LCSM Evolution

Discuss the evolution of the LCSM
• Concerns
• Remedy Selection
• Remedy Performance (Covered in IBT 3)

Relate the LCSM to Site Strategy
• Identification and Classification of Concerns
• Establishing Remedial Goals to Address Concerns
• Development of Remediation Objectives
Poll the Group

The projects I work on are limited by: (choose the best answer)

A. Budget constraints, there is sufficient time and technical understanding how goals could be achieved

B. Technical constraints, site characteristics (fine grained soil, depth to impacts, bedrock) limit effectiveness of technologies and ability to reduce impacts

C. Time constraints, there is a time driver which limits the available approaches to addressing concerns achieving goals
The LCSM is continually updated, but each update represents a focus specific to that project phase.

Figure 4-1, LNAPL-3
Data Collection & Evaluation is Parallel with Decision Making

**INITIAL STAGE**

- **Data Collection & Interpretation**
  - Initial CSM/LCSM

- **Decision Making**
  - Identify LNAPL Concerns
  - Verify Concerns via Threshold Metrics
  - Establish Remedial Goals
  - Determine Remediation Objectives
  - Select LNAPL Remedy(ies)

**2ND STAGE**

- **Remedy Selection LCSM**
- **Decision Making**
  - Select Remedial Metrics Implement Remedy

**FINAL STAGE**

- **Design & Performance LCSM**
- **Decision Making**
  - Performance Metrics Technology Transition Points Remediation Endpoints

Concerns Addressed
LNAPL Concerns
The Initial LCSM identifies specific LNAPL concerns
Overall, the Concerns portion of the LCSM are typically well developed and mature

Recent improvements in this area include

- PVI (PVI IBT)
  - Screening distances (ITRC, 2015)
- Natural Source Zone Depletion
- Plume stability & NSZD (IBT#1)
- LNAPL transmissivity to improve understanding of recoverability as related to maximum extent practicable
- Sheens – Related Appendix in LNAPL Update document

Ongoing Development

- TPH guidance is being updated

Recommended completeness test for Initial LCSM

- LCSM should be able to inform a series of typical questions
- Amount of detail for a given question is decided by asking “is there sufficient understanding to enable Decision Making?”
What is Needed for the Initial LCSM
Consistently Needed or Possibly Needed?

- Receptors – NEED to understand where they are relative to plume
- Extent of impacts – NEED to understand if receptors are affected
- Migration – NEED to understand if existing impact extent will change
- LNAPL Occurrence in wells – Regulatory driven NEED
- Hydraulic Conductivity – Typically not needed to evaluate Concerns. Site Specific – for Concerns and Often Needed in Remediation
- Distribution of LNAPL and dissolved/vapor within the extent of Impacts – Typically not needed to evaluate concerns, Site Specific – for Concerns and Often Needed in Remediation
The Concerns LCSM Litmus Test

The questions provided:

- Are typical of multiple guidance (ASTM, CRCcare, IPECA, EPA)
- Encourage a systematic framework to develop an LCSM
- Encourage a systematic thought process to help confirm the completeness of the LCSM
- Only apply to the Initial LCSM & may not be sufficient to select a remedy

1. Is current and future land use known?
2. Does the potential for preferential pathways exist?
3. How does stratigraphy relate to affecting impacts and potential migration?
4. Is the source and extent of the LNAPL known?
5. Are dissolved or vapor issues expected based on LNAPL composition?
6. Are dissolved or vapor plumes characterized?
7. Do soil or groundwater concentrations exceed criteria?
8. Are exposure pathways complete or incomplete?
9. Is the LNAPL body stable?
10. Is the mobile LNAPL hydrogeologic condition known?
The Amount of Knowledge

INCREASING COMPLEXITY

Site Setting and Physical Factors

Offsite Plume/Sensitive Receptors
Occupied Above-Ground Structure
 Preferential Pathway/GW Use
Business and Community Factors

Aboveground Receptors
Utilities, Groundwater Use
On-going Development

Tier 1
Homogenous
Low Solubility
Degradable
Unconsolidated
Consistent GW Flow Trends

Tier 2
Undeveloped
Limited Access
No Surface Water
No Groundwater Use

Tier 3
Heterogeneous,
Fractured Bedrock,
High Solubility/Toxic
Persistent, Seasonal

InCREASING COMPLEXITY

LCSM Evolution

Hydrogeologic & LNAPL Composition Factors

Migration / Transport / Toxicity / Persistence
Geologic Heterogeneity Fractured Rock/Karst
Transient / Seasonal Conditions Affect Distribution

Figure 4-2, LNAPL-3 (adapted from ASTM 2014)
Tier 1 vs. Tier 3

**Tier 1 Retail – Diesel in Sand**
- 10 – 15 feet to Water-table
- Dissolved plume contained onsite (MNA)
- Mobile LNAPL in wells – $T_n$ 1.0 ft$^2$/day
- LNAPL is not under any buildings
- Release occurred 10+ years ago

- Well Defined Remedial Concerns
- No risk, $T_n$ above but close to 0.8 ft$^2$/day

**Tier 3 Retail – Gasoline Interbedded Soil Over Bedrock**
- Water- Table 15-20 ft. depth
- Fractured bedrock at ~25 ft depth,
- Down gradient receptors - 30 year old bedrock screened wells exhibit impacts
- LNAPL is off-site in unconsolidated soil
- What are remaining questions for the LCSM?
  - Likely requires nest well pairs (unconsolidated bedrock) for dissolved delineation
The concept of continually updating the LCSM throughout the remedial process means:

A. The LCSM should become increasingly complex throughout the remedial process

B. Even if performance monitoring indicates progress toward endpoints, better check between borings to ensure uniform treatment

C. Reinvestigate with the latest tools as new characterization technologies evolve

D. The LCSM is updated to inform decisions throughout the project. Each decision point may require different data.
Summary
Initial LCSM and The Decision

► Is there sufficient information for a given question to support identification of Concerns?

► Is additional site characterization required for evaluating the Concerns LCSM?

• Initial characterization activities may go beyond collecting data for concerns

• Combining mobilizations for concerns and remedial selection characterization may improve efficiency at sites where remediation is already known to be needed

• Collecting remedial-technology-focused characterization data at more complex sites may result in incomplete data collection, or less efficient data collection
Learning Objectives

1. Become familiar with LNAPL decision process and key terms:
   - LNAPL Concerns, Remedial Goals, and Remediation Objectives

2. Understand three classes of LNAPL remediation objectives:
   - Mass Recovery, Phase Change, and Mass Control

3. Understand how metrics are applied:
   - Threshold Metrics and Performance Metrics
ITRC LNAPL Management

1. Initial LCSM
2. Identify LNAPL Concerns and Establish LNAPL Remedial Goals
3. Select Remediation Technology to Achieve Remedial Objectives
4. Install Remedial Technology and Monitor Performance

What do you have?
What needs to be done?
How do you do it?

LNAPL Decision Process
LNAPL Concerns

The LCSM identifies specific LNAPL concerns

- Risk & Safety
- Migration
- Mobile LNAPL Occurrence in Wells
- Other

LCSM
Example LNAPL Concerns

- **Risk & Safety**
  - Petroleum vapor intrusion
  - Groundwater ingestion
  - Acute safety hazards

- **Migration**
  - Spread of LNAPL body, resulting in future risk

- **Mobile LNAPL Occurrence in Wells**
  - Addresses “Maximum Extent Practicable” regulatory requirement

- **Other**
  - Sheens
  - Geotechnical
  - Aesthetics (stains and odors)
Verifying Concerns with Threshold Metrics

LNAPL Concern

Risk & Safety

Threshold Metric

Yes

Verified Concern?

No

Verified concerns need remedial goals

Migration

Threshold Metric

Yes

No
LNAPL Remedial Goals

LNAPL Concern

Risk

Migration

Occurrence (MEP)

Other

Type of LNAPL Goal

Composition

Saturation

Saturation

Aesthetic or Combination
LNAPL Remedial Goals

Each LNAPL Remedial Goal expresses a desired change in LNAPL conditions

**Composition-Based Goals**
- Reduce vapor concentrations
- Reduce groundwater concentrations
- Etc.

**Saturation-Based Goals**
- Reduce LNAPL saturation
- Contain migrating LNAPL
- Etc.

Remedial Goals must be identified before choosing remedial technology(ies)
Remedial Goal vs. Remediation Objectives

**LNAPL Remedial Goal:**
- the desired change in LNAPL conditions
  - Aspirational… envisioning a future state
  - Established before choosing remedy

**LNAPL Remediation Objectives:**
- the actions and desired outcomes that need to occur using the chosen technology
  - Tactical… how to get to the goal
  - Determined in parallel with remedy selection

These definitions are the opposite of what they were in the previous ITRC LNAPL Guide
LNAPL Remediation Objectives

- LNAPL remediation objectives describe how the goal will be accomplished by the selected technology(ies).
- Remediation objectives state the actions and desired outcomes that need to occur using the chosen technology.
- Combined with the agreed-upon endpoint and performance metrics, the remediation objectives become SMART.
Technology Groups and Objectives

Mass Recovery
- **Abate** LNAPL body migration by removal of LNAPL Mass
- **Remove** mobile LNAPL to the MEP
- Etc.

Phase Change
- **Abate** unacceptable vapor accumulations by sufficient depletion of volatile constituents from LNAPL
- **Reduce** dissolved concentrations at point of compliance by sufficient depletion of soluble constituents from LNAPL
- Etc.

Mass Control
- **Contain** LNAPL at a defined boundary
- **Prevent** migration beyond a point of compliance
- Etc.
Technology Groups and Objectives

- Mass Control
- Phase Change
- Mass Recovery

Key Point: Some technologies have more than one effect and may serve more than one objective.
Choose Remedial Technology(ies), then Identify Performance Metrics & Endpoints

Remedy

Performance Metrics

Endpoint

These assure effective implementation

This defines remedial action completion

Performance Metrics and Endpoints are SMART and technology-specific
Performance Metrics

- Technology-specific!
- Verifies that remedy is being effectively implemented
- Allows for mid-course corrections
- Tracks progress toward endpoint
- Example performance metric for bioventing:
  - Maintain a specified minimum oxygen content in a targeted region of LNAPL-affected soil (to deplete LNAPL mass by aerobic biodegradation)
Endpoints

- Also technology-specific!
- Defined as:
  - LNAPL concern has been addressed, OR
  - Practicable limit of the technology
- If technology reaches its practicable limit before LNAPL concern is abated, then the endpoint marks the transition to the next technology in the treatment train
Examples of Concerns Leading to SMART Remedial Outcomes

Identify LNAPL Concerns
- LNAPL is the source of a dissolved phase plume that may affect a supply well
- Groundwater Standards
- Reduce dissolved-phase concentrations to generic or site-specific standards
- Reduce dissolved-phase impacts
- Air sparging and soil vapor extraction
- Stable dissolved plume
- Stabilized dissolved concentrations; standards met at compliance point

Verify Concerns
- LNAPL may be migrating
- Contain LNAPL and reduce the potential for migration
- Reduce mobile LNAPL mass
- Dual-pump liquid extraction
- Stable LNAPL plume
- Demonstration of functional LNAPL stability

Establish Remedial Goals
- LNAPL present in a well
- ITRC recommended endpoint range for recoverability
- Reduce LNAPL saturation
- Recover LNAPL mass to recoverable limit
- Dual-pump liquid extraction
- LNAPL transmissivity
- Transmissivity decreased to practical limit of recovery

Establish Remedial Objectives
- Specific
- Measurable
- Attainable
- Relevant
- Timely

Select Remedy
- Identify LNAPL Concerns
- Verify Concerns
- Establish Remedial Goals
- Determine Remediation Objectives
- Select Remedy
- Establish Metrics
- Remediation Endpoints

Figure 5-2, ITRC LNAPL-3
Decision Making and Technology Selection Summary

- Use the systematic decision-making process
- A robust LCSM identifies LNAPL Concerns
- Establish Remedial Goals to address Verified Concerns
- Identify the right technology(ies) to abate the Verified Concerns
- LCSM is referred to and refined as-needed to design and implement the remedy
- SMART objectives lead to project success