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1 Introduction

An effective site characterization begins with developing or updating a conceptual site model (CSM) based on a thorough review of existing information. A CSM describes the locations and timing of potential past releases to the environment; soil properties and geology; hydrogeologic conditions; contaminant nature and extent; information regarding utilities; and other preferential pathways, potential receptors, and additional relevant data. After a thorough review of the CSM, data gaps are identified, acceptable levels of uncertainty are assessed, and the goals of the next stage of investigation is determined. Additional information regarding the development of a CSM and data quality objectives are provided in the following documents:

- Characterization and Remediation in Fractured Rock. FracRx-1 (ITRC 2017).
- Integrated DNAPL Site Characterization and Tools Selection. ISC-1 (ITRC 2015).
- USEPA Guidance on Systematic Planning Using the Data Quality Objectives Process (USEPA 2006)
- Expedited Site Assessment Tools for Underground Storage Tank Sites: A Guide for Regulators (USEPA 2016c)
- Best Practices for Data Management Technical Guide (USEPA 2018a)

Advanced site characterization tools (ASCTs) are capable of rapid implementation and data generation and can be used to provide data for a more precise and accurate CSM. ASCTs deliver semi-quantitative or qualitative data that provides a means to identify locations and depths where quantitative data should be collected to improve or complete a CSM or allow decisions to be made. Specifically, ASCTs offer images of site conditions in three dimensions, providing spatial context of variations in geology and contaminant distribution. These capabilities help target investigations and remedial actions in the most beneficial areas, potentially reducing characterization and monitoring costs while improving results. Similarly, tools designed to provide contaminant-related data are often combined with tools designed to generate geologic data that allows a better understanding of the subsurface. This understanding enhances the CSM and allows for the development of more effective remedial strategies.

ASCTs have greatly expanded the ability to understand contaminant concentration and mass, as well as the stratigraphy of the contaminated media. Although these tools have been available for several years, they often are not used because users perceive them to be expensive and unavailable or do not understand how ASCTs work and how to interpret the acquired data. Yet advances in computing and supporting technologies have vastly improved data analysis, presentation, and user experience with these tools. The amount of data collected versus time invested exceeds that provided by more traditional approaches, and the number of companies offering these services and their geographic range have increased. Despite this progress and evolution, ASCTs continue to be underutilized.

ASCTs are valuable resources and cost effective when available, understood, and used appropriately. We hope that the value of advanced site characterization tools will be reflected in future regulatory expectations and requirements.

ASCTs expand and enhance CSMs by providing a better understanding of contaminant concentration, mass, and distribution in the subsurface and the stratigraphy, geology, and hydrogeology of a site.

1.1 Purpose and Scope

The purpose of this document is to improve stakeholders’ fundamental understanding of environmental projects and foster responsible decision making as follows:

- Assist in appropriately selecting and applying ASCTs and performing basic data interpretation.
- Use the results from ASCTs to update CSMs, evaluate cleanup options, and meet the technical needs of projects.

This guidance does not include all available tools but includes those most widely used and readily available. While this document contains extensive information on various ASCTs, it is not a guide to designing CSMs or a user’s manual for any specific tool.

1.2 Technologies

The ASCTs in this document are divided into four general categories: direct sensing tools, borehole geophysical tools, surface geophysical tools, and remote sensing tools. These tools may be deployed together to collect multiple streams of data and provide multiple lines of evidence. Specific information for the applications and technical limitations of each tool are described in the section addressing each tool. Each section also provides the information needed to ensure the tools are used only where appropriate. Some tools are expected to be modified and improved in the future while others are expected to be developed for widespread use.

1.2.1 Direct Sensing

Direct sensing tools included here are technologies that measure the parameter of interest through direct contact or precise, discrete sampling. Several of these tools are advanced into the subsurface to obtain logs of lithology or the permeability of soils or unconsolidated formations. Some tools provide logs about the presence and level of volatile organic compounds (VOCs) while others are used to provide information about the presence of nonaqueous phase liquids (NAPLs). Tools can also be combined to provide sensors for both contaminant detection and lithologic identification in one device to provide insight into lithologic control on contaminant migration.

1.2.2 Borehole and Surface Geophysics

Geophysics is the measurement of contrasts in the physical properties of different materials (through active or passive detection methods) that are used to indirectly infer or estimate parameters of interest. For example, contrasts observed in gamma radiation can be used to infer changes in lithology while changes in temperature in a borehole can be used to infer groundwater flow direction and velocity. Geophysical methods have been used in resource exploration, civil engineering, and the environmental industry to characterize subsurface conditions.

This guidance divides geophysical methods into borehole geophysics and surface geophysics. Borehole geophysics is used in open or cased wells or boreholes to collect data that can be correlated to other nearby boreholes or wells or related site information. Surface geophysical methods are non-intrusive and used to evaluate the subsurface over large areas.

1.2.3 Remote Sensing

Remote Sensing generally refers to use of satellite or aircraft-based sensors to detect and classify objects on the ground surface, in the atmosphere, and in surface water based on propagated signals [typically electromagnetic (EM) radiation]. The rising availability of remotely piloted aircraft systems (RPAS) has opened new opportunities for remote sensing and spurred the development of new technologies and applications that are being applied at the typical spatial extent of site characterization activities. Remote sensing may be split into active remote sensing (when a signal is emitted by a satellite or aircraft and its reflection by the object is detected by the sensor) and passive remote sensing (when a signal from the surface of interest, such as heat via infrared, is detected by the sensor).

This guidance provides a broad overview of remote sensing technologies, discusses in more detail how RPAS can be used to provide site information, and describes how to overcome the barriers associated with using RPAS.

1.3 How to Use this Document

The ASCT in this document are divided into four general categories: direct sensing tools, borehole geophysical tools, surface geophysical tools, and remote sensing tools. Using the table of contents or the figure on the main page, you can go to one of the four sections that describe the tools under a general category or go directly to an individual tool. Tool summary tables, case studies, and checklists are also included. The summary tables provide additional information to evaluate the applicability of each tool. Case studies are examples of the use of these tools at a site. Checklists provide information to be considered when planning to use a tool, describe typical content of a report, and identify appropriate quality control checks.

If you are interested in identifying and reviewing tools that might address a data need for a site, you can use the ASCT Selection Tool. The ASCT Selection Tool is a Microsoft Excel spreadsheet that can be downloaded from the ITRC ASCT page. To select tools to evaluate you will need to provide the following information using the pulldown boxes on the spreadsheet:

- **The type of data needed** – chemistry (chemical identification, NAPL presence, contaminant concentration, pH, conductivity, organic content, total organic solids), geology (lithology, stratigraphy, fractures, structural, physical properties), or hydrology (porosity, permeability, flux, groundwater flow, hydraulic conductivity, hydraulic gradient)

- **The type of subsurface** – consolidated/bedrock (cannot penetrate with direct-push platforms) or unconsolidated
- **Data quality needed** – quantitative (for chemistry – concentrations based on standards, for geo or hydro – parameter measurements that are generally repeatable), semi-quantitative (measurements that fall within a range), or qualitative (an indirect measurement)
- **Data collection characteristics** – invasive (requires a boring or subsurface access), non-invasive (, access restrictions (surface cover, topology or other characteristics that may restrict or make access difficult).

Based on your input, the selection tool will provide a list of tools that meet these four criteria. Once a shortlist of tools has been identified, you can follow links to the category section, individual tool subsections, summary tables, case studies, and checklists.

Click here to download the entire document.