2. LNAPL Regulatory Context, Challenges, and Outreach

The 2009 ITRC LNAPL guidance noted that implementing agencies have historically required removal of LNAPL ("free product" as used in the Code of Federal Regulations (CFR)) to the "maximum extent practicable" (MEP) at underground storage tank (UST) sites. This was largely due to a provision in the Code of Federal Regulations (40 CFR §280.64) pertaining to USTs, with the specific definition of MEP left to the "implementing agency." At a minimum, LNAPL removal was intended to minimize the spread of contamination into previously uncontaminated zones. This regulation was intended to protect human health and the environment while giving program flexibility to the implementing agencies. Since MEP was not defined in the regulation, agency interpretations could range from no formal meaning to a specific maximum allowable LNAPL thickness in a monitoring well (e.g., sheen or 1/8-inch thickness). If these thickness interpretations were then incorporated into a state statute, LNAPL monitoring or recovery activities might continue long after the LNAPL body had stabilized.

In contrast, the Resource Conservation and Recovery Act (RCRA) Corrective Action regulations or guidance do not discuss removal of LNAPL to MEP, even though numerous RCRA Corrective Action sites (e.g., petroleum refineries and chemical plants) have LNAPL in monitoring wells. In RCRA Corrective Action, EPA guidance discusses "returning usable groundwater to its maximum beneficial use, where appropriate, within a timeframe that is reasonable given the particular circumstances of the facility" (EPA 1996) When restoration of groundwater is not practicable, EPA expects to prevent or minimize further migration of the plume, prevent exposure to contamination and evaluate further risk reduction (EPA 1996). The April 2004 guidance, "Handbook of Groundwater Protection and Cleanup Policies for RCRA Corrective Action for Facilities Subject to Corrective Action Under Subtitle C of the Resource Conservation and Recovery Act" indicates that "The term 'restore' or 'restoration' used in this context refers to achieving a certain cleanup level(s) developed to ensure protection based on maximum beneficial use of the groundwater at a particular facility. Restoring contaminated groundwater does not necessarily imply cleanup to pristine conditions" (EPA 2004).

LNAPL removal to MEP may leave LNAPL in the subsurface. As noted in the 2009 guidance, the EPA recognized that "…only a portion of the total volume of the LNAPL release will be recoverable. Even under ideal conditions a significant proportion of the free product will remain in the subsurface as immobile residue" (EPA 1996). Likewise with RCRA Corrective Action sites, since a significant proportion of immobile free product will remain in place, returning groundwater to its maximum beneficial use may simply not be feasible or realistic.

One of the goals of the original LNAPL guidance was to provide a framework for implementing agencies and stakeholders to evaluate and approve appropriate LNAPL remedial technologies within the confines of guidance interpretations or regulatory requirements (such as MEP). As with the original guidance, the ITRC LNAPL Team sent an updated survey in 2017 to implementing agencies in all 50 U.S. states, the District of Columbia, and Puerto Rico. The purpose was to gauge any change in how an implementing agency addresses LNAPL management issues, remedy selection, and site closures since the issuance of the 2009 ITRC LNAPL guidance. Multiple implementing agencies from 48 states responded, with the majority of responses from the programs directly involved with underground and aboveground petroleum storage tanks. Other responses were provided by the brownfields/voluntary remediation or waste programs. The recent survey indicated that 20 states had updated or changed their LNAPL management approach since the issuance of the original guidance.

2.1 Regulatory Challenges

Both the 2008 and 2017 surveys indicated that implementing agencies face regulatory challenges when managing, evaluating, or remediating LNAPL sites. If a requirement exists to remove LNAPL to a specified thickness, the implementing agency may assume that any selected removal strategy will be long and costly. This assumption could have a detrimental impact on the assessment and remediation decision. However, a more cost-effective or risk-appropriate decision, consistent within the regulatory constraints of the implementing agency, may be made if there is sufficient or increased understanding of the site and LNAPL concerns.

For RCRA Corrective Action sites, EPA outlines Technical Impracticability (TI), and believes that it is appropriate to recognize the limitations of current technologies to clean up groundwater to its maximum beneficial use. When discussing a TI, the

presence of LNAPL is one of the factors to consider. Examples of a TI for LNAPL sites may be LNAPL distribution within low-permeability or highly heterogeneous soils, or complex fractures in bedrock. EPA guidance states a TI evaluation should be based on a comprehensive understanding of hydrogeological factors, chemical characteristics, as well as limitations of conventional and innovative technologies (EPA 2004). Section 6 of this guidance discusses these factors and characteristics as well as various conventional and innovative remedial technologies. Additional relevant discussion on TI can also be found in the ITRC Guidance Document "Remediation Management of Complex Sites" (ITRC 2017b).

The following subsections summarize six primary themes encountered in the 2017 regulator survey.

2.1.1 Lack of Familiarity and Understanding of LNAPL Subsurface Behavior

Sufficient understanding of LNAPL behavior in the subsurface is important in making appropriate site management decisions. Without a sufficient LCSM, the most appropriate remedies or endpoints may not be selected. This lack of understanding or familiarity of the site may be due to multiple reasons. Case managers may have minimal experience with LNAPL sites or funding for LNAPL site work may be limited or constrained. Additionally, site owners or consultants may not propose technologies or strategies outside of their experience or abilities. The 2017 updated LNAPL survey responses indicated that:

- Over half of the regulatory staff had less than 10 years of experience dealing with LNAPL sites.
- The majority of the responses indicated formal internal LNAPL training is not required.

Since issuance of the original guidance, over 2,000 participants have attended the multi-day LNAPL classroom training. These participants represented local/state/federal agencies, environmental consultants, site owners, academia, and other interested parties. Additionally, over 17,000 have participated in the three-part ITRC internet-based training (IBT). This suggests a real and tangible interest in understanding the complexities and issues associated with management and remedy selection of LNAPL sites. The 2017 regulator survey is a telling indicator that formal LNAPL training is useful. Seventy-seven percent of respondents indicated that their program uses the 2009 LNAPL guidance and 20 respondents indicated that there have been changes or updates in their program since the issuance of the 2009 ITRC guidance.

2.1.2 Undefined Strategies or Objective-Based LNAPL Characterization

Standard practice in many petroleum release investigations has been to include general remediation objectives in the CSM. These objectives, or the strategies to achieve them, may be defined by regulatory or guidance procedures utilized by the implementing agencies. However, as noted in the 2008 survey, risk-based approaches to define LNAPL remediation objectives were not considered within many regulatory agencies. The 2017 survey indicated that although 31 programs define when active recovery of LNAPL is no longer required, only half of the respondents indicated that their specific programs define when a site with remaining LNAPL can be issued a no further action/case closure/site completion letter. Many respondents commented that the site remedial goals and objectives were selected on a case-by-case basis. While this approach may promote flexibility, it can lead to cases being unresolved or inadequately defined.

It is important to develop and select realistic and SMART remediation objectives. Section 4 and Section 5 of this guidance describe the development of an LCSM and the factors affecting SMART remedial strategies and objectives. Additional discussion on the development and selection of SMART objectives can be found in the November 2011 ITRC Integrated DNAPL Site Strategy guidance (ITRC 2011).

2.1.3 Lack of Familiarity with Nontraditional LNAPL Characterization Methods

Many regulators are accustomed to traditional investigative methods such as borings to collect soil and soil gas samples and monitoring wells to collect groundwater. These traditional methods are sometimes incorporated into state regulations or reimbursement criteria for petroleum trust funds. Both the 2008 and 2017 regulator surveys indicated that some non-traditional methods, such as Laser Induced Fluorescence (LIF), coupled with Cone Penetrometer Testing (CPT), are utilized for investigative work. However, the recent survey did not indicate a clear increase or decrease in use of these methods over the years. Some of the comments indicated that non-traditional methods were used, but they were not "successful," or that new methods were not proposed by the consultant/owner. This may simply be a function of inexperience with the case managers within the implementing agency, or an insufficient LCSM.

As discussed in this guidance, the use of non-traditional methods can provide useful, higher resolution information that provides an improved understanding of LNAPL distribution. Although not included in this guidance, a discussion of non-traditional methods or tools can be found in Section 4 of the April 2015 ITRC Integrated DNAPL Site Characterization and Tools Selection guidance (ASTM 2015). Additionally, in 2017, ITRC approved the development of new guidance to address

the selection, application, and integration of Advanced Site Characterization Tools (i.e., non-traditional methods) into the project life cycle of site characterization, remediation, monitoring, and closure. This guidance will be available in 2020.

2.1.4 Establishing Appropriate Remedial Goals and Determining Remediation Objectives

Establishing appropriate cleanup goals promotes consistency within the program and allows the regulated community to understand what is expected or required for LNAPL investigations. Most decisions regarding remedial goals and remediation objectives at LNAPL UST sites are driven by thickness and contaminant concentrations. The 2017 regulator survey responses indicated that:

- Twenty-four state programs define MEP.
- Nineteen programs use total petroleum hydrocarbon (TPH) toxicity or screening values as an indicator if LNAPL is not readily apparent in soil or groundwater.
- Twenty-three programs evaluate individual constituents for analytical compliance.

Thickness or concentration data alone may not provide a sound basis for defining the point at which a cleanup objective is achieved. These decisions can be improved by also considering contaminant mass discharge and mass flux. Mass discharge and flux estimates can help the implementing agency or regulated community understand the role or influence of natural attenuation and the risks to downgradient receptors. The estimates can also help prioritize which sites need further characterization and remediation, identify stratified aquifers, and evaluate performance data, all of which can promote more cost-effective cleanups. A discussion of mass discharge and flux can be found in the April 2010 ITRC Use and Measurement of Mass Flux and Mass Discharge guidance (ITRC 2010).

2.1.5 Differentiating Between Residual, Mobile, and Migrating LNAPL

In choosing an effective source remedy, it is important to differentiate between residual, mobile, and migrating LNAPL. The 2017 survey indicated that only 13 programs have defined these terms. In order for the implementing agencies to establish appropriate cleanup objectives, it is important to understand the differences between residual, mobile, and migrating LNAPL. Section 3 of this guidance discusses the differences and provides tools (e.g., LNAPL transmissivity) and suggestions in understanding the importance of establishing realistic and achievable objectives.

2.1.6 Transitioning between Technologies

One of the principal components of this guidance is to identify and select appropriate remediation strategies and technologies for LNAPL sites. Multiple technologies or “treatment trains” may be necessary in order to effectively control, recover, or conduct a phase change of the LNAPL mass. It is important to recognize and address this “transition” from one technology or strategy to the next in order to address the LNAPL and the identified risks and concerns effectively. Just as important, this should include the transition from an active technology driven strategy to the next, and perhaps final, less active strategy. The latter may include identification and measurement of NSZD rates, moving the site into Monitored Natural Attenuation (MNA), establishing institutional controls, or even approving case closure.

Describing the process and metrics for transitioning between LNAPL strategies or technologies can promote consistent remedial progress and navigation through the regulatory process as the site moves through investigation, cleanup, and beyond. This can allow the regulatory program to identify relevant permits, technical reviews, and approvals that may be required as the site transitions from one technology to the next. Describing the transition process and metrics can also provide financial efficiencies and assist with the budgeting process. Identifying relevant objectives and concerns during the transitions is just as important and can promote understanding and support from stakeholders that may be impacted or involved with the LNAPL case. A more detailed discussion of treatment trains and transitioning is located in Section 5 of this guidance.

2.2 Weather Vulnerabilities

In recent years, the EPA has identified possible additional LNAPL concerns associated with extreme weather events. There may be a need to increase engineering controls for contaminant migration at sites where a remedy is constructed in areas that are vulnerable to a greater incidence of flooding, hurricanes, drought, wildfires, or other consequences of extreme weather. The EPA’s Office of Underground Storage Tanks published the Underground Storage Tank Flood Guide (EPA 2010) to provide information about preparing for a flood, important actions to take after the flood, and information on financial assistance. In addition, the Institute for Sustainable Communities (ISC), partnering with the EPA, provides states and tribes with an increased understanding of specific vulnerabilities for sites under extreme weather conditions (EPA 2010).

2.3 Stakeholder Concerns, Community Outreach and Engagement

As noted in the 2017 regulator survey, multiple implementing agencies have made changes and improvements to project decision-making practices regarding LNAPL. However, it should be expected that changes in any implementing agencies' past actions regarding site assessment, remediation, or closure strategies (e.g., "What does "clean" mean?") can be met with skepticism in the stakeholder community. Presenting and explaining both the technical information and regulatory requirements to those who may be unfamiliar with the process can create difficulties and challenges for any case manager and implementing agency.

Identifying and recognizing potential stakeholders is of primary importance. Stakeholder types are listed and defined in several ITRC publications [(ITRC 2014) and (ITRC 2017b)] and can be generally defined as any person, group of persons, or organizations with some interest in a specific site, area or project. Stakeholders may include: local residents, tenants, and other potentially-impacted local parties or groups; local and other government agencies (as implementing agencies, land use officials, and safety professionals); local landowners; and/or land operators or tenants and their representatives. Impairments or impacts to these persons or groups can be physical (community health), mental (stress-related), financial (property values, loss of business activity, loss of property rights, etc.) and/or cultural (loss of resources).

Stakeholder issues for LNAPL are not dissimilar from other types of contaminants. Petroleum and potential LNAPL issues can be present in any industrial, commercial, or residential setting regardless of size or location. Petroleum and LNAPL can be associated with releases of short or long duration, from emergency responses to long-term maintenance and monitoring. Stakeholder issues for each of these situations will be dealt with in different ways, in accordance with a well-informed plan for dissemination of information, public education, and stakeholder outreach.

Recommended resources for public education and outreach involving public and tribal stakeholder issues include:

- stakeholders and stakeholder concerns (ITRC 2014),
- communication methods (ITRC 2014),
- community engagement plans and planning (ITRC 2014) that also include existing federal and state resources,
- risk communication (ITRC 2014), and
- regulatory processes for stakeholder involvement (ITRC 2017b).

Presenting technical data to the stakeholder community can be challenging. Presentations may need to include the science supporting the technology as well as the science-based conclusions that can be drawn from the data. Statistical representation of the confidence associated with the data can also be part of the presentation. It is recommended that explanations of the technology and how it contributes to the LCSM be presented in a manner that is understood easily by the stakeholders. Public acceptance and understanding of the difficulties with the site can be enhanced if the information is presented and explained in a way that defines the technical and regulatory steps in a clear and understandable format.

2.4 Streamlining the Corrective Action Process by Increased Communication

Inadequate or limited communication between the implementing agencies, the responsible party, and identified stakeholders can increase the amount of time to move a site through the investigation and corrective action process. In some cases, performance of initial emergency actions and abatement may be needed prior to communication with stakeholders. However, it is recommended that outreach and communication occur before corrective action is performed. Identifying and discussing difficult issues before any field work or report writing is done can often mitigate interruption, delay, and additional expense. RCRA FIRST (EPA 2015) is a streamlined process promoted by EPA for investigation and remediation at RCRA Corrective Action sites. This process can be applied at LNAPL corrective action sites.

Not every LNAPL site will require outreach or significant communication with stakeholders. The implementing agencies will determine the amount and effort based on their specific requirements and guidance. When appropriate, increased communication between the groups can facilitate better agreements on major issues at the beginning of the process, thereby reducing the amount of time to project completion.