Maximum Extent Practicable

For the Department to achieve state program authorization for the regulation of underground storage tanks, the U.S. Environmental Protection Agency has determined that Pennsylvania regulations under Chapter 245 for storage tank sites are consistent with federal regulations under 40 CFR Chapter 280. 40 CFR§ 280.64 requires owners and operators to remove free product to the maximum extent practicable as determined by the implementing agency. 40 CFR§ 280.64(b) requires owners and operators to use abatement of free product migration as a minimum objective for the design of the free product removal system.

As the implementing agency, the Department defines maximum extent practicable (MEP) under 40CFR § 280.64 as the extent of removal necessary to prevent migration to uncontaminated areas and prevent or abate immediate threats to human health. Migrating Separate Phase Liquids (SPL) is defined as a SPL body and its associated phases that are observed to spread or expand laterally or vertically into previously uncontaminated areas. Migrating SPL does not necessarily include SPL that appears in a well due to fluctuating water table conditions.

In the majority of cases, liquids released at regulated storage tank sites are Light Non-Aqueous Phase Liquids (LNAPLs). Recent advances in the understanding of LNAPL behavior have illustrated that in some cases, continued attempts to reduce LNAPL to an arbitrarily measured thickness in a monitoring well (e.g. 0.01 ft. or less) is neither practicable nor even necessary. Even in cases where the presence of LNAPL is the only reason for remediation, continued recovery of LNAPL beyond a technically achievable thickness may provide little or no positive impact on the environment.

In order to meet the corrective action requirements under 25 Pa Code, Chapter 245 and meet removal of SPL to the MEP, technical data has to demonstrate that the SPL is stable and not migrating and that the associated phases will not pose a risk to potential receptors and attains a cleanup standard under Act 2. Demonstration of this requirement is further described in section IV.E.4. of this guidance.

Management of Light Non-Aqueous Phase Liquids (LNAPL) under Act 32

LNAPL typically has been viewed as separate phase liquid that is less dense than water and can be measured in a well or on a water surface. When measureable LNAPL is not detected within a well, LNAPL can remain trapped in nearby soils. Depending on site conditions and how conditions can change, this residual LNAPL may remain trapped or become mobile. Therefore, it is important to keep the following in mind:

- The absence of measurable LNAPL in a well does not definitively establish the absence of mobile LNAPL at a site.
- The presence of measurable LNAPL in a well does not definitively establish the size, volume, thickness, or recoverability of LNAPL at the site or in the vicinity of the well.
- The measured LNAPL thickness in a well may not be indicative of the actual LNAPL thickness or volume within the formation.
- The presence of recoverable LNAPL in a well may only indicate that mobile LNAPL exists in the immediate vicinity of that well.
- The observation that LNAPL is no longer accumulating at a significant or appreciable rate in a well may only indicate that the LNAPL in the vicinity of the well is no longer mobile under the present conditions.
- The mass of residual LNAPL remaining in the soil and/or rock matrix after recovery to the MEP may be orders of magnitude larger than the amount of mobile LNAPL that was recovered at the site.
- LNAPL may spread in many directions not necessarily coincident with groundwater gradients (including but not limited to structural influences, preferential pathways, permeability contrasts, and pumping well influences).
- LNAPL migration rates may not be the same as the groundwater flow rates.
- Some mobile LNAPL is persistent and can be bailed, but quantities removed may be relatively small. Product bailing alone rarely achieves significant LNAPL recovery.

LNAPL exists in residual and non-residual (mobile) phase, so some LNAPL may remain at the site after reaching removal to MEP as defined in section I.D.8 of this guidance. Although the remaining LNAPL may take years to degrade, the low recoverability combined with the low risk posed by the LNAPL source make recovery of remaining LNAPL infeasible or unnecessary. Information necessary to determine when LNAPL removal meets the MEP is identified below.

Site Characterization and LNAPL Conceptual Site Model

25 Pa Code § 245.309 requires completion of a site characterization. A complete and concise site characterization is an important step in identifying the presence, properties, distribution and migration of LNAPL. Simple visual observations during site work and interpretation of analytical results can help identify the presence of LNAPL. Information collected in the field to define LNAPL properties and distribution may include, but is not limited to soil type, LNAPL transmissivity tests, porosity (primary and secondary), seasonal water table

fluctuations (indicated by the possible smear zone size), and viscosity of the LNAPL. The level of detail needed in a site characterization is equal to the complexity of the site. The characterization of a site with LNAPL includes the development of an appropriate LNAPL Conceptual Site Model (LCSM) Documents that should be used to guide the development of a LCSM are included in the list of references, below. The LCSM may require revisions as site conditions change due to remediation and other site factors. Figure IV-10 is a worksheet that can be used when preparing a LCSM.

Information needed to characterize LNAPL at a site and develop a thorough LCSM typically includes, but is not limited to:

- **Delineation:** LNAPL does not necessarily form a "pancake" on the groundwater surface, but shares the pore space in the vadose zone, the capillary fringe, and/or beneath the water table within the smear zone. Different industry standard practices can be used to identify LNAPL trapped in soils or bedrock (ranging from shake test to Laser-Induced Florescence (LIF) in conjunction with core photography).

- **Sources and Pathway:** Geologic or manmade features such as fractures in bedrock or clay, and fill material adjacent to underground utilities may also contain LNAPL and may serve as pathways for vapor and dissolved phases. The movement and storage of LNAPL in these features needs to be considered as part of the characterization and their presence may significantly increase risk by accelerating potential migration to receptors.

- **Volume:** Where possible, the volume (or plausible volume range) of LNAPL within the subsurface should be established to allow the development and selection of an appropriate recovery strategy as well as a basis for the risk evaluation. Historic records for the site should be reviewed to identify past releases that may have contributed to the volume of LNAPL.

- **Age and Chemical/Physical Character:** LNAPL and groundwater can be analyzed to identify or verify the type of product as well as assess if the product poses a risk to receptors. As LNAPL weathers, the physical and chemical properties of the LNAPL can change. Weathered LNAPL can be more viscous and therefore less mobile and less recoverable than unweathered LNAPL. LNAPL properties can also assist in determining a probable date or time frame for the product release. Knowing the amount of time the product has been present compared to the known impacts (or lack thereof) can provide valuable insight on whether case closure is advisable.

- **LNAPL Migration:** The potential for mobile LNAPL to migrate may depend on geologic conditions, changing hydraulic or LNAPL gradients as well as precipitation and groundwater recharge. The presence of other contaminants may help migration of LNAPL.

- **LNAPL Mobility:** LNAPL in porous media exist at saturations greater than residual saturation to be mobile. It is the mobile portion of the LNAPL body that is typically

recovered by LNAPL extraction and recovery technologies. However, the presence of mobile LNAPL in a well does not necessarily indicate that the LNAPL body is migrating. Gauging or recovery data from drought and heavy precipitation events may provide mobility data.

- **LNAPL Recoverability/Transmissivity:** LNAPL Transmissivity (LNAPL Tn) is a useful metric for determining the recoverability of mobile LNAPL. Since LNAPL Tn accounts for multiple LNAPL properties such as density, viscosity, and LNAPL saturation, LNAPL Tn can be more useful than just the measured thickness for determining LNAPL recoverability (ASTM E2856). However, LNAPL Tn can vary over time due to subsurface conditions such as groundwater fluctuations, corrective action implementation (reduced LNAPL saturation), or weathering of LNAPL.

  LNAPL Tn tests should be performed at sites where LNAPL is present to aid in determining the recoverability of the LNAPL. LNAPL Tn tests can also be completed over time to document the progress of LNAPL recovery efforts. The ASTM Standard E2856 discusses several LNAPL Tn test methods and how to select the most appropriate method for site conditions. More information about LNAPL transmissivity may be found in the references to this section, particularly ASTM Standard E2856.

Characterization of LNAPL is found through direct and indirect indicators. Both types of indicators determine where and how much LNAPL is on the property and are especially important if the release history is unknown.

Some direct methods of detecting the presence of LNAPL include:

- Laser Induced Fluorescence (LIF) and Rapid Optical Screening Tool LIF; and
- LNAPL presence in wells, borings or test pits.

LIF is used to collect real-time, in situ field screening of residual and non-aqueous phase hydrocarbons in undisturbed vadose, capillary fringe and saturated subsurface soils and groundwater. Detailed information regarding this technology can be found at EPA's Contaminated Site Clean-Up Information website).

LNAPL presence in wells, borings or test pits indicates that LNAPL is in the surrounding formation. In unconfined conditions, the LNAPL could rise and fall with the fluctuation of the water table. However, it is not a reliable indicator of vertical and lateral extent in the formation or for determining the volume of the release. The absence of LNAPL in a well does not necessarily mean the source is eliminated; it may be trapped deeper in the formation by a high water table.

Some indirect indicators of LNAPL presence in the formation include:

- A persistent dissolved phase plume;
- Dissolved phase groundwater concentrations that are close to the effective solubility of the LNAPL that was released;
- Total Petroleum Hydrocarbons (TPH) concentrations (EPA method 418.1) that are greater than the Carbon Saturation (Csat) in a given soil;
- Field screening tests such as staining, odors, Organic Vapor Analyzers, Photo Ionization Detectors, Flame Ionization Detectors, shake test using oleophyllic dyes, paint filter test (EPA method 9095B) and paper towel tests;
- Ultra violet light boxes and soil cores;
- Direct push technologies that can measure for the presence of LNAPL such as LIF, Membrane Interface Probes and cone penetrometers;
- Soil and rock core lab analysis;
- Core photography under UV light, pore fluid saturations, soil properties, fluid properties, and LNAPL fingerprinting.

The level of detail needed when using these methods is commensurate with the complexity of the site.

LNAPL Conceptual Site Model (LCSM) Worksheet

LCSM-describes the physical properties, chemical composition, occurrence and geologic setting of the LNAPL body from which estimates of flux, risk and potential remedial action can be generated. (definition taken from ASTM E2531-06)

Site Characterization	Yes	No	N/A
1. Do you have the site use history?			
2. Do you know the geology of the site?			
3. Do you know the hydrogeology of the site?			
3.a. Unconfined aquifer?			
3.b. Confined/Semi-confined aquifer?			
3.c. Perched aquifer			
4. Is the source known?			
4.a. If yes, what is the source and quantity released?			
5. Has the LNAPL body been delineated?			
5.a. If yes, what methods have been employed to determine if LNAPL is trapped in soils and/or bedrock?			
6. Do any dissolved concentrations in groundwater approach their effective solubility?			
7. Have the physical and chemical properties of the LNAPL been determined?			
8. Have potential migration pathways been identified (i.e. fractures in bedrock and clay, karst features, utilities)?			
9. Are there complete or potentially complete exposure pathways present (potable wells, surface water, vapor intrusion, etc.)?			
10. Are there ecological receptors impacted by the LNAPL body?			

11. Has sufficient gauging data been gathered to determine if LNAPL is mobile?			
11.a. Has gauging taken place during drought or after heavy precipitation events?			
12. Has LNAPL transmissivity been determined?			
13. Has a qualitative assessment of NSZD been completed?			
14. Does characterization indicate that the LNAPL is no longer migrating?			