This document is not an ASTM standard and is intended only to provide the user of an ASTM standard an indication of what changes have been made to the previous version. Because it may not be technically possible to adequately depict all changes accurately, ASTM recommends that users consult prior editions as appropriate. In all cases only the current version of the standard as published by ASTM is to be considered the official document.

Designation: ~~E3268 – 20~~ E3268 – 21

Standard Guide for NAPL Mobility and Migration in Sediment—Sample Collection, Field Screening, and Sample Handling[1]

This standard is issued under the fixed designation E3268; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide provides considerations to inform sample collection, field screening, and sample handling of sediments impacted with non-aqueous phase liquid (NAPL) to assist in data collection for the evaluation of NAPL movement in sediment. The conditions affecting NAPL emplacement and movement in sediments are significantly different than in upland soils. As such, the framework for the assessment of NAPL movement in upland soils has been determined to have limited applicability for sediments.

1.2 This guide is applicable to sediment sites where the presence or suspected presence of NAPL has been identified. Sediments are the subject media considered in this guide, not surface water or groundwater.

1.3 The goal of this guide is to provide a technical framework for sample collection, field screening, and sample handling activities used to evaluate NAPL conditions, in particular NAPL movement (that is, mobility at the pore scale and migration at the NAPL body scale) in sediments, which can be used to inform the development and selection of remedial options and post-remedial monitoring activities.

1.4 This guide discusses sample collection procedures, including direct methods (that is, core and grab samples) and indirect methods (that is, DART®[2], laser-induced florescence, and porewater samplers) for assessing NAPL presence or absence in sediment.

1.5 This guide discusses field characterization procedures for assessment of NAPL-impacted sediments including visual screening, stratification assessment, shake test, ultraviolet (UV) light test, NAPL FLUTe™[3], and headspace vapor monitoring.

1.6 This guide discusses considerations to obtain samples representative of *in situ* conditions. This includes methods used to evaluate sediment integrity, sample retrieval from the sediment bed, core identification, sample storage onboard the vessel, sample retrieval from the coring device, sufficient sample recovery, core cutting techniques, sample removal from the core, and sample freezing/cooling considerations.

1.7 This guide discusses the objectives, approaches, and materials for the storage and transport of NAPL-impacted sediment, focusing on samples taken for laboratory NAPL mobility and geotechnical tests. Considerations include sample packaging and handling, storage temperature, and hold times.

iTeh Standards (https://standards.iteh.ai) Document Preview
ASTM E3268-21

[1] This guide is under the jurisdiction of ASTM Committee E50 on Environmental Assessment, Risk Management and Corrective Action and is the direct responsibility of Subcommittee E50.04 on Corrective Action.

Current edition approved ~~Dec. 15, 2020~~July 1, 2021. Published ~~March 2021~~August 2021. Originally published in 2020. Last previous edition approved in 2020 as E3268–20. DOI: ~~10.1520/E3268–20~~10.1520/E3268–21

[2] Trademarked by Dakota Technologies. http://www.dakotatechnologies.com/products/darts

[3] Trademarked by Flexible Liner Underground Technologies.

Copyright © ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959. United States

1.8 NAPLs such as fuels, oils, coal tar, and creosote are the primary focus of this guide.

1.9 *Units*—The values stated in SI or CGS units are to be regarded as the standard. No other units of measurement are included in this standard.

1.10 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.11 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[4]

D425 Test Method for Centrifuge Moisture Equivalent of Soils
D854 Test Methods for Specific Gravity of Soil Solids by Water Pycnometer
D1587 Practice for Thin-Walled Tube Sampling of Fine-Grained Soils for Geotechnical Purposes
D2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
D2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
D2488 Practice for Description and Identification of Soils (Visual-Manual Procedures)
D2937 Test Method for Density of Soil in Place by the Drive-Cylinder Method
D3213 Practices for Handling, Storing, and Preparing Soft Intact Marine Soil
D4044 Test Method for (Field Procedure) for Instantaneous Change in Head (Slug) Tests for Determining Hydraulic Properties of Aquifers
D4104 Practice for (Analytical Procedures) Determining Transmissivity of Nonleaky Confined Aquifers by Overdamped Well Response to Instantaneous Change in Head (Slug Tests)
D4318 Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
D4464 Test Method for Particle Size Distribution of Catalytic Materials by Laser Light Scattering
D4823 Guide for Core Sampling Submerged, Unconsolidated Sediments
D5073 Practice for Depth Measurement of Surface Water
D5084 Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter
D5413 Test Methods for Measurement of Water Levels in Open-Water Bodies
D5906 Guide for Measuring Horizontal Positioning During Measurements of Surface Water Depths
D6151 Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling
D6169 Guide for Selection of Soil and Rock Sampling Devices Used With Drill Rigs for Environmental Investigations
D6282/D6282M Guide for Direct Push Soil Sampling for Environmental Site Characterizations
D6836 Test Methods for Determination of the Soil Water Characteristic Curve for Desorption Using Hanging Column, Pressure Extractor, Chilled Mirror Hygrometer, or Centrifuge
D6913/D6913M Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis
D6914/D6914M Practice for Sonic Drilling for Site Characterization and the Installation of Subsurface Monitoring Devices
D7203 Practice for Screening Trichloroethylene (TCE)-Contaminated Media Using a Heated Diode Sensor
D7263 Test Methods for Laboratory Determination of Density and Unit Weight of Soil Specimens
D7928 Test Method for Particle-Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation (Hydrometer) Analysis
E1391 Guide for Collection, Storage, Characterization, and Manipulation of Sediments for Toxicological Testing and for Selection of Samplers Used to Collect Benthic Invertebrates
E3163 Guide for Selection and Application of Analytical Methods and Procedures Used during Sediment Corrective Action
E3164 Guide for Sediment Corrective Action – Monitoring
E3248 Guide for NAPL Mobility and Migration in Sediment – Conceptual Models for Emplacement and Advection

iTeh Standards
(https://standards.iteh.ai)
Document Preview
ASTM E3268-21
-8b09-09fa31afbbee/astm-e3268-21

3. Terminology

3.1 *Definitions:*

[4] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

3.1.1 *immobile NAPL, n*—NAPL that does not move by advection within the connected void spaces of the sediment under specified physical and chemical conditions, as may be demonstrated by laboratory testing, or may be interpreted based on mathematical calculations or modeling. **E3248** ~~**E3248**~~

3.1.2 *migrating NAPL, n*—NAPL that can move at the NAPL body scale, such that the NAPL body may advectively expand in at least one direction under observed or reasonably anticipated field conditions. **E3248** ~~**E3248**~~

3.1.3 *mobile NAPL, n*—NAPL that may move by advection within the connected void spaces of the sediment under specific physical and chemical conditions, as may be demonstrated by laboratory testing, or as may be interpreted based on mathematical calculations or modeling. **E3248** ~~**E3248**~~

3.1.4 *non-aqueous phase liquid, NAPL, n*—chemicals that are insoluble or only slightly soluble in water that exist as a separate liquid phase in environmental media. **E3248**

3.1.4.1 *Discussion*—
NAPL may be less dense than water (light non-aqueous phase liquid [LNAPL]) or more dense than water (dense non-aqueous phase liquid [DNAPL]).

3.1.5 *sediment, n*—a matrix of pore water and particles including gravel, sand, silt, clay, and other natural and anthropogenic substances that have settled at the bottom of a body of water. **E3163**

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *core catcher, n*—for the purposes of this guide, a device that grips and supports the core while the sampler is being pulled from the sediment and hoisted to the water surface. ~~**D4823**~~

3.2.2 *recovery ratio, n*—for the purposes of this guide, the ratio A/B where A is the distance from the top of the sediment core to the bottom of the cutting bit and B is the distance from the surface of the parent deposit to the bottom of the cutting bit. ~~**D4823**~~

3.2.3 *undisturbed sample, n*—for the purposes of this guide, sediment particles that have not been rearranged relative to one another by anthropogenic activity including the collection, transport, and analysis of the sample. In common usage, the term "undisturbed sample" describes particles that have been rearranged, but only to a slight degree. ~~**D4823**~~

iTeh Standards
(https://standards.iteh.ai)
Document Preview
ASTM E3268-21
https://standards.iteh.ai/catalog/standards/sist/82aa281b-c73d-46eb-8b09-09fa31afbbee/astm-e3268-21

4. Significance and Use

4.1 Many contaminants, including chlorinated solvents and petroleum products, enter the subsurface in the form of an immiscible liquid, known as a NAPL. Understanding the potential emplacement and transport mechanism for NAPL in sediment is an important element of an overall conceptual site model (CSM) that forms a basis for *(1)* investigating the nature and extent of NAPL, *(2)* evaluating if (and how) human and ecological receptors may be exposed to NAPL, and *(3)* assessing remedial alternatives. In addition, demonstrating the potential movement of NAPL in sediments is hampered by the lack of standardized terminology and characterization protocols, thus necessitating this guide.

4.1.1 Understanding the presence and movement of NAPL in sediments is complicated by the lack of standardized protocols for characterizing NAPL movement in the diverse range of sediment environments. Literature searches have indicated that there is a limited body of available, applicable research. Current research has focused on site-specific sediment NAPL mobility assessment approaches, but application of common methods or decision-making processes identified across sites were limited.

4.1.2 The movement (or lack of movement) of NAPL in sediments is a key factor in developing protective remedial options for NAPL-impacted sediments and for the long-term management of sediment sites. Typical exposure pathways that are addressed through risk management decisions at upland sites are usually not applicable to sediment sites. Rather, "contaminants in the biologically active layer of the surface sediment at a site often drive exposure" (**1**)[5], because in aquatic environments, benthic organisms live in the surface sediment to maintain access to oxygenated overlying water. NAPL that is present in subsurface sediment below the biologically active layer that is not migrating and has an overlying sediment that is expected to remain in place (that is, is not dredged or eroded) does not pose a risk to human or ecological receptors, because there is no pathway for exposure. Therefore, remediation of the NAPL may not be warranted. Thus, understanding NAPL presence, extent and potential movement is a key factor in managing contaminated sediment sites.

[5] The boldface numbers in parentheses refer to the list of references at the end of this standard.

4.2 This guide will aid users in developing the scope and method selection for investigating the presence and characteristics of NAPL in a sediment environment. This guide provides an overview of the sample collection, field screening and sample handling methods for investigating the presence or absence of NAPL, as well as characteristics of NAPL in the sediment environment.

4.2.1 Use of this guide supports a multiple lines of evidence approach to evaluate NAPL movement in sediments.

4.2.2 This guide should be used to support existing decision frameworks for field screening and sample collection for NAPL-impacted sediments.

4.2.3 This guide is not intended to provide specific guidance on sediment site investigation, risk assessment, monitoring or remedial action.

4.3 Assessment of NAPL movement in sediments is an evolving science. This guide provides a systematic, yet flexible, decision framework to accommodate variations in approaches by regulatory agencies and users, based on project objectives, site complexity, unique site features, programmatic and regulatory requirements, newly developed guidance, newly published scientific research, use of alternative scientifically based methods and procedures, changes in regulatory criteria, advances in scientific knowledge and technical capability, multiple lines of evidence approach, and unforeseen circumstances.

4.4 The use of this guide is consistent with the sediment risk-based corrective action (RBCA) process that guides the user to acquire and evaluate appropriate data and use each piece of data to refine goals, objectives, receptors, exposure pathways, and the CSM. As the sediment RBCA process proceeds, data and conclusions reached at each tier help focus subsequent tiered evaluations. This integrated process results in efficient, cost-effective decision-making and timely, appropriate response actions for NAPL-impacted sediments.

iTeh Standards
(https://standards.iteh.ai)
Document Preview

4.5 This guide is not intended to replace or supersede federal, state, local, or international regulatory requirements. Users of this guide should confirm the regulatory guidance and requirements for the jurisdiction in which they are working. This guide may be used to complement and support such requirements.

4.5.1 This guide may be used by various parties involved at a sediment site, including regulatory agencies, project sponsors, environmental consultants, site remediation professionals, environmental contractors, analytical testing laboratories, data reviewers and users, and other stakeholders.

ASTM E3268-21
https://standards.iteh.ai/catalog/standards/sist/82aa281b-e73d-46eb-8b00-0063.1afbbee/astm-e3268-21

4.5.2 This guide does not replace the need for engaging competent persons to evaluate NAPL emplacement and movement in sediments. Activities described in this guide should be conducted by persons familiar with NAPL-impacted sediment site characterization and remediation techniques, as well as sediment NAPL movement assessment protocols. The users of this guide should consider assembling a team of experienced project professionals with appropriate expertise to scope, plan, and execute sediment NAPL data acquisition activities.

4.6 The user of this guide should review the overall structure and components of this guide before proceeding with use, including the following sections:

4.6.1 Section 1: Scope;

4.6.2 Section 2: Referenced Documents;

4.6.3 Section 3: Terminology;

4.6.4 Section 4: Significance and Use;

4.6.5 Section 5: NAPL Mobility Field Investigation Overview;

4.6.6 Section 6: Sediment Sample Collection Procedures;

4.6.7 Section 7: Sediment Sample Field Characterization;

4.6.8 Section 8: Sediment Sample Handling, Storage, and Transport;

4.6.9 Section 9: Field Methods for Determining Hydraulic Conditions;

4.6.10 Section 10: Keywords;

4.6.11 Appendix X1: Additional Sediment Sample Collection Considerations; and

4.6.12 Appendix X2: Case Study.

5. NAPL Mobility Field Investigation Overview

5.1 *Pre-Investigation Planning:*

5.1.1 Pre-investigation planning and pre-sampling surveys should be considered to help guide sediment characterization activities. Pre-investigation planning typically includes review of fire insurance maps, manufacturing facility infastructure maps, historical aerial photographs, and historical and current municipal sewer records to identify areas on which to focus future investigative efforts. Planning also should consider researching publicly available information about the water body, including bathymetry, tidal information, and gauging stations. If previous sediment investigations have been completed at the site, useful information regarding historical contaminant distribution, viable sample collection methods, and historical releases/source of impacts can also be obtained.

5.1.2 Pre-sampling survey activities should include documentation of water column depth (using methods presented in Appendix X1); the thickness of soft sediment and presence of rocks/debris (for example, by probing sediment with a pole) may also be obtained. Additional information regarding the potential for NAPL presence may also be qualitatively assessed by identification of outfall locations, sheens on surface water, and sheens generated from prodding sediment with a pole. These field observations may be combined with historical records to develop a sampling strategy.

5.2 *NAPL Distribution Investigations and NAPL Movement Evaluations:*

5.2.1 Sediment sample collection methodologies will evolve as the CSM is refined. A summary of typical sediment sample collection methodologies is included in Section 6. Initial characterization typically focuses on identifying the lateral and vertical distribution of NAPL. Accordingly, direct sediment sample collection methods that allow for logging sediment grain size and assessing NAPL presence or absence in the field (using visual observations or shake tests, or both) are often used. In addition to direct sampling collection methods, indirect methods are often useful to characterize the NAPL extent and distribution during initial investigations. A site-specific evaluation of the viability of indirect methods to improve the accuracy and efficiency of NAPL distribution investigations should be completed prior to the full-scale implementation of the field program.

5.2.2 Once a preliminary understanding of NAPL distribution has been developed, subsequent characterization typically focuses on understanding NAPL body continuity, NAPL emplacement, and the potential for NAPL movement (that is, NAPL pore scale mobility potential and NAPL body scale migration potential). Accordingly, methods to collect undisturbed sediment samples are generally required. During NAPL movement investigations, collecting multiple samples at the same interval (that is, samples from the same elevation with similar stratigraphy), by offsetting multiple collocated cores from one another, may be advantageous. The advantages of this approach include assessment of NAPL continuity between adjacent cores, the ability to complete multiple pore scale mobility tests on the same interval, and the ability to evaluate supplemental NAPL mobility or migration parameters, or both. Prior to collecting samples from multiple cores, thoughtful planning should be completed, with particular focus on sample documentation, chain-of-custody management, and applicable hold times, as well as the location, orientation, and temperature of sample storage. As part of NAPL movement evaluations, characterization of supplemental parameters to inform NAPL body scale migration conditions are also typically completed or refined, as discussed in 5.3.

iTeh Standards
(https://standards.iteh.ai)
Document Preview
ASTM E3268-21

5.3 *NAPL Emplacement Field Investigations:*

5.3.1 Sediment sampling with subsequent field characterization and laboratory analysis is a critical component of developing a NAPL Conceptual Model and the primary focus of this guide. Guide E3248 describes the importance of supplemental field characterization data to evaluate NAPL emplacement. In addition to sediment sampling, secondary field characterization data typically needed to assess NAPL emplacement includes bathymetry/topography, energy of the environment, water quality/salinity, groundwater elevation, surface water elevation, and tidal conditions. Refer to Guide E3164 for guidance on secondary field data collection procedures to inform NAPL emplacement evaluations. A case study using field investigation results to draw some preliminary conclusions about the NAPL emplacement mechanism at a site is presented in Appendix X2.

5.4 *Field Assessment of Hydraulic Conditions:*

5.4.1 Understanding the hydraulic conditions at a sediment site is critical to select pore scale mobility test conditions and to inform NAPL body scale migration evaluations. Developing a preliminary understanding of site-wide hydraulic conditions (including groundwater and surface water elevations, hydraulic conductivity, and hydraulic gradients) is generally recommended during the initial phase of sediment characterization. Depending on the scale of the site, additional focused assessment of hydraulic conditions (for example, seepage, groundwater exchange, and location/magnitude of upwelling) may be completed at later phases of characterization, with the goal of informing NAPL body scale migration evaluations. A summary of field methods to assess hydraulic conditions is included in Section 9.

6. Sediment Sample Collection Procedures

6.1 *Direct Sediment Sampling:*

6.1.1 *Surface Grab Sampling Methods:*

iTeh Standards (https://standards.iteh.ai) Document Preview

6.1.1.1 Although employed less frequently than core sampling methods, surface grab sampling devices, such as ponar samplers, are occasionally selected to sample NAPL-impacted surface sediment. Identification of surface grab sampling devices, along with corresponding advantages and limitations, is provided in Guide E1391.

6.1.2 *Core Sampling Methods:*

ASTM E3268-21

6.1.2.1 Core sampling is widely used at NAPL-impacted sediment sites to support characterization, including stratigraphic logging, laboratory testing, and NAPL movement evaluations. Table 1 summarizes typical sediment coring methods and presents selection criteria to choose the optimal coring method for use at a NAPL-impacted sediment site.

6.1.3 *Core Liners:*

6.1.3.1 Incorporating core liners is required if collecting undisturbed samples for NAPL-impacted sediment investigations or NAPL movement evaluations, or both. The core methods in Table 1 either rely on a core liner as an integral part of sample collection or can be modified to incorporate core liners. Typical core liner materials include aluminum, mild steel, stainless steel, and rigid plastic. When selecting a core liner, consideration should be given to the compatibility of the liner material with suspected contaminants (for example, potential incompatibility of some types of NAPL with polycarbonate liner) and to the ease with which samples can be obtained from the liner. If pore scale mobility testing is anticipated, consultation with the testing laboratory is recommended to ensure that the liner type and diameter used are compatible with the test apparatus.

TABLE 1 Summary of Coring Methods

Coring/Sampling Method	Brief Description	Typical Target Depths into Sediment (meters)	Advantages	Limitations/ Difficulties	Reference Standard
Punch (aka Push)	Open-barrel sampler, typically advanced with manually operated tooling (fence post driver).	0–1	No mechanical equipment; well suited for low accessibility areas.	Overcoming friction with manual extraction; penetrating dense deposits (cohesive clay and sand/gravel); water depths greater than approximately 2 m.	Guide D4823
Piston	Typically, a punch core with a piston seal fixed to the top of the sample interval. Occasionally incorporated into other methods.	0–1	Similar to punch core; however, a suspension cable is typically attached to a fixed point on sample vessel; the use of piston results in a vacuum to enhance core recovery.	Same as punch core.	Guide D4823
Vibratory-Driven (also known as Vibracore)	Open-barrel sampler affixed to the weighted head. High-frequency vibration of the weighted head advances barrel into the sediment. Method lacks outer casing and penetration is limited to barrel length.	0–4	Continuous sampling of entire length in a single push; ability to penetrate soft sediment, sand, small-diameter gravel; comparatively high production rates.	Water depths greater than approximately 4 m; vibrations may cause a realignment of sediment grains, particularly in soft sediment; inconsistent success in penetrating dense clay.	Guide D4823
Sonic	Drill-bit and core barrel advanced into the sediment by a drill head that applies high-frequency vibration aided with direct push and rotation. The method includes outer casing to maintain borehole integrity.	0–25+	Capable of continuous or intermittent sampling; suitable for nearly all subsurface materials, including rock; comparatively high production rates; most sonic rigs are multi-functional (thin-walled sampler, lined core-barrel advanced via direct push, etc.).	Vibrations may cause a realignment of sediment grains, particularly in soft sediment.	Practice D6914/D6914M
~~**Thin-Walled Sampler (Shelby Tube®[A])**~~	~~Hollow metal tube advanced into sediment via steady pressure from drill rig (sonic, direct push, or hollow-stem).~~	~~Dependent on equipment used to deploy.~~	~~Consensus as the most undisturbed sampling method; suitable in fine-grained soil.~~	~~Practice D1587 does not recommend use for coarse sand, gravel, or very hard soil; thin-walled samplers are typically 0.6 m long, limiting production rate.~~	~~Practice D1587~~
Thin-Walled Sampler (Shelby Tube®[A])	Hollow metal tube advanced into sediment via steady pressure from drill rig (sonic, direct push, or hollow-stem).	Dependent on equipment used to deploy.	Consensus as the most undisturbed sampling method; suitable in fine-grained sediment.	Practice D1587 does not recommend use for coarse sand, gravel, or very hard sediment; thin-walled samplers are typically 0.6 m long, limiting production rate.	Practice D1587
Direct Push	Cutting shoe and core barrel with interior liner advanced into sediment via static pressure or impact hammer. Experience indicates dual-tube systems are preferred in sediment environments to maintain borehole integrity.	0–15	Capable of continuous or intermittent sampling; able to penetrate most unconsolidated sediment; most direct push drill rigs are multi-functional (thin-walled sampler and vibratory options).	Sample diameter typically less than 7.5 cm, limiting sample volume; difficulty penetrating dense deposits (cohesive clay and rock).	Guide D6282/D6282M
Hollow-Stem Auger with Split-Barrel Sampler	Cylindrical hollow tube with helical fluting. Coupled with split-barrel samplers advanced into the sediment by hammering with a constant weight. Auger flights provide outer casing to maintain borehole integrity.	0–25	Capable of continuous or intermittent sampling; ability to penetrate most unconsolidated sediment; rig suitable for thin-walled sampling.	Comparatively low production rate; generally unable to penetrate dense clay or rock; low recovery of non-cohesive sediment.	Practice D6151

[A] Trademarked by Shelby Steel Tube Company.

iTeh Standards
(https://standards.iteh.ai)
Document Preview
ASTM E3268-21
https://standards.iteh.ai/catalog/standards/sist/82aa281b-c73d-46eb-8b0…astm-e3268-21

6.1.4 *Thin-Walled Sampling Methods:*

6.1.4.1 Thin-walled sampling is the industry standard to collect undisturbed samples in upland sites; however, obtaining adequate recovery ratios in soft sediment with a thin-walled sampler may be impractical. In situations where an undisturbed sample is necessary, thin-walled sampling should be attempted to assess site-specific viability. If thin-walled sampling proves to be impractical, push methods (punch core, piston core, direct push/sonic with static pressure only) should be considered. If push-based methods are shown to be impractical, the use of rotary or vibratory methods, or both may be required.

6.1.5 *Non-Thin-Walled Sampling Methods:*

6.1.5.1 If non-thin-walled sampling methods are used to collect an undisturbed core, the integrity of the core should be evaluated, because most other methods may disturb or mix the sample during collection. Once collected, subsampling along the top, bottom, and the walls of the core should be avoided. Field methods used to evaluate the potential magnitude of core disturbance are outlined in Guide D6169.

6.1.6 *Core Catchers:*

6.1.6.1 Core catchers may be incorporated into coring methods to improve recovery ratios for non-thin-walled sampling methods. Their use is a relevant consideration in non-cohesive materials (that is, sand and unconsolidated silt). Core catchers that are typically used in sediment sampling are identified in Guide D4823. Although core catchers aid in improving sample recovery ratios, these devices may also increase core disturbance. If an undisturbed sample is required, other recommendations outlined in Appendix X1 should be attempted prior to using a core catcher.

6.2 *Indirect Methods:*

iTeh Standards
(https://standards.iteh.ai)
Document Preview

6.2.1 Indirect sampling methods for assessing NAPL presence or absence are typically used during the initial phase of NAPL distribution investigations, because these tools can offer advantages in reduced costs and increased efficiency compared to traditional sediment coring and logging. During later phases of investigation, select indirect tools have also been employed to semi-quantitatively estimate the magnitude (for example, saturation, concentration) of NAPL present, based on a well-developed, site-specific correlation between the output of the tool and field observations or laboratory testing, or a combination thereof. In some cases, sediment core observations and results from indirect methods are well-correlated. Development of a correlation between the indirect method and the field observations or laboratory testing, or both may not be useful or practical for all sites. A summary of indirect methods is included in Table 2, along with a summary of the advantages and limitations for each method.

ASTM E3268-21
https://standards.iteh.ai/catalog/standards/sist/82aa281b-c73d-46eb-8b09-09fa31afbbee/astm-e3268-21

6.3 *Additional Sample Collection Considerations:*

6.3.1 Collecting minimally disturbed sediment cores for the integrity of pore scale NAPL mobility testing (performed as part of a NAPL movement evaluation) is a primary focus of this guide. Other important considerations for NAPL mobility sediment sampling that are shared with traditional sediment sampling methods are summarized in Appendix X1.

7. Sediment Sample Field Characterization

7.1 This section describes field characterization methods to evaluate the presence of NAPL in sediment cores. These methods provide qualitative and quantitative data on the presence of NAPL. The data can be used to make field decisions on which samples to analyze and help develop a CSM.

7.2 *Visual Observation Methods:*

7.2.1 This section describes visual observation methods to evaluate the presence of NAPL in sediment cores. The visual observation results will be used primarily to understand the spatial distribution of NAPL or to select samples for laboratory analysis, or both. It is important that all stakeholders understand that visual observations from the following methods cannot be used to make a determination about NAPL mobility or migration.

7.2.2 *Stratification Observation:*

7.2.2.1 Sediment coring, in conjunction with the identification of NAPL stratification, documents NAPL presence. The location

TABLE 2 Summary of Indirect Methods

Sampling Method	Brief Description	Typical Constituents	Typical Target Depths (meters)	Advantages	Limitations
Solid Phase Extraction, Laser-Induced Fluorescence (DART®)[A]	Rod coated with solid-phase extraction media, onto which PAHs adsorb for future laser-induced fluorescence (LIF) logging.	NAPL containing PAHs.	0–2	Capable of being deployed with no mechanical equipment; well-suited for shoreline/marsh.	Rod must equilibrate for hours or days before extraction; analysis is performed at lab, delaying real-time decisions. Potential for disturbance of sediment.
Laser-Induced Fluorescence[B]	Logs a vertical profile of the magnitude of target constituents (for example, PAHs) fluorescence that results from pulses of laser light.	Instrument dependent. Variations of LIF are suitable for petroleum-based NAPL (UVOST®[C]), coal tar/creosote-based NAPL (TarGOST®[C]), and chlorinated-solvent-based NAPL (DyeLIF®[C]).	0–15	Higher production rate; continuous logging not affected by recovery considerations; semi-quantitative results allow for correlations to other parameters.	Unable to penetrate debris or highly dense material; naturally fluorescing materials (that is, calcite-based shells) may complicate interpretation of results; energy transfer problems in fine-grained sediment; potential for disturbance of sediment.
~~**Porewater Samplers (Guide E1391)**~~	~~Temporary screens, diffusive samplers, passive samplers, or similar tools, used to collect a sample of porewater for laboratory analysis.~~	~~NAPL composed of soluble factions (for example, volatile organic compounds and lighter PAHs).~~	~~0–1~~	~~Elevated laboratory porewater concentrations may be used as a potential indicator of NAPL; may be used to develop a correlation between NAPL presence and porewater concentrations.~~	~~Composite of sample interval; requires laboratory analysis for interpretation; potential for disturbance of sediment.~~
Porewater Samplers (Guide E1391)	Temporary screens, diffusive samplers, passive samplers, or similar tools, used to collect a sample of porewater for laboratory analysis.	NAPL composed of soluble factions (for example, volatile organic compounds and lower molecular weight PAHs).	0–1	Elevated laboratory porewater concentrations may be used as a potential indicator of NAPL; may be used to develop a correlation between NAPL presence and porewater concentrations.	Composite of sample interval; requires laboratory analysis for interpretation; potential for disturbance of sediment.

[A] http://www.dakotatechnologies.com/products/darts
[B] https://clu-in.org/characterization/technologies/lif.cfm
[C] Trademarked by Dakota Technologies.

iTeh Standards (https://standards.iteh.ai) Document Preview ASTM E3268-21 https://standards.iteh.ai/catalog/standards/sist/82aa281b-c73d-46eb-8b09-09fa31afbbee/astm-e3268-21

of NAPL and the NAPL characteristics can be used in updating the CSM and evaluating NAPL mobility. Practice D2488 presents methods for soil (and sediment) descriptions. A standard method for the description of NAPL should be used to ensure consistency among field staff and between sampling events. A well-defined logging procedure at the beginning of the project will allow for the comparison of observations between phases of investigations. Based on the NAPL stratification, samples can be selected for analysis.

7.2.3 *Shake Tests:*

7.2.3.1 Sediments are often dark in color, making it difficult to observe small amounts of NAPL in the sediment, so a shake test is performed to provide qualitative information about the presence or absence of NAPL in a sediment sample. The shake test method is based on USEPA Method 1617 (**2**) and the Maine Department of Environmental Protection SOP TS004 (**3**). An aliquot of sediment is placed in a wide-mouth bottle with distilled water. The bottle is shaken to disaggregate the sediment matrix and mix the sediment and water. The sediment is allowed to settle. The surface of the water is observed for a separate phase. To maintain consistency in the shake tests, a standard set of descriptions should be used for the results (for example, no sheen, trace sheen, heavy sheen, oil blebs, oil layer). Each description should document the approximate percentage of coverage of the surface water with NAPL.

7.2.3.2 Shake tests provide qualitative information about the potential presence or absence of NAPL in the sediment. Shake tests are typically performed to assist in field decisions on which samples to submit to the laboratory for pore scale NAPL mobility testing or chemical analysis, or both, and which samples to archive. The shake test agitates and disaggregates the sediment, liberating NAPL that may not be mobile under *in situ* conditions. The shake test also may liberate natural organic sheen, which is not indicative of NAPL. Thus, observation of a sheen is not definitive proof of the presence of NAPL in the sample. However, the observation of NAPL blebs or layers does confirm the presence of NAPL in the sample. A shake test result may form a layer of NAPL on the water surface (typically LNAPL) or coat the walls of the shake test jar (typically DNAPL). The density of NAPL should not be informed by a shake test observation, but rather determined by a laboratory measurement.

7.2.3.3 A positive result that is observed from a shake test should not be interpreted as the presence of NAPL that is mobile at the pore scale or migrating at the NAPL body scale. Shake tests provide no information on NAPL mobility or migration (the matrix is totally disrupted and disaggregated in the testing procedure); these results only give an indication of the presence or absence of NAPL in the sediment sample.

7.2.4 *UV Light Observation:*

7.2.4.1 UV light observation may provide qualitative detection of NAPL in the sediment. Polycyclic aromatic hydrocarbons (PAHs), which are constituents of petroleum hydrocarbons and coal tars, will fluoresce under excitation by UV light. The color and intensity of fluorescence provide information on the composition and distribution of NAPL within the sediment. Since NAPL can be difficult to visually identify in darkly colored sediments, UV light can provide information on the presence, distribution, and composition of NAPL within the sediment. It does not provide information on NAPL mobility or migration. False positives may occur, because certain minerals and organic material will fluoresce at the same wavelength as NAPL that contains PAHs.

7.2.5 *NAPL FLUTe™:*

7.2.5.1 NAPL flexible liner underground technologies (FLUTe™) is a color-reactive hydrophobic fabric. NAPL wicks through the material and dissolves the dye stripes on one side of the material. The NAPL carries the dye to the back side of the material. The stain on the back side of the material identifies the presence of NAPL. NAPL FLUTe™ responds to various refined petroleum products and creosote.

iTeh Standards
(https://standards.iteh.ai)
Document Preview

7.2.5.2 NAPL FLUTe™ has been pressed against sediment cores to evaluate the presence of the NAPL in the core. The result can be used to select sediment samples for laboratory testing for NAPL mobility at the pore scale and to revise the CSM. However, standard procedures for the application of NAPL FLUTe with sediment cores have not been developed.

7.3 *Headspace Vapor Monitoring:*

ASTM E3268-21
https://standards.iteh.ai/catalog/standards/sist/82ee781b-c73d-46e0-8b09-09fa31afbbee/astm-e3268-21

7.3.1 Headspace monitoring is performed to evaluate the presence of volatile organic compound vapors in sediment. In conjunction with other methods, the results of vapor monitoring may further support the presence of volatile constituents within NAPL. Headspace monitoring is described in Practice D7203.

8. Sediment Sample Handling, Storage, and Transport

8.1 This section describes sample handling of NAPL-impacted sediment cores collected for geotechnical measurement or laboratory testing associated with NAPL movement evaluations where undisturbed or minimally disturbed sample cores are necessary for testing.

8.1.1 As cited in Guide E3163, three common physical property tests require minimally undisturbed samples: bulk density (Test Methods D2937 and D7263; (**4**)), porosity (Test Methods D854; (**4**)) and hydraulic conductivity (Test Methods D5084; (**5**)). Laboratory tests for capillary pressure analyses (Test Methods D6836) and NAPL mobility (Test Method D425) also require minimally disturbed samples.

8.1.2 Physical property tests not requiring undisturbed cores include grain (particle) size distribution (gradation) of materials using sieve analysis (Test Methods D6913/D6913M and D4464), grain (particle) size distribution (gradation) of fine-grained materials using sedimentation (hydrometer) analysis (Test Method D7928), water content (Test Method D2216), Atterberg Limits (Test Method D4318), and sediment texture classification (Practices D2487 and D2488).

8.2 When collecting, handling, and transporting undisturbed soil cores, it is important to consider how to maintain the pore fluid distribution within the core, preserve the pore structure, and minimize chemical changes within the NAPL.

8.3 In land-based investigations, the freezing of soil cores containing NAPL to ensure fluid retention and retain the general structural integrity of the core during transport and storage has been a common practice in the industry.

8.3.1 Although the practice of freezing NAPL-containing soil cores has been widespread, technical studies to determine the implications of the process have been limited. The majority of investigations regarding the freezing of NAPL-impacted soils have focused on how these have affected the oil-water-ice-soil interaction and how freeze-thaw conditions may be affected by the presence of NAPL (**6, 7, 8**).

8.3.2 The results of these studies have documented a broad range of responses to the NAPL-water-ice-soil distribution, ranging from minimal to no effect on the soil characteristics, to inducing NAPL redistribution within the pore network. The variability in these results reflects the complex conditions within the NAPL-water-ice-soil mixture.

8.3.2.1 Ice formation associated with freezing is a concern, because the formation of ice from water induces a volumetric increase in the water phase of approximately 9 %. The increase may disturb the sediment pore structure and influence the distribution of NAPL within the sample. Professional judgment should be used in the decision to freeze or not to freeze sediment samples. It is recommended that a trial freezing be performed on a spare core sample in the field prior to deciding whether to freeze samples for mobility testing.

8.3.3 Compared to soils, fine-grained and organic sediments commonly have a higher water content and are more loosely consolidated. As such, the potential effects of freezing of sediment cores are larger than when freezing upland soils or sandy sediments. Water content of fine-textured sediments may range from ~~40~~40 % to 75 % on a wet mass basis, so a volumetric increase of 9 % may produce a considerable change in the pore structure of the sediment. For example, a ~~5-ft-long~~ 1.5 m long sediment core with a water content of 62 % contained within a ~~3-in.-diameter~~ 7.6 cm diameter core barrel could increase in length by up to ~~3.2 in.~~8.1 cm. upon freezing, while a similar core of upland soil with a water content of 18 % could increase in length by less than ~~1 in.~~2.5 cm upon freezing.

8.3.3.1 The unconsolidated nature of sediments may also pose difficulties for unfrozen samples, particularly in transport and sample preparation, as noted in 8.5 and 8.6. It is not uncommon for fluids to drain from core tubes after collection, and freezing will mitigate these impacts.

iTeh Standards
(https://standards.iteh.ai)
Document Preview
ASTM E3268-21

8.3.4 The freezing of NAPL may produce chemical changes within this phase. Although the NAPL phase will not crystallize, the NAPL will increase in viscosity. For middle distillate and heavier hydrocarbons, paraffinic waxes may precipitate upon cooling and freezing (**9**). This may not only affect the composition of the remaining NAPL, but may also affect NAPL entry head pressures and mobility at the pore scale.

8.3.5 The respective benefits and potential impacts of freezing NAPL-impacted sediments require consideration by practitioners involved in sediment characterization, risk evaluation, and remedial programs. The practitioner must evaluate the advantages and disadvantages of sediment freezing relative to the objectives of the investigation.

8.3.5.1 Where the objectives of the study require testing of physical properties related to the minimally disturbed sediment pore structure (that is, bulk density, porosity, and hydraulic conductivity) or pore scale mobility of the NAPL, it should be recognized that freezing may bias the results of these tests. If feasible, a trial freeze-thaw cycle should be performed with site sediments within a core prior to processing all core samples to estimate the impact of freezing. Sample integrity can be evaluated visually or through imaging (for example, CT scans) before and after the freeze-thaw cycle.

8.4 Core sample transport and storage methodologies vary, depending on the size and type of the cores, as well as if the cores will be frozen prior to shipment and processing. Refer to 6.1 for a discussion of the different types of core samples and liners; refer to 8.3 for considerations regarding freezing of the core samples.

8.5 *Preparation of Core Samples for Transport:*

8.5.1 *Orientation*—Efforts should be made to maintain the core in a vertical position until the core is frozen to prevent the movement of sediment or pore fluids within the core. Cores that are not frozen should be maintained in the vertical position for transport and storage.

8.5.1.1 *Shipping Containers*—Frozen cores may be shipped horizontally in a cooler. Large plastic marine ice chests are typically used, which can contain core samples up to about ~~2.5 ft~~0.75 m in length. However, smaller ice chests may be adequate and more convenient in some cases. Unfrozen cores may be cut into small segments and shipped vertically in a cooler, or in larger containers designed to ship larger segments of core. Geotechnical testing laboratories frequently have recommended designs or shipping units that they can supply to the practitioner.