profiling Tool |

| | |
|---|---|
| MNA | monitored natural attenuation |
| MTCA | Washington State Model Toxics Control Act |
| MW | monitoring well |
| NMR | nuclear magnetic resonance |
| NSZD | natural source zone depletion |
| ODCs | other direct costs |
| OIP | optical image profiler |
| ORP | oxidation reduction potential |
| OSRTI | Office of Superfund Remediation and Technology Innovation |
| OUST | Office of Underground Storage Tanks |
| PCS | petroleum contaminated soil |
| PDF | portable document format |
| PID | photoionization detector |
| PVI | petroleum vapor intrusion |
| PWS | performance work statement |
| QAPP | quality assurance project plan |
| SOP | standard operating procedure |
| SOW | scope of work |
| TPH | total petroleum hydrocarbons |
| TPH DRO | total petroleum hydrocarbons diesel range organics |
| TPH GRO | total petroleum hydrocarbons gasoline range organics |
| UST | underground storage tank |
| UVOST® | Ultra Violet Optical Screening Tool |
| VDOT | Virginia Department of Transportation |
| VOCs | volatile organic compounds |

# Attachment One – Example Performance Work Statement.

Note: This sample PWS includes recommended language and instructions specific to HRSC projects that are noted in *italics*.

**Contract No. x** **Call Order y**

**Title: High Resolution Site Characterization for Site, Reservation, City, State – U.S. EPA Region**

**Date:**

**PERFORMANCE WORK STATEMENT**

## 1. General Information

**Contract Level Contracting Officer Representative**

Primary:

Alternate:

**Call Order Contracting Officer's Representative**

Primary: (Pending CO Appointment)
Telephone
email

Alternate:

**Subject Matter Experts (SMEs)***
Region Staff,
Telephone, email

**Tribal Contacts***
Name
telephone
email
***** SMEs and Tribal contacts are not authorized CORs and are not authorized to provide technical direction and/or to function as a COR under this call order.

## 2. Site Name/Background

Site Name:
Site Location: Reservation
City, State
Tribe:

Location description.

Site layout

The following is a timeline of events for the site:

| | |
|---|---|
| | |
| | |
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**3. Applicable Scope Under the BPA Performance Work Statement**

In this section, you would refer to the overall contract level PWS to illustrate that the work requested here is in scope.

**4. Scope**

The purpose of this call order is to use high-resolution methods and direct sensing technologies to determine *{**define data need**}**. This will be used to *{**describe project objective**}**.*

* Go to Table 2.1 of the HRSC guidance to identify the appropriate HRSC tools for the data needs and project objectives.

To the extent possible, the EPA prefers the use of local subcontractors for the tasks that either the contractor does not plan to conduct themselves or have a primary subcontract in mind for that work. If the contractor needs additional time to identify local subcontractors beyond the time requested for a proposal, please make this request in writing the to the contracting officer and the contract level COR.

**5. Tasks**

**Task 1 – Reporting and Planning (Administrative)**

**Task 1.1 - Statement of Work/Performance Work Statement/Specifications (Budget) –** The contractor shall contact the Administrative Task Order Manager within ten (10) business days upon receipt of the government's Task Order Performance Work Statement to discuss the scope of the work before the contractor submits its Performance Work Statement/Specifications (budget). The contractor shall have fourteen (14) business days following the conference call to submit its Performance Work Statement/Specifications (budget) electronically to the Contracting Officer and Administrative Task Order Manager.

The Performance Work Statement/Specifications (budget) shall include (1) a narrative description of its technical approach to perform the work; (2) estimated budget that includes the contractor's staffing plan according to the labor categories for this work, other than direct costs (e.g., material, equipment, permits, taxes) subcontractor(s), and travel estimates; (3) deliverable (milestone) schedule; (4) certification pursuant to 1552.209-72 that the contractor is or is not aware of any potential Organizational Conflicts of Interest for the work outlined in the Government's Performance Work Statement; and (5) any other requested information. The contractor's cost component must include a breakdown of costs for each major task and/or subtask and an overall summary for the full task for the prime and any subcontractor(s).

Work will <u>not</u> commence until the contractor is in receipt of an approved call order signed by the Contracting Officer.

**Deliverable:** Conference Call with contract level COR and call order COR
**Due Date:** Within ten (10) business days upon receipt of Performance Work Statement

**Deliverable:** Performance Work Statement/Specifications (Budget)
**Due Date:** Within fourteen (14) business days after Conference Call

**Task 1.2 - Monthly Progress/Financial Reports (Administrative) –** The contractor shall prepare the monthly progress/financial reports in accordance with the contract. Upon approval of the Task Order, the contractor shall maintain routine communication with the Subject Matter Expert (SME) and summarize all task order activities in the monthly progress/financial reports.

**Deliverable:** Monthly Progress/Financial Reports (Administrative)
**Due Date:** According to Contract Term

**Task 1.3 – Conference Calls (Administrative)**

The contractor shall participate with the COCOR in conference calls, monthly, during investigation planning, implementation and report writing. For planning purposes, assume a total of twenty hours of conference call time.

**Deliverable:** Status Conference Call(s)
**Due Date:** As necessary based on the needs of the work being performed. For budgeting purposes, assume 20 hours total of status conference calls

**Task 2.1 – Workplan, Site-Specific Quality Assurance Project Plan (QAPP), and Health and Safety Plan**

**Workplan –** The contractor will develop a workplan describing how all office and field activities associated with this call order will be executed, including project planning, field activities, and reporting.

**Site-Specific Quality Assurance Project Plan (QAPP) -** The contractor shall develop a QAPP in accordance with CIO 2105-S-02.1 Quality Assurance Project Plan Standard, April 3, 2024 for all environmental data collection, generation and/or use including existing data identified in this Task Order for the SME's review and comment. The contractor shall use the *(insert regional requirements for QA/QC)* (The contractor can use the attached direct sensing HRSC QAPP crosswalk as a guide for HRSC specific elements of the QAPP, but in general the HRSC QAPP can be relatively concise.)

The contractor shall document on the QA Crosswalk, where each element of the project activities is located including page number(s) and SOP(s) applicable to the project-specific QAPP.

The contractor will finalize the QAPP addressing all EPA comments. The QAPP must be approved and signed by the Region Quality Assurance Manager or Designated Approval Officer (DAO) before starting environmental data collection, generation and/or use.

The contractor shall maintain and document necessary changes of the approved QAPP.

**Deliverable:** Draft QAPP
**Due Date:** Within 30 business days after receipt of approved call order

**Deliverable:** Final QAPP
**Due Date:** Within seven (7) days after receipt of SME's comments on draft QAPP.

**Site-Specific Health and Safety Plan (HASP) -** The contractor shall prepare a HASP that defines the sampling and data collection methods that shall be used for the project based on the field activities listed in Task 4.

**Deliverable:** Draft HASP
**Due Date:** 30 days after receipt of approved Task Order

**Deliverable:** Final HASP
**Due Date:** Within seven (7) days after receipt of SME's comments

**Task 3 -- Site Assessment (Assessment)**

The contractor shall review existing information as directed and provided by the SME, including analytical data. Available site-specific information will be provided by the SME. The contractor shall investigate and satisfy any Tribal Employment Rights Ordinance (TERO) requirements that may be required by the Tribes. The Tribal contact(s) are listed in Section 1 of this Task Order.

The contractor shall prepare site specific plans including:

- *Prepare a premobilization review of existing information, including survey data and existing analytical information, to provide a template for presenting daily field reports and interim reports.*
- *Coordinate mobilization and demobilization activities for this Task Order concurrent with planned field activities outlined below.*
- *Conduct field work activities and analysis to define the extent of contamination as follows:*

*Describe project objective and data need/data gaps to be resolved using the selected HRSC technologies. Refer the contractor to the HRSC guidance. The HRSC project will include:*

- *Surveying.*
- *Preclearance for underground utilities or structures.*
- *Completion of HRSC locations.*
- *Confirmatory sampling.*
- *Daily and final reporting in online formats.*

*A generic HRSC QAPP crosswalk is provided as a guide to developing the HRSC work plan. See section 2.0 and 3.0 of the HRSC guidance for more detailed descriptions of HRSC assessment activities.*

**Task 4 – Technical Report**

The contractor shall prepare a technical report, analyzing the data collected. The report should include the following:

- *Site vicinity map displaying adjacent land use.*
- *Site map to include soil borings, former tank locations, piping, pump islands, property boundaries, roads, residences, adjacent land use, underground utilities and rural/city water lines. The site map should also include roads and underground utilities and land use immediately adjacent to the site based on observations and historical reports.*

- *A three-dimensional visualization of high-resolution response data, (MIP and/or LIF, and permeability) including all existing and historic data.*
- *A comparison and correlation coefficient between the direct sensing data and previously available concentration data and results of confirmatory analyses from this investigation.*
- *A discussion of the resulting Conceptual Site Model (CSM) should include a comparison of the direct sensing data and the TPH concentrations in soil and/or groundwater samples, the timing and quantity of the release, and the prior conceptual site model. Any discrepancies and changes in the CSM should be discussed and explained. The consistency and completeness of the CSM story is the best check of the quality and success of the HRSC.*
- *Additionally, the contractor should provide the raw high-resolution response data to the EPA SME in electronic format with the report deliverable.*
- *See section 4.0 of the HRSC guidance for more detailed discussion of typical reporting products for HRSC sites.*

**Deliverable:** Draft Summary Report (NTE 25 pages of text)
**Due Date:** Within 30 days after completion of field activities.

**Deliverable:** Final Summary Report (NTE 25 pages of text)
**Due Date:** Within 5 days of receipt of SME's comment

## 6. Performance Work Table

| Performance Requirement | Performance Standard | Metric | Acceptable Quality Level | Monitoring System |
|---|---|---|---|---|
| **Task 1.1 - Work Plan/Budget Development** | Prepare and submit work plan/budget proposal. | Brief technical proposal, description of contractor's approach to completion of requirement, including metrics and cost proposal that enables EPA to make a determination of price reasonableness. | Deliverables submitted in accordance with agreed upon schedule. | EPA review and on-time delivery. COR will review and document. |
| **Task 1.2 – Monthly Progress/Reports** | Deliverables submitted in accordance with schedule. | Reports are provided. | Deliverables submitted in accordance with schedule. | EPA review and on-time delivery. COR will review and document. |
| **Task 1.3 – Meetings/ Conference Calls** | Participate in conference calls. | Participation in discussion on conference calls. | Clear, concise, understandable. | SME will ensure that there is agreement of all parties on planned site activities. |
| **Task 2 – WP/QAPP/HASP** | Deliverables submitted in accordance with schedule. | The QAPP describes the work to be performed, procedures to be used, number of environmental samples to be collected, existing data use and criteria, and field parameters to be measured. The QAPP describes quality objectives and measures necessary to achieve data that are adequate for use in making decisions. [QAPP's for HRSC specific work can be relatively concise given the nature of the work carried out. See the QAPP crosswalk for suggested items to include]. | Deliverables submitted in accordance with schedule. | EPA review and on-time delivery. COR will review and document. |

## 6. Performance Work Table (cont'd.)

| Performance Requirement | Performance Standard | Metric | Acceptable Quality Level | Monitoring System |
|---|---|---|---|---|
| **Task 3 – High Resolution Site Characterization** | Deliverables submitted in accordance with schedule. | Evaluate site conditions according to the approved QAPP. | According to the approved QAPP, data is presented in a clear, concise manner. | SME will ensure that the evaluation is based on consideration of available data gaps and uncertainties in the data that may affect the success of the investigation. |
| **Task 4 – Technical Report** | Deliverables submitted in accordance with schedule. | Evaluate site conditions according to the approved QAPP. Analyze the available data and provide a Summary Report to the SME. | According to the approved QAPP, data is presented in a clear, concise manner. Report presents an evaluation of the data and site conditions. | SME will ensure that the evaluation is based on consideration of available data gaps and uncertainties in the data that may affect the success of the investigation. SME will ensure that the site assessment/characterization represents the best approach to reach a decision on the risks posed by the site, leading to a decision on the need for remediation. |

## 7. Period of Performance

One year (365 days) from the date of the contracting officer's approval.

## 8. Technical Direction

The COCOR is authorized to provide technical direction to the extent allowed under EPAAR (1552.237-71) (APR 1984) (DEVIATION). Other than the COCOR, only the Contract-Level COR and the Contracting Officer are authorized to provide technical direction. Therefore, the contractor shall not discuss work related to a call order with EPA personnel unless the COCOR, Contract-Level COR or Contracting Officer is present.

Technical direction includes: (1) direction to the contractor which assists the contractor in accomplishing the Statement of Work; and (2) comments on and approval/acceptance of reports or other deliverables. Technical direction must be within the contract and the Call Order Performance Work Statement. The Contract-Level COR and the COCOR do not have the authority to issue technical direction which (1) institutes additional work outside the scope of either the contract or this Call Order Performance Work Statement; (2) constitutes a change as defined in the "Changes" clause; (3) causes an increase or decrease in the estimated cost of the contract or Call Order Performance Work Statement; (4) alters the period of performance; or (5) changes any of the other express terms or conditions of the contract or Call Order Performance Work Statement.

Technical direction will be issued in writing or confirmed in writing within five (5) calendar days after oral issuance. The COCOR will provide the technical direction memorandum to the contractor, with electronic copies to the Contract-Level COR and Contracting Officer. If the contractor has not received written confirmation within five (5) calendar days of an oral issuance, the contractor must so notify the Contracting Officer.

Calendar days in this PWS will use the definition, as outlined in the Federal Acquisition Register Subpart 33.1.

## 9. Funding

This call order shall be funded 100% with LUST appropriated funds. No other appropriations may be utilized or augmented to complete this work.

# Attachment Two – EPA Region 8 QAPP Crosswalk and Simplified QAPP Crosswalk for Direct Sensing HRSC

### EPA REGION 8 QAPP REVIEW CROSSWALK
### CIO 2105-S-02 (QA/S-2)

This crosswalk will be used to review the Quality Assurance Project Plans (QAPPs) submitted to EPA Region 8 for review under the EPA Quality Policy and Procedure Order 2105 (current version). Items from this checklist are discussed in detail in the *EPA Quality Assurance Project Plan Standard CIO 2105-S-02* (QA/S-2) and *EPA Environmental Information Quality Policy CIO 2105* (current versions), https://www.epa.gov/irmpoli8/environmental-information-policy-procedures-and-standards. Consult these resources for more information on the items below. Note that a separate crosswalk is used for Uniform Federal Policy-Quality Assurance Project Plans (UFP-QAPPs) (https://www.epa.gov/quality/managing-quality-environmental-data-epa-region-8).

This crosswalk is a controlled document. Do not modify the Region 8 EPA QAPP Review Crosswalk format or document type. Information in the "Elements" column within the crosswalk describe requirements, and may not be modified. Sections/lines in green are to be completed if the QAPP preparer is an EPA Organization; sections/lines in orange are to be completed if the QAPP preparer is a Non-EPA Organization. Remaining sections / lines must be completed by all organizations.

| **QAPP Preparer must complete as part of the submission:** | | | |
|---|---|---|---|
| **QAPP and Crosswalk completion/submission INSTRUCTIONS:** | | | |
| • The QAPP must address all required elements and include all attachments/appendices (SOPs, figures, tables, etc.). If a Crosswalk section is not relevant due to organization type, leave blank in the Crosswalk. If a QAPP element is not applicable, an explanation must be provided in the QAPP and in the Comments column of this crosswalk.<br>• The "**Organization's QAPP Section"** column on the Crosswalk must be completed to reference the precise location(s) in the QAPP that addresses that specific element.<br>• Processes may either be described or referenced in the QAPP; all references must be readily accessible within the organization **and** provided in or as attachments to the QAPP.<br>• Cited directives and regulations provided within this QAPP Review Crosswalk are for clarity and convenience. Please ensure the directive(s), regulation(s), requirement(s), and language are adhered to within the QAPP.<br>• QA review comments will be provided in the "**Summary of Comments**" section and in the "**Comments**" column of the crosswalk. Address the comments by revising the QAPP and documenting within the crosswalk where "**Organization Response**" is indicated. | | | |
| **QAPP Prepared for:** *(Check appropriate box below)* | | | |
| **EPA Organizations:** *Also, complete element requirements specific to EPA Organizations in A2, A11, A12, and B (green lines)* | ☐ **EPA R8 PROGRAM**<br>☐ **EPA R8 RESEARCH** (e.g., ROAR, R2P2) | **Non-EPA Organizations:** *Also, complete element requirements specific to Non-EPA Organizations in A1, A2, and A10 (orange lines)* | ☐ **GRANT RECIPIENT** 2 CFR 1500.12<br>☐ **CONTRACTOR** 48 CFR 46<br>☐ **INTERAGENCY AGREEMENT (IA)**<br>☐ **Other (list):** |
| **Organization** *(grant recipient, contractor, EPA AO, EPA Program, other):* | | **Organization Point of Contact and Information:** *(Name, Title, Email)* | |
| **Document Title:** | Implementing Direct Sensing High Resolution Site Characterization at EPA UST Release Sites in Indian Country | **QAPP Preparer:** *(If different than Organization POC)* | |
| **Document Version and** | | **Contract, Grant, or IA Number:** | |

| | | | |
|---|---|---|---|
| **Date:** | | | |
| **QAPP Period of Performance:** | | **EPA PO / COR:** *(Name, Email)* | |
| **Review Type/Status:** | ☐ **New or Revised QAPP**<br>☐ **Annual Review** *(complete "Annual Review Information")* | | |
| **Annual Review Information** (*if applicable*): | | | |
| QAPP Approval Date: | MM/DD/YYYY | **Attestation of the Annual Review** (*select as appropriate*): | |
| Annual Review Completion Date(s):<br>**Year 2:** MM/DD/YYYY **Year 4:** MM/DD/YYYY<br>**Year 3:** MM/DD/YYYY **Year 5:** MM/DD/YYYY | | ☐ Changes are documented in the Crosswalks Comments column.<br>☐ No significant changes were made. | |
| **Documents to be submitted along with the QAPP and Crosswalk:** | | | |
| **All Organizations:** | | **Non-EPA Organizations:** | |
| If this is an overarching or programmatic QAPP with nested SAPs, the QAPP must be submitted with the templates. Subsequent SAPs must be submitted with the approved QAPP. | | A QAPP written by a Grant Recipient or Federal Partner <u>must include</u> for review: Work Plan (WP) / Statement of Work or Scope of Work (SOW) / Performance Work Statement (PWS/QASP) / Program Plan (PP) / Research Proposal (RP) and funding mechanism.<br><br>A QAPP written by a Contractor <u>must include</u> for review:<br>**a)** Copy of Task Order Work Assignment/SOW/PWS/QASP;<br>**b)** Copy of the contractor's approved QMP (link or document);<br>**c)** Copy of Contract SOW (if no QMP has been approved); and<br>**d)** Copy of EPA Court Order, if applicable. | |
| **EPA Organizations:** | | | |
| A QAPP written by an EPA Program to describe programmatic work will only submit the QAPP and Crosswalk.<br><br>A QAPP written by EPA personnel that is for a research activity <u>must include</u> for review the scope of work or research proposal. | | | |

| | | | |
|---|---|---|---|
| **EPA QA Reviewer must complete as part of the review:** | | | |
| *All submissions and responses must be tracked on this Crosswalk. Information in blue and green are the suggested approach to ensuring that each review process is independently tracked.* | | | |
| EPA Technical Reviewer and Contact Information: | | Date Received for QA Review: | 1st Review: MM/DD/YYYY<br>2nd Review: MM/DD/YYYY |
| EPA QA Reviewer and Contact Information: | | Date Review Completed: | 1st Review: MM/DD/YYYY<br>2nd Review: MM/DD/YYYY |
| EPA QA Reviewer (QA Branch or DAO)? | QAB ☐ DAO ☐<br>QAB ID#: | EPA QA Approving Official and Contact Information: | |
| **Funding Mechanism Information:** | | | |
| interagency agreement ☐ / contract ☐ / grant ☐ / court order ☐ / Other ☐ __________________ / NA ☐ | | WP/SOW/TO/PP/RP Date: | |
| Funding Amount $ | | Performance Period: | |
| **QA document(s) reviewed:** | | | |
| Stand-alone QAPP? | Yes ☐ No ☐ | QA document consistent with WP/SOW/TO/PP/RP? | Yes ☐ / No ☐ / NA ☐ |
| SAP submitted with QAPP?<br>Date of QAPP: | Yes ☐ / No ☐ / NA ☐<br>MM/DD/YYYY | All attachments included? | Yes ☐ / No ☐ / NA ☐ |
| **Annual Review** (*if applicable, Select One*): | | | |
| ☐ The EPA QA Reviewer concurs no significant change was made to the document and the annual review is complete.<br>Date Completed: MM/DD/YYYY | | ☐ The EPA QA Reviewer concluded that significant changes were made to the document, and a complete review was conducted, see below for comments. | |

| Complete as part of the QA review: |
|---|
| **Crosswalk Guidance:** |
| • "**EPA Notes**" are notes, recommendations, or observations that may improve the QAPP; but do not require compliance.<br>• An "NA" in the Acceptable column signifies agreement that the element is not applicable and the reason is included & appropriate.<br>• "**EPA Comments**" require the QAPP author to address for compliance with the EPA QAPP Standard (QA/S-2).<br>• Include in the "**Summary of Comments**" a highlight of the significant concerns or issues identified within the QAPP.<br>• It is recommended to follow the example format in "**Summary of Comments**" to provide comments throughout the crosswalk.<br>• When reviewing the revised QAPP, all comments must be addressed, as documented by completion of the "**EPA Resolved (date)**." |
| **Summary of Comments** *(highlight significant concerns/issues)*: |
| **1.** EPA Comment:<br>Organization Response (date):<br>EPA Resolved (date):<br>**2.** EPA Comment:<br>Organization Response (date):<br>EPA Resolved (date): |

| Element | Acceptable (Yes/No/NA) (*Completed by EPA QA Reviewer*) | Organization's QAPP Section (*Completed by QAPP Author*) | Comments (*Completed by QAPP Author and EPA QA Reviewer*) |
|---|---|---|---|
| **A. Project Management and Information/Data Quality Objectives** | | | |
| **A1. Title Page (QA/S-2 Pages 8-9)** | | | |
| a. Name of the document | | | |
| b. Date of QAPP preparation | | | |
| c. Organization conducting environmental information operations (EIO) | | | |
| d. Organization that developed the QAPP | | | |
| e. Period of applicability | | | |
| f. Revision / version control information | | | |
| **Non-EPA Organizations shall also specify:** | | | |
| g. Agreement Traceability:<br>• Grant or cooperative agreement number<br>• Contract and task order numbers<br>• Interagency agreement number<br>• Title and date of Memoranda of Understanding / Agreement<br>• Citation of regulatory requirement(s)<br>• Title / date of enforcement / legal agreement | | | |
| **A2. Approval Page (QA/S-2 Page 9)** | | | |
| **EPA Organization shall include signature/date for:** | | | |
| a. Operations Manager | | | |
| b. EPA Quality Assurance Manager (QAM) | | | |
| **Non-EPA Organization shall include signature/date for:** | | | |
| c. Operations Manager for project | | | |
| d. Project QA Officer | | | |
| e. EPA Operations (e.g., COR, PO) | | | |
| f. EPA RQAM | | | |

| Element | Acceptable (Yes/No/NA) *(Completed by EPA QA Reviewer)* | Organization's QAPP Section *(Completed by QAPP Author)* | Comments *(Completed by QAPP Author and EPA QA Reviewer)* |
|---|---|---|---|
| **A3. Table of Contents, Document Format, and Document Control (QA/S-2 Pages 9-10)** | | | |
| a. Table of contents, including locations of sections, tables, diagrams, charts / figures, worksheets, other attachments / appendices | | | |
| b. Document control information on every page (title, version number, date, page number in relation to total pages) | | | |
| **A4. Project Purpose, Problem Definition, and Background (QA/S-2 Page 10)** | | | |
| a. Identifies and addresses other relevant QA planning documents (e.g., QMP) | | | |
| b. Describes the purpose of the project's EIO (e.g., research, monitoring, environmental technology, use of existing information) | | | |
| c. Defines the problem(s) to be addressed and describes the question(s) to be answered | | | |
| d. Documents the environmental decision(s) that need to be made and the level of information quality needed | | | |
| e. Identifies the type, quantity, and quality of information needed and describes the acceptance and performance criteria | | | |
| f. Identifies the applicable regulatory programs and standards | | | |
| g. Includes the conceptual site model(s) | | | |
| h. Discusses how the results of the EIO are linked to possible actions/decisions | | | |
| i. Includes a description/ citation of background information, plans, and/or reports to provide the historical, scientific, and regulatory perspective for the project | | | |
| j. Identifies the sources for existing information for the project | | | |
| **A5. Project Task Description (QA/S-2 Page 11)** | | | |
| a. Includes the schedule for all project tasks | | | |
| b. Describes the work to be performed | | | |
| c. Includes the products to be produced | | | |
| **A6. Information/Data Quality Objectives and Performance/Acceptance Criteria (QA/S-2 Pages 11-12)** | | | |
| a. Describes the project's information/data quality objectives | | | |
| b. Describes the performance and/or acceptance criteria | | | |
| c. Describes the following principal information/data quality indicators and their application for the project: | | | |
| 1. Precision | | | |
| 2. Accuracy (bias) | | | |
| 3. Representativeness | | | |
| 4. Comparability | | | |
| 5. Completeness | | | |
| 6. Sensitivity | | | |
| **A7. Distribution List (QA/S-2 Page 12)** | | | |

| Element | Acceptable (Yes/No/NA) *(Completed by EPA QA Reviewer)* | Organization's QAPP Section *(Completed by QAPP Author)* | Comments *(Completed by QAPP Author and EPA QA Reviewer)* |
|---|---|---|---|
| a. Includes a distribution list of all individuals with organizations who are to receive a copy of the QAPP and subsequent revisions | | | |
| b. Describes how the approved QAPP and all revisions shall be maintained on file and made available upon request | | | |
| **A8. Project Organization (QA/S-2 Pages 12-13)** | | | |
| a. Identifies individual(s) and organization(s) participating in the project | | | |
| b. Describes the QAPP approval authorities | | | |
| c. Describes the organization's project roles and responsibilities, including the roles of:<br>• Senior manager<br>• Project operations manager<br>• Project QAO<br>• Individual responsible for QAPP management<br>• Titles, roles, and names (if determined during planning) of operations and quality individuals within the organization conducting or supporting EIO and their reporting relationships | | | |
| d. Identifies all contractors, subcontractors, and sub-grant recipients supporting EIO and describes their project roles and responsibilities | | | |
| e. Identifies principal EIO users within and outside of the organization | | | |
| **A9. Project Quality Assurance Manager Independence (QA/S-2 Page 13)** | | | |
| a. Describes how the Project QAO's independence from EIO is ensured | | | |
| **A10. Project Organization Chart and Communications (QA/S-2 Pages 13-14)** | | | |
| a. Includes a project organization chart with:<br>1. Lines of authority, including reporting relationships<br>2. Lines of communication within the organization and with other organizations involved in the project | | | |
| b. Project organization chart shows the names of the organizations and all individuals identified in Element A8 | | | |
| c. Project organization chart demonstrates the project QAO's independence from EIO, reporting relationship(s), and authority outside the supervisory chain | | | |
| d. Documents communication procedures, including timing of communication, in sufficient detail to understand the processes, roles, and responsibilities | | | |

| Element | Acceptable (Yes/No/NA) *(Completed by EPA QA Reviewer)* | Organization's QAPP Section *(Completed by QAPP Author)* | Comments *(Completed by QAPP Author and EPA QA Reviewer)* |
|---|---|---|---|
| e. Standard procedures for communications are described or cited, including:<br>1. Elevating discrepancies and QAPP non-conformances<br>2. Process improvements<br>3. Seeking project concurrence and approvals | | | |
| **Non-EPA Organizations:** | | | |
| f. Describes communication procedures to EPA to include elevating discrepancies and QAPP non-conformances | | | |
| **A11. Personnel Training/Certification (QA/S-2 Pages 14-15)** | | | |
| a. Identifies the individual responsible for ensuring personnel conducting EIO are qualified, trained, and experienced | | | |
| b. Identifies the individual responsible for documenting personnel training | | | |
| c. Identifies and describes any specialized training or certifications needed | | | |
| d. Describes how the training will be provided | | | |
| e. Describes assurance of the necessary skills | | | |
| f. Describes the procedure or system for documenting training records and skill evaluation | | | |
| **EPA Organizations:** | | | |
| g. Includes or references QAFAP Personnel & Training requirements | | | |
| **A12. Documents and Records (QA/S-2 Page 15)** | | | |
| a. Identifies documents and records that will be produced for the project | | | |
| b. Describes or references processes for management of documents and records, including the QAPP | | | |
| c. Includes or references applicable requirements for the final disposition of records and documents, including location and length of retention period | | | |
| d. Describes or references the system for control of documents, including preparation, review, approval, issuance, revision, and archiving | | | |
| **EPA Organizations:** | | | |
| e. Includes or references QAFAP Document Control and Records Management requirements | | | |
| **B. Implementing Environmental Information Operations** | | | |
| a. Describes all guidance, tools, and templates used to develop the QAPP | | | |
| **EPA Organizations:** | | | |
| b. Includes or references QAFAP requirements for all B elements | | | |
| **B1. Identification of Project Environmental Information Operations (QA/S-2 Pages 16-17)** | | | |

| Element | Acceptable (Yes/No/NA) (*Completed by EPA QA Reviewer*) | Organization's QAPP Section (*Completed by QAPP Author*) | Comments (*Completed by QAPP Author and EPA QA Reviewer*) |
|---|---|---|---|
| a. Describes how the EIO is to be conducted and accomplishes the project purpose | | | |
| b. Describes how the EIO will satisfy the information/data quality objectives and performance/acceptance criteria (*reference: A4 and A6 Elements*) | | | |
| **B2. Methods for Environmental Information Acquisition (QA/S-2 Pages 17-18)** | | | |
| a. Identifies and describes the acquisition methods and procedures for EIO | | | |
| b. Identifies methods by number / identifier, version / revision date, regulatory citation; and indicates options / modifications | | | |
| c. Identifies, describes, or references SOPs used for acquisition of EIO, includes version / revision date and options / modifications | | | |
| d. Identifies or references the process for managing SOPs (e.g., individuals responsible, process for updating, accessibility to personnel) | | | |
| ***Field Activities Environmental Measurements*** | | | |
| e. Describes or references field activity procedures (e.g., information derived from tools, instruments, observational results, investigations, and sample collection) | | | |
| f. Identifies or references maximum holding times for sample extraction and/or analysis | | | |
| g. Describes or references selection and preparation of sample containers, sample volumes, and preservation methods | | | |
| h. Describes or references sample handling and custody processes | | | |
| ***Laboratory Analyses*** | | | |
| i. Identifies analytical methods by number / identifier, version / revision date, regulatory citation, and options / modifications | | | |
| j. Describes or references procedures to be conducted when a non-compliance or failure in the analytical system occurs (e.g., Laboratory QAM, SOP) | | | |
| k. Specifies the laboratory data package turnaround time needed | | | |
| l. Non-standard method application: describe method performance study information | | | |
| ***Existing Information (EI)*** | | | |
| m. Describes EI to be obtained from databases, software applications, decision support tools, websites, existing literature, etc. | | | |
| n. Describes the collection process | | | |
| o. Describes the intended use and criteria for acceptance & evaluation | | | |

| Element | Acceptable (Yes/No/NA) (*Completed by EPA QA Reviewer*) | Organization's QAPP Section (*Completed by QAPP Author*) | Comments (*Completed by QAPP Author and EPA QA Reviewer*) |
|---|---|---|---|
| for suitability | | | |
| p. Indicates if the EI is to be combined with new EIO and describes the criteria to ensure compatibility | | | |
| ***Environmental Technology*** | | | |
| q. Identifies the purpose of the technology (e.g., pollution prevention, contamination containment, storage, remediation) | | | |
| r. Describes physical parameters or processes collected using environmental technologies | | | |
| s. Describes systems, devices, and components applicable to hardware and methods or techniques that measure &/or remove pollutants or contaminants &/or prevent from entering the environment[11] | | | |
| **B3. Integrity of Environmental Information (QA/S-2 Pages 18-19)** | | | |
| a. Describes or cites procedures for ensuring the integrity of project EIO | | | |
| b. Describes or cites procedures and requirements for sample handling and custody (e.g., field logs, packaging / transport / shipment, laboratory storage) | | | |
| c. Includes examples of sample labels and chain of custody forms/sample custody logs | | | |
| d. Identifies the laboratory(ies) to be used | | | |
| e. Describes processes for ensuring laboratory accreditation and/or certification for applicable analytes and matrices | | | |
| **B4. Quality Control (QA/S-2 Page 19)** | | | |
| a. Describes the QC activities needed for each EIO to meet project environmental information/data quality objectives and performance/acceptance criteria | | | |
| b. Describes or references the frequency of QA activities, corrective actions (CA), and how the effectiveness of the CA shall be determined and documented | | | |
| c. Describes or references procedures to calculate statistics (e.g., precision, bias) | | | |
| d. Describes field / laboratory sampling QC activities (e.g., blanks, duplicates, matrix spikes, laboratory control samples, surrogates) | | | |
| e. Describes existing information QC activities (e.g., use of systematic review, independent secondary | | | |

[11] For additional advice on QAPPs for design, construction, and operation or application of environmental technology, refer to the current version of EPA Guidance on Quality Assurance for Environmental Technology Design, Construction and Operation, https://www.epa.gov/sites/default/files/2015-06/documents/g11-final-05.pdf.

| **Element** | **Acceptable (Yes/No/NA)** *(Completed by EPA QA Reviewer)* | **Organization's QAPP Section** *(Completed by QAPP Author)* | **Comments** *(Completed by QAPP Author and EPA QA Reviewer)* |
|---|---|---|---|
| review of studies in the open literature, QC of constructed databases or spreadsheets) | | | |
| f. Describes QC activities for EIO using models or modeling (e.g., model calibration, model validation, sensitivity analyses) | | | |
| **B5. Instrument/Equipment Calibration, Testing, Inspection, and Maintenance (QA/S-2 Page 19)** | | | |
| a. Identifies instruments/equipment used for EIO (e.g., tools, gauges, and pumps) | | | |
| b. Describes procedures and documentation activities to ensure that the instruments / equipment are available / in working order | | | |
| c. Describes or references how calibration will be conducted, documented, and traceable to the instrument | | | |
| d. Describes or references how instruments and equipment will be tested, inspected, and maintained | | | |
| e. Discusses availability of critical spare parts | | | |
| **B6. Inspection/Acceptance of Supplies and Services (QA/S-2 Page 20)** | | | |
| a. Describes procedures for inspection and acceptance of supplies and services, including traceable documentation of the acceptance | | | |
| b. Identifies the individual(s) responsible for inspection/acceptance of supplies/services | | | |
| c. Specifies the vendor's responsibilities for specific S-2 elements and verification of adherence | | | |
| **B7. Environmental Information Management (QA/S-2 Page 20)** | | | |
| a. Describes or cites the environmental information management process for the project, including from generation to final use or storage (e.g., field, laboratory, office, database) | | | |
| b. Describes or references standard record-keeping procedures, document control system, and process for information storage and retrieval on electronic media | | | |
| c. Describes or references the control mechanism for detecting/correcting errors and for preventing loss of information during data entry/reduction/reporting, and data entry to databases/forms/reports/ databases | | | |
| d. Includes or references forms or checklists to be used in these processes | | | |
| e. Describes or references procedures to process, compile, and analyze project EIO | | | |
| f. Describes or references required | | | |

| Element | Acceptable (Yes/No/NA) (*Completed by EPA QA Reviewer)* | Organization's QAPP Section *(Completed by QAPP Author)* | Comments *(Completed by QAPP Author and EPA QA Reviewer)* |
|---|---|---|---|
| computer hardware/software requirements, including performance, acceptability, and assurance that applicable information resource management requirements are satisfied | | | |
| **C. Assessment, Response Actions, and Oversight** | | | |
| **C1. Assessments and Response Actions (QA/S-2 Pages 21-22)** | | | |
| ***Note:*** *Assessment activities may include audits, readiness reviews, peer review, in-field data document reviews, etc.* | | | |
| a. Describes project assessment activities, including the number, frequency, and types of planned assessments | | | |
| b. Identifies the individual(s) who will perform the assessments and how they are free of any conflicts of interest | | | |
| c. Describes the documentation of assessment findings, non-conformances, and corrective actions | | | |
| d. Describes who is responsible and how response actions associated with assessments will be developed, documented, and tracked | | | |
| e. Describes the reporting of response actions | | | |
| **C2. Oversight and Reports to Management (QA/S-2 Pages 22-23)** | | | |
| a. Identifies the individual(s) responsible for oversight activities | | | |
| b. Describes oversight activities that ensure response actions and reporting mechanisms capture the project status and any QA issues that arise during implementation and through assessments | | | |
| c. Identifies project reports to management, including content requirements, the process for submission, and distribution list | | | |
| **D. Elements For Environmental Information Review and Usability Determination** | | | |
| **D1. Environmental Information Review (QA/S-2 Pages 23-24)** | | | |
| a. Describes or cites the processes for information/data verification and validation | | | |
| b. Describes or references how performance and/or acceptance criteria will be incorporated in the review process | | | |
| c. Describes or references how information/data quality indicators will be incorporated in the review process | | | |
| d. Describes the data quality assessment documentation that will occur after the EIO phase of the project is completed | | | |
| e. Identifies the individual(s) conducting each of these activities | | | |
| f. Describes the documentation and | | | |

| Element | Acceptable (Yes/No/NA) *(Completed by EPA QA Reviewer)* | Organization's QAPP Section *(Completed by QAPP Author)* | Comments *(Completed by QAPP Author and EPA QA Reviewer)* |
|---|---|---|---|
| communication processes for review | | | |
| **D2. Usability Determination (QA/S-2 Pages 24-25)** | | | |
| a. Describes or references the process based on the review that determines whether the EIO is useable | | | |
| b. Describes the documentation of the usability determination | | | |
| c. Identifies the individual(s) responsible for the usability determination activities | | | |
| d. Describes the communication of any known or anticipated limitations on the use of the environmental information | | | |
| **END** | | | |

**EPA HRSC QA DOCUMENT CROSSWALK BASED ON REGION 8**

HRSC QAPP Crosswalk is annotated to include applicable references in the HRSC Guide. Elements common to all assessments have been minimized or shaded grey. Refer to the full QAPP crosswalk for minimized elements.

| Element | HRSC GUIDE SECTION APPLICABLE | Comments |
|---|---|---|
| **A. Project Management and Information/Data Quality Objectives** | | |
| **A1. Title Page (QA/S-2 Pages 8-9)** | | |
| **A2. Approval Page (QA/S-2 Page 9)** | | |
| **A3. Table of Contents, Document Format, and Document Control (QA/S-2 Pages 9-10)** | | |
| **A4. Project Purpose, Problem Definition, and Background (QA/S-2 Page 10)** | | |
| k. Identifies and addresses other relevant QA planning documents (e.g., QMP) | | |
| l. Describes the purpose of the project's EIO (e.g., research, monitoring, environmental technology, use of existing information) | | |
| m. Defines the problem(s) to be addressed and describes the question(s) to be answered | 2.0 | Problem definition should be consistent with performance work statement – example objectives and data needs described in HRSC guidance provide an outline of the actions to be taken and why and what decision-making criteria should be followed interpreting HRSC direct sensing data. |
| n. Documents the environmental decision(s) that need to be made and the level of information quality needed | 2.0 | |
| o. Identifies the type, quantity, and quality of information needed and describes the acceptance and performance criteria | 3.0 | |
| p. Identifies the applicable regulatory programs and standards | 5.0 | |
| q. Includes the conceptual site model(s) | 2.1 | |
| r. Discusses how the results of the EIO are linked to possible actions/decisions | 5.0 | |
| s. Includes a description/ citation of background information, plans, and/or reports to provide the historical, scientific, and regulatory perspective for the project | | |
| t. Identifies the sources for existing information for the project | | |
| **A5. Project Task Description (QA/S-2 Page 11)** | | |
| d. Includes the schedule for all project tasks | 3.0, 4.0 | Includes discussion of project plan, confirmatory sampling schedule, and reporting deadlines |
| e. Describes the work to be performed | Table 2.1, 3.6 | Describe HRSC tools to be used |
| f. Includes the products to be produced | 4.0, Attachment Five | Describe how data will be presented |
| **A6. Information/Data Quality Objectives and Performance/Acceptance Criteria (QA/S-2 Pages 11-12)** | | |
| d. Describes the project's information/data quality objectives | | |
| e. Describes the performance and/or acceptance criteria | 3.3, 3.4 | |
| f. Describes the following principal information/data quality indicators and their application for the project: | | |

| Element | HRSC GUIDE SECTION APPLICABLE | Comments |
|---|---|---|
| 7. Precision | | |
| 8. Accuracy (bias) | | |
| 9. Representativeness | | |
| 10. Comparability | | |
| 11. Completeness | | |
| 12. Sensitivity | | |
| **A7. Distribution List (QA/S-2 Page 12)** | | |
| c. Includes a distribution list of all individuals with organizations who are to receive a copy of the QAPP and subsequent revisions | | Includes the EPA OUST contracting office, region COR, region SME, Tribal representative, specialist project manager and field personnel. |
| d. Describes how the approved QAPP and all revisions shall be maintained on file and made available upon request | | |
| **A8. Project Organization (QA/S-2 Pages 12-13)** | | |
| f. Identifies individual(s) and organization(s) participating in the project | | Should include EPA central and regional COR and SME, specialist QA manager, data manager and field personnel. Should list identified subcontracted task, contractor and key personnel. |
| g. Describes the QAPP approval authorities | | |
| h. Describes the organization's project roles and responsibilities, including the roles of:<br>• Senior manager<br>• Project operations manager<br>• Project QAO<br>• Individual responsible for QAPP management<br>• Titles, roles, and names (if determined during planning) of operations and quality individuals within the organization conducting or supporting EIO and their reporting relationships | | |
| i. Identifies all contractors, subcontractors, and sub-grant recipients supporting EIO and describes their project roles and responsibilities | 2.3.1 | Describe HRSC contractor and any subcontractors used |
| j. Identifies principal EIO users within and outside of the organization | | |
| **A9. Project Quality Assurance Manager Independence (QA/S-2 Page 13)** | | |
| **A10. Project Organization Chart and Communications (QA/S-2 Pages 13-14)** | | |
| **Non-EPA Organizations:** | | |
| **A11. Personnel Training/Certification (QA/S-2 Pages 14-15)** | | |
| **A12. Documents and Records (QA/S-2 Page 15)** | | |
| f. Identifies documents and records that will be produced for the project | 3.0, 4.0, Attachment Five | Describes the report products for HRSC |
| **B. Implementing Environmental Information Operations** | | |
| b. Describes all guidance, tools, and templates used to develop the QAPP | 3.0, 4.0 | See also Attachment Three |
| **EPA Organizations:** | | |
| c. Includes or references QAFAP requirements for all B elements | | |

| Element | HRSC GUIDE SECTION APPLICABLE | Comments |
|---|---|---|
| **B1. Identification of Project Environmental Information Operations (QA/S-2 Pages 16-17)** | | |
| c. Describes how the EIO is to be conducted and accomplishes the project purpose | | |
| d. Describes how the EIO will satisfy the information/data quality objectives and performance/acceptance criteria (*reference: A4 and A6 Elements*) | | |
| **B2. Methods for Environmental Information Acquisition (QA/S-2 Pages 17-18)** | | |
| ***Field Activities Environmental Measurements*** | | |
| t. Describes or references field activity procedures (e.g., information derived from tools, instruments, observational results, investigations, and sample collection) | 3.0, Attachment Three | |
| ***Laboratory Analyses*** | | |
| ***Existing Information (EI)*** | | |
| ***Environmental Technology*** | | |
| **B3. Integrity of Environmental Information (QA/S-2 Pages 18-19)** | | |
| **B4. Quality Control (QA/S-2 Page 19)** | | |
| g. Describes the QC activities needed for each EIO to meet project environmental information/data quality objectives and performance/acceptance criteria | 3.3 to 3.6 | |
| h. Describes or references the frequency of QA activities, corrective actions (CA), and how the effectiveness of the CA shall be determined and documented | 3.3 to 3.6, Attachment Three | |
| **B5. Instrument/Equipment Calibration, Testing, Inspection, and Maintenance (QA/S-2 Page 19)** | | |
| f. Identifies instruments/equipment used for EIO (e.g., tools, gauges, and pumps) | 3.3 to 3.6, Attachment Three | |
| g. Describes procedures and documentation activities to ensure that the instruments / equipment are available / in working order | | |
| h. Describes or references how calibration will be conducted, documented, and traceable to the instrument | | |
| i. Describes or references how instruments and equipment will be tested, inspected, and maintained | | |
| j. Discusses availability of critical spare parts | 2.6 | Spare parts on site or available within four hours travel time |
| **B6. Inspection/Acceptance of Supplies and Services (QA/S-2 Page 20)** | | |
| **B7. Environmental Information Management (QA/S-2 Page 20)** | | |
| g. Describes or cites the environmental information management process for the project, including from generation to final use or storage (e.g., field, laboratory, office, database) | 2.0, 4.0, 5.0 | Section 4.0 describes generation of electronic data and planning and use are described in section 2.0 and 5.0 |
| h. Describes or references standard record-keeping procedures, | | |

| Element | HRSC GUIDE SECTION APPLICABLE | Comments |
|---|---|---|
| document control system, and process for information storage and retrieval on electronic media | | |
| i. Describes or references the control mechanism for detecting/correcting errors and for preventing loss of information during data entry/reduction/reporting, and data entry to databases/forms/reports/ databases | | |
| j. Includes or references forms or checklists to be used in these processes | | |
| k. Describes or references procedures to process, compile, and analyze project EIO | | |
| l. Describes or references required computer hardware/software requirements, including performance, acceptability, and assurance that applicable information resource management requirements are satisfied | | |
| **C. Assessment, Response Actions, and Oversight** | | |
| **C1. Assessments and Response Actions (QA/S-2 Pages 21-22)** | | |
| ***Note:*** *Assessment activities may include audits, readiness reviews, peer review, in-field data document reviews, etc.* | | |
| **C2. Oversight and Reports to Management (QA/S-2 Pages 22-23)** | | |
| **D. Elements For Environmental Information Review and Usability Determination** | | |
| **D1. Environmental Information Review (QA/S-2 Pages 23-24)** | | |
| g. Describes or cites the processes for information/data verification and validation | 3.3 to 3.6, 4.0 | |
| h. Describes or references how performance and/or acceptance criteria will be incorporated in the review process | | |
| i. Describes or references how information/data quality indicators will be incorporated in the review process | | |
| j. Describes the data quality assessment documentation that will occur after the EIO phase of the project is completed | | |
| k. Identifies the individual(s) conducting each of these activities | | |
| l. Describes the documentation and communication processes for review | | |
| **D2. Usability Determination (QA/S-2 Pages 24-25)** | | |
| e. Describes or references the process based on the review that determines whether the EIO is useable | | |
| f. Describes the documentation of the usability determination | | |

| Element | HRSC GUIDE SECTION APPLICABLE | Comments |
|---|---|---|
| g. Identifies the individual(s) responsible for the usability determination activities | | |
| h. Describes the communication of any known or anticipated limitations on the use of the environmental information | 4.0, Attachment Five | |
| **END** | | |

# Attachment Three – Standard Operating Procedures for Certain HRSC Technologies

SOP 1 – Dakota Technologies, Inc. UVOST®

SOP 2 -- Geoprobe Systems® HRSC SOPs

Geoprobe Membrane Interface Probe (MIP) SOP March 2021

Geoprobe Optical Image Profiler (OIP) SOP October 2021

Geoprobe Hydraulic Profiling Tool (HPT) System SOP May 2021

Geoprobe Systems Electrical Conductivity (EC) System SOP January 2015

Nuclear Magnetic Resonance DART manual and documentation June 2023

# Attachment Four -- ITRC ASCT Checklists

ITRC developed a series of checklists for direct sensing HRSC projects, covering the following topics:

- Proposal Considerations.
- Reports.
- MIP-Quality Control Checks to Expect to See During Site Work.
- OIP-Quality Control Checks to Expect to See During Site Work.
- LIF-Quality Control Checks to Expect to See During Site Work.
- CPT-Quality Control Checks to Expect to See During Site Work.
- HPT-Quality Control Checks to Expect to See During Site Work.
- EC-Quality Control Checks to Expect to See During Site Work.

The checklists are available online at https://asct-1.itrcweb.org/tables_checklists/asct_direct_sensing_checklists.pdf

# Attachment Five -- 3D Visual Analysis

HRSC provides many physical and chemical data points that can be used to develop detailed three-dimensional models. Several software packages exist for interpreting these large data sets, each with their advantages and disadvantages.

All the packages carry out some degree of modeling, using statistical and geographic smoothing techniques to develop informative visual descriptions of the site data. 3DVA with HRSC data allows conceptual site models to move beyond “cartoon-”like simplifications of source-pathway-receptor relationships to three-dimensional visual descriptions of actual site data based on georeferenced geological, hydrogeological, and analytical data. Before data can be incorporated into a model they need to be validated and data that do not meet particular quality thresholds removed or corrected.

**Data Quality Review.**

For an accurate 3DVA to be completed, data need to have complete and accurate positional information, including elevation and plan position. Most direct sensing HRSC data can be positioned using GPS positioning software and located using GIS systems. Traditional monitoring well and soil sample analytical information may need to have position data assigned to it to be integrated into a 3DVA.

Once sufficiently accurate positional information has been assigned to the data, data need to be reviewed for completeness and accuracy. UVOST®, OIP, and MIP data need to be reviewed to remove false positives and to ensure a consistent baseline. Analytical data need to be verified against quality control metrics.

As noted in EPA OSRTI’s draft guide to 3DVA, an experienced hydrogeologist should review the geology and hydrology visualizations, and a person with first-hand experience at the site should review the site infrastructure. Additionally, consider the following questions during the quality control reviews:

- Compare geology/lithology visualizations to pre-existing geology interpretations. If a detailed or conceptual cross section or geologic map was prepared during an earlier phase of the project, how does it differ from the 3DVA visualizations? Is the 3DVA showing new data gaps or could the error be due to a data processing mistake?
- Compare hydrology visualizations to known potentiometric surfaces and flow regimes. Do older groundwater contour maps align with 3DVA flow directions? Do the 3DVA flow directions align with the path and extent of the plume? Can the differences be attributed to known factors (e.g., seasonal variability, tidal fluctuations, supply well cycling, etc.)?
- Compare chemistry visualizations to previous contaminant maps. Does the extent of the plume match older plume maps? Is NAPL shown at the locations and depths that you expected?
- Do the layers make sense together? Are contaminants following geologic structures? Does NAPL attenuate in predictable areas (high OM-strata, aquiclude boundaries, clay beds)? Do discrete zones of contaminants indicate a separate source or an interpolation error?
- If any of the visualizations do not align with the CSM or your expectations, the original data and data processing may need to be revisited. Given the volume of data in most 3DVAs, this should be an anticipated part of the process.

**Data Adjustments.**

Review the data logs for each location for the following potential corrections.

**All data validation between data points.** If logging locations are separated by a significant distance compared to desired log separation (for example where UST infrastructure, buildings, or roads prevent locations being completed), extrapolating between locations needs to be done carefully. Depending on overall observations and the anticipated conceptual model, this entails creating control points that bound the model and prevent false interpolations between data points.

**MIP.** Review MIP data for evidence of false PID or FID spikes. Adjust baseline as appropriate if unduly elevated. Look for and adjust data for “burn off” where the probe either is affected by moisture or passes through a zone of elevated contamination that takes a certain amount of probe driving distance (beyond the contaminated interval) to “burn off” back to a representative reading; this is also referred to as “carry-over.”

**OIP**. Review for false fluorescence and for evidence of window smearing and remove data appropriately.

**UVOST®** and **EC.** Check data logs are realistic, with no flat line data indicating errors or zones of missed data.

**HPT.** Ensure that HPT baseline data has been properly normalized.

**3DVA software**

Many software packages are available for 3DVA, but in practice most direct sensing HRSC specialists will already have a preferred system they use routinely. Software packages should be capable of:

- 3-dimensional block diagram of the subsurface.
- Incorporation of a variety of data types.
- Aerial/topo/site plan overlay.
- Creation of cross-sections and fence diagrams in any direction.
- Statistics: total contaminant mass, contaminant mass by partitions, center of mass of a plume, trend evaluations, correlations between data sets (e.g., concentration vs. lithology), mass flux, etc.[12]

Some of the more commonly used 3D software packages are listed below, with links to the provider's webpage.

**RockWare, Rockworks.** https://www.rockware.com/product/rockworks/.

**C Tech Earth Volumetric Studio.** http://client.ctech.com/.

**Leapfrog.** https://www.seequent.com/products-solutions/leapfrog-works/.

**Arc GIS3D.** https://www.esri.com/en-us/capabilities/3d-gis/overview.

[12] From OSRTI 3D Technical Guide Draft March 2024

# Attachment Six -- HRSC Resources

For additional information on direct sensing HRSC and other HRSC tools please refer to the resources below.

- *High Resolution Site Characterization at Petroleum Underground Storage Tank Release Sites: Applicability, Benefits and Costs.* IEc April 2023.
- *To HRSC or Not Part 1.*
- *To HRSC or not Part 2.*
- Site Assessment II, High Resolution Site Characterization, National Tanks Conference 2022 (experience from Kentucky, Sac and Fox Tribe and South Carolina).
- Clu-in High Resolution Site Characterization Resources.
- *Expedited Site Assessment Tools for Underground Storage Tank Sites: A Guide for Regulators* (EPA 510-B-16-004, October 2016).

From the ITRC

- LNAPL Site Management: LCSM Evolution, Decision Process, and Remedial Technologies
- Implementing Advanced Site Characterization Tools).
- Characterization and Remediation in Fractured Rocks.
- Integrated DNAPL Site Characterization and Tools Selection.
- Mass Flux

Contractor resources

- Geoprobe Systems® Direct Image.
- Dakota Technologies, Inc. and Dakota Introduction to LIF.
- Cascade High Resolution Site Characterization and Cascade HRSC webinars.
- Columbia Technologies.
- Eagle Synergistics HRSC and webinar registration.
- Vista Geoscience services and webinars.