Standard Guide for Collection of Soils and Other Geological Evidence for Criminal Forensic Applications

Geological Materials Subcommittee
Chemistry/Instrumental Analysis Scientific Area Committee
Organization of Scientific Area Committees (OSAC) for Forensic Science

OSAC Proposed Standard

Standard Guide for Collection of Soils and Other Geological Evidence for Criminal Forensic Applications

Prepared by
Geological Materials Subcommittee
Version: 1.0
June 2019

Disclaimer:

This document has been developed by the Geological Materials Subcommittee of the Organization of Scientific Area Committees (OSAC) for Forensic Science through a consensus process and is *proposed* for further development through a Standard Developing Organization (SDO). This document is being made available so that the forensic science community and interested parties can consider the recommendations of the OSAC pertaining to applicable forensic science practices. The document was developed with input from experts in a broad array of forensic science disciplines as well as scientific research, measurement science, statistics, law, and policy.

This document has not been published by an SDO. Its contents are subject to change during the standards development process. All interested groups or individuals are strongly encouraged to submit comments on this proposed document during the open comment period administered by ASTM International (www.astm.org).

Standard Guide for Collection of Soils and Other Geological Evidence for Criminal Forensic Applications

1. Scope

1.1 This is a guide for the documentation, collection, and preservation of soil and other geological evidence for use in criminal investigations. Sampling for environmental geology is outside of its scope. It is designed as a resource for professionals whose job responsibilities include the collection and preservation of soil evidence and for forensic scientists to enable them to advise crime scene investigators.

1.2 *Units* - The values stated in SI units are to be regarded as the standard. Non-SI units are also included for the convenience of the guide user.

1.3 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 and health practices and determine the applicability of regulatory limitations prior to use.

2. Referenced Documents

2.1 *ASTM Standards*[1]:

D6966 − 13 Standard Practice for Collection of Settled Dust Samples Using Wipe Sampling Methods for Subsequent Determination of Metals

D7296 – 12 Standard Practice for Collection of Settled Dust Samples Using Dry Wipe Sampling Methods for Subsequent Determination of Beryllium and Compounds

D7659 – 10 Standard Guide for Strategies for Surface Sampling of Metals and Metalloids for Worker Protection

[1] 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.

D7144 –05a Collection of Surface Dust by Micro-vacuum Sampling for Subsequent Metals Determination

D5755 – 09 Microvacuum Sampling and Indirect Analysis of Dust by Transmission Electron Microscopy for Asbestos Structure Number Surface Loading

D5756 – 02 Microvacuum Sampling and Indirect Analysis of Dust by Transmission Electron Microscopy for Asbestos Mass Surface Loading

E1188 − 11 Standard Practice for Collection and Preservation of Information and Physical Items by a Technical Investigator

E1459 − 13 Standard Guide for Physical Evidence Labeling and Related Documentation

3. Terminology

3.1 *Definitions:* For definitions of terms not listed in Section 3 see the OSAC Lexicon (**1**)[2].

3.2 *Definitions of terms specific to this guideline*:

3.2.1 *aggregate(s) [clump(s)]*, n – a group of soil particles that cohere to each other more strongly than to other surrounding particles (**2**).

3.2.2 *alibi location(s)*, n – a known source of soil and/or other geological material, suggested by or linked to a subject (e.g., locations at a subject's home) and distinct from the crime scene.

3.2.3 *soil*, n – sediments or other unconsolidated accumulations of solid particles (e.g., minerals and organic matter) that are produced by the physical, chemical, and biological disintegration of parent material and/or which has the ability to support rooted plants in a natural environment; and which may or may not include manufactured materials (adapted from **2**).

3.2.4 *soil horizon*, n – a layer of soil or soil material approximately parallel to the land surface and differing from adjacent genetically related layers in physical, chemical, and biological properties or characteristics such as color, structure, texture, consistency, kinds and numbers of organisms present, degree of acidity or alkalinity, etc. (**2**).

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

3.2.5 *soil core sampler [soil corer; soil probe]*, n – a device used to collect virtually undisturbed sub-surface soil samples for documenting a soil profile and for environmental investigations

3.2.6 *soil profile*, n – a vertical section of soil exposed from the ground surface to a depth of interest. A soil profile may be observed in a freshly dug pit, along a road bank, or in many other places (**2**).

3.2.7 *questioned sample* - An item located at a crime scene of undetermined origin, that is analyzed in an attempt to identify or associate it with a known exemplar or sample. (adapted from **1**).

Discussion of questioned soil sample – Soil evidence of unknown origin, or questioned soil sample, typically consists of: debris adhering to an evidentiary object (tire, wheel well, garment, shoe, digging tool); foreign soil left at a crime scene (transferred from a shoe/tire, or adhering to a re-buried body/object); or debris recovered from within a body (nasal, stomach or lung contents).

3.2.8 *known sample* - Of established origin associated with the matter under investigation (**1**).

Discussion known soil sample – Known soil samples are intentionally collected, typically from crime scene or alibi locations, for comparison to a questioned soil sample. Soils are heterogeneous mixtures of organic matter and minerals that vary with depth and across the landscape.

4. Significance and Use

4.1 This guide describes the goals and techniques for the collection of soils in criminal forensic investigations. Examples of the geological materials encompassed in this document

include: soil, dust, debris, sediment, sand, gravel, etc. These materials are collectively referred to as soils throughout the remainder of this document. This guide describes good practices for the documentation, collection, packaging, and preservation of forensic soils associated with evidence items (e.g., questioned soil samples) and for intentional sampling of soils from known sources that may be compared with the questioned samples (e.g., known soil samples from the crime scene or other site). Individual agencies might use this guide to develop agency-specific procedures regarding the collection of soils for forensic applications. Veneers of fine material or dust may be sampled for forensic geological analysis, but will be fully addressed in a companion document developed under OSAC-Geological Materials; prior to release of this document, ASTM standards for environmental dust collection (D6966 – 13, D7296 – 12, D7659 – 10, D7144 –05a, D5755 – 09, and D5756 – 02) may be adapted for forensic dust collection.

5. Overview of Forensic Soil Samples:

5.1 *Questioned Soil Samples* are soil evidence of unknown origin including: debris adhering to an evidentiary object (tire, wheel well, garment, shoe, digging tool); exogenous or foreign soil left at a crime scene (soil aggregates transferred from a shoe/tire, or adhering to a re-buried body/object); or debris recovered from a body (adhering to skin; beneath finger nails; nasal, stomach or lung contents). Questioned soil samples can have probative value in a criminal investigation and should be collected, aiming to preserve any intact structures or soil aggregates. Questioned soil samples are often very limited in size. Collection of questioned soil samples is similar to collection of other types of trace evidence from crime scenes. *It is preferable to submit soil with the underlying substrate (example: mud-encrusted tire) to the forensic laboratory*, but guidance for removing questioned soils from objects is provided in sections 7.2 to 7.3 for circumstances when submission of the entire object is not feasible.

5.2 *Known Soil Samples* are soil specimens collected from an area of interest, typically a crime scene, grave site, or alibi location, for the purpose of comparison to a questioned soil. Collection of representative known soil samples is significantly more involved than collection of appropriate known exemplars of manufactured materials (glass, paint, tape, etc.) because soils are composed of complex mixtures of particles which usually vary with distance and depth. Known soil samples should be collected to be both relevant to the questioned soil(s) and sufficient in number and spatial coverage to adequately represent the range of possible soil variation within a location of interest. Details of collection of known soils are described in section 8.

6. Collection Tools

6.1 *Collection tool materials*: Tools for forensic soil collection should either be new, disposable items (plastic spoons, swabs, wipes, filters) or non-porous tools, cleaned prior to each use to prevent contamination from either the tool itself or a previously collected sample. Non-disposable tools for softer materials (unconsolidated sand) may be made of plastic, but for harder materials, tools made of hardened or stainless steel are recommended. Examples of some non-disposable tools are shown in FIG. 1. (See section 9.2 for soil evidence packaging materials and recommendations.) In general, tape-lifts are not recommended for soil collection, but to remove thin deposits from porous materials, low-tack tapes can be used. Do not use high tack tapes or those used to lift fingerprints because their strong adhesives prevent soil recovery and analysis (3).

6.2 *Cleaning tools*: In most circumstances, non-disposable tools can be cleaned by rinsing with clean water (ideally deionized or distilled) and dried (preferably with a lint free material). Alcohol, bleach, or other suitable disinfectant solutions such as Virkon, can be used to help with

the decontamination of tools used to collect samples with biological components. Do not re-use tools that cannot be cleaned. Pre-moistened wipes are convenient for cleaning tools during field collections. An item is considered sufficiently clean when no particles are detected on a clean cloth used to wipe the tool.

6.3 *Tools for collection of questioned soils*.

6.3.1 *Tools for collection of small quantities of questioned soils:* Tweezers, forceps, dental picks or palette knives may be used to collect small quantities of soil on an object, or to collect a non-native soil aggregate from a crime scene. A spatula and/or spoon may be used to dislodge soil from materials like upholstery (FIG. 1A).

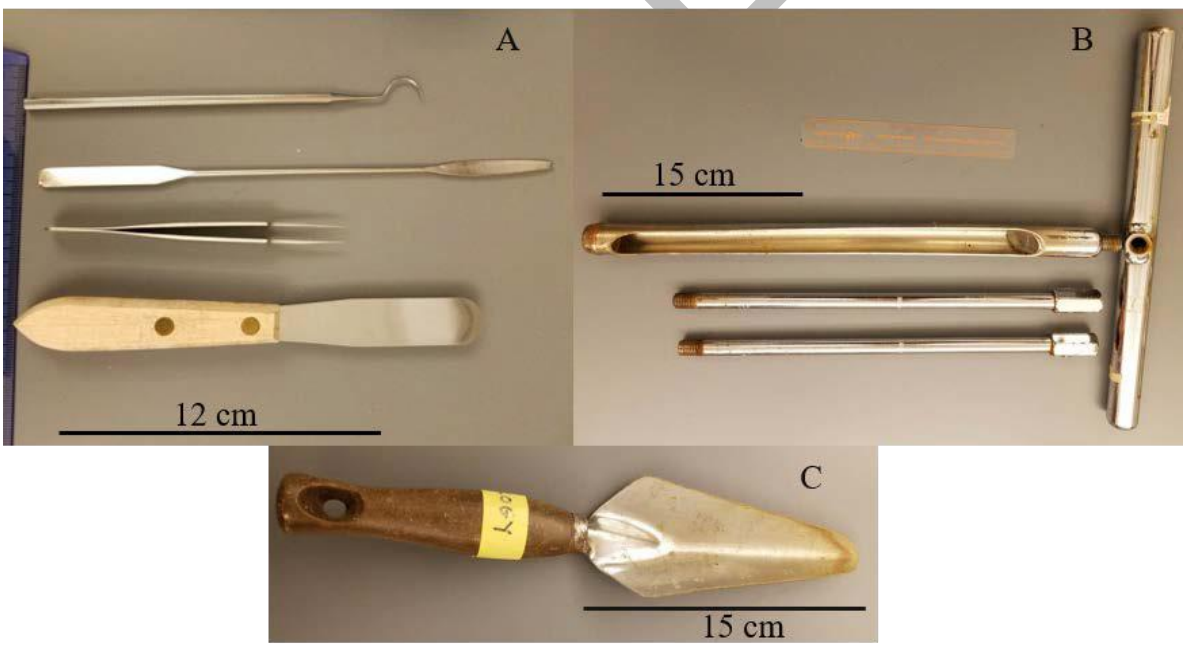

FIG. 1 Some common tools used to collect soil evidence. (A, top to bottom) dental pick, micro-spatula, forceps, and spatula; (B) soil corer (with T-handle and two extension rods); (C) trowel.

6.3.2 *Tools for collection of thin deposits of questioned soil*: To remove thin soil deposits from a non-porous object (example: mud deposited on a wheel well), use: spatulas, ice scrapers, clean/new razor blades, or other flat, suitable implements. Pry or scrape the soil deposit loose,

attempting to keep any soil aggregates intact, and transfer the material into a suitable sample container (9.2.2), onto a clean piece of paper, or onto a clean collection pan. The intention is to keep the questioned soil aggregate intact and to minimize mixing when removing the soil deposit.

6.4 *Tools for collection of known soils*: In most cases known soils are collected to represent the range of soil present at a location. As a result known soils samples tend to be larger than questioned soil samples, requiring larger tools such as garden trowels (FIG. 1C), soils corers (FIG. 1B), picks, pointed (archaeologist's) trowels, spades, or spoons. A soil corer may be used to collect a surface to near-surface soil profile. Smaller tools, such as pallet knives, or tweezers may be used to collect soils from within impressions. Use of a spade is recommended to access soils from sub-surface, but smaller tools are typically used for collection of known soil specimens.

7. Collection of questioned soils

7.1 *Collection of questioned soil on object of interest:* Objects that have soil evidence adhering to them (e.g., shoes, tires, garments) should be collected intact and submitted to the forensic laboratory whenever possible. (See 9.2.4 for packaging of soil adhering to objects.)

7.2 *Removal of questioned soil from non-porous objects when object cannot be submitted intact*: Evidentiary soil may occur on the surfaces and in crevices of objects that cannot be delivered to the laboratory. Special care should be taken to preserve any depositional (structure or layer) characteristics (**4**,**5**). Soil dried on a large hard surface, such as a vehicle, should be pried or scraped off, while trying to preserve intact aggregates which may have layering. See 6.3.2 for collection tools and 9.2.5 for packaging this type of soil evidence.

7.3 *Removal of questioned soil from porous objects when object cannot be submitted intact*: Remove soil from porous surfaces, such as upholstery, by gentle scraping with a spatula or similar tool, taking care to preserve intact soil aggregates. See 6.3.2 for tools and 9.2 for packaging.

7.4 *Foreign soil transferred to a crime scene*: Foreign soil (or soils derived from another location) may be left at a crime inadvertently when the soil material, usually as dried aggregates, falls off of shoes, tires, or vehicles. Evidence collection teams should seek foreign soil aggregates from locations in or near tire tracks and shoe prints. If foreign soil aggregates are found within a shoe or tire impression, soil collection should be done after documentation of the impressions by casting, photography or both. After documentation of the impression evidence, this questioned soil should be collected along with known soils adjacent to and from within the impression. Collect these foreign soil aggregates using a small spoon, pallet knife or tweezers.

7.5 *Questioned soil on or within bodies:* A living crime victim may have soils on or within them (under fingernails, on skin, within nasal cavities, or within the vagina); these soils would typically be collected by a medical professional so they are beyond the scope of this document. Questioned soil samples associated with a corpse, in particular those soils recovered from within a body, are often recovered by a medical examiner or coroner. But evidence collection professionals may encounter soil on a body or its garments which are exotic to the body recovery site. These soils may be probative as indications of the prior locations of the victim either pre- or post-mortem. If permitted, exotic soils should be collected and preserved prior to removal of the body from the recovery location. It is important to collect additional known soils from the body recovery location as elimination samples (8.4.1.1). If soil cannot be collected from a body prior to its removal from the scene, then any visible soil evidence should be documented

photographically, and appropriate personnel (medical examiners) should be contacted about the need to preserve the soil evidence.

8. Collection of known soils:

Known or reference soil samples are purposefully collected to represent the range of soil characteristics at a crime scene or alibi location to enable a forensic soil examiner to compare a questioned soil to the known soils and conclude if it is possible that the questioned soil could have originated from the same source as the known soil(s). Known soils may also be collected as reference materials in a soil provenance investigation, but the collection strategies described here are primarily aimed at collection for soil comparisons.

8.1 *Surface versus sub-surface origin of questioned soils*: It is important to try to determine if the questioned soil is derived from a surface or sub-surface soil source. For example, soil on a shovel may have originated from soil from beneath the surface, whereas soil on a shoe or garment is likely to be derived from soil at the ground surface. Prior knowledge of the nature of the questioned soil evidence and the crime scene will affect the types of known soil samples collected. Unless there is prior knowledge that the source of a questioned soil may be from burial sites, holes, river banks, cut banks, or deep tracks or ruts, collection of known surface, rather than sub-surface, soils is recommended. (See 8.5 for surface soil collection and 8.6 for sub-surface soil collections.)

8.2 *Background information***:** Acquire background information prior to the collection of known soil samples to aid in the selection of appropriate known soils samples. The types of background information that can be gathered include: case information (for example: is digging relevant?; is it known where the suspect/vehicle may have been walking/driving?), soil survey information, geological survey information, appropriate maps (including geo-political,

topographical, road, vegetation, land cover, geological, and soil survey maps), and the exact location where the questioned sample was collected, including geographic (GPS) coordinates or equivalent such as total-station or orthogonal drone imagery.

8.3 *Minimizing environmental alteration***:** Soil evidence and other related materials (such as botanical evidence) may be subject to environmental alteration or degradation over time (**3**). For this reason, known soil samples should be collected and preserved as early as possible in the course of an investigation. This does not preclude the possibility of collecting additional samples at a later date, but it should be noted that these samples may not represent the materials that were present at the time of the crime.

8.4 *Known soil sample volume*: When possible, collect at least 2 – 3 tablespoons (~30 ml) per sample. Coarse-grained and/or lower density materials, such as gravel, pebbles, or soils with high botanical content may require a significantly larger sample volume/size. If objects or features larger than approximately 2 mm (or about 1/8 inch) are present, attempt to collect a volume of soil that is at least 10 times larger in its linear dimensions than the largest grain or feature. For example, if soil has 4 mm diameter grains, collect sample volume greater than ~40 mm x 40 mm x 40 mm, or 64 ml, or about a quarter cup.

8.4.1 *Number of known soil samples to collect*: The number of known soils samples to collect is case- and scene-dependent. While there is no specific minimum number of samples that must be collected, some authors have made recommendations regarding appropriate sample numbers (**6,11**). In general, it is recommended to collect a greater number of samples rather than fewer, with typically 3 to 20 known soil samples collected depending on the site details.

8.4.1.1 *Collection of elimination soils:* Known soils from locations, which are not presumed to be a likely source of a questioned soil, are important for elimination purposes. Example 1:

When a digging tool is recovered from a suspect's home for comparison to a distant burial site, elimination soils from the suspect's yard should be collected as elimination samples, because if these elimination samples are similar to the soil on the digging tool the yard must be included as a possible soil source. Example 2: When a crime victim has soil on their trousers, collect an elimination soil from the victim recovery location to allow comparison to the soiled trousers to allow elimination of the recovery site as source of the soil.

8.5 Collection of known surface soil samples:

8.5.1 *Strategies for collection of known surface soils:* When collecting known soils from a location, there are several different strategies which can be employed. The particular strategy used will depend upon case circumstances. The strategies in 8.5.1.1 to 8.5.1.3 describe where to collect surface soils from an area of interest (crime scene or alibi location) to represent the soil variability. (See 8.6 for details about sampling sub-surface soils.)

8.5.1.1 *PURPOSEFUL*: Collection of known surface soils from identified areas of interest is a purposeful collection strategy. Such specific areas of interest may include areas of entry, areas of egress, burial sites, areas of disturbance, footwear or tire impressions, areas with visual (texture or color) similarities to questioned samples, or areas with anomalous appearances relative to the surrounding materials. If background information (section 8.2) indicates soil variation within the area of interest, intentional collection of soils representing each soil type is recommended (FIG. 2). For additional examples of this type of collection, see (**4, 6-8**).

8.5.1.2 *SYSTEMATIC*: This approach is a pattern-based technique for the collection of samples. A variety of patterns can be used, to include grids, circular patterns, compass points, etc. (**7,9,10**). This technique may be of value when there are no obvious features from which to sample (e.g., looking for a burial site or buried object) or for sampling around a single object of

interest (such as a body) when no other features (such as shoeprints or tire impressions) are present. Example: If suspects claim that the soil on their shoes came from somewhere in their backyard, and the yard is featureless, a systematic sampling approach may be warranted (FIG. 2).

8.5.1.3 *COMBINATION*: Many cases may benefit from a combined approach including both purposeful and systematic sampling techniques (FIG. 2). When processing a crime scene, a systematic approach to sampling minimizes individual bias and ensures that soils will be collected from a wide range of locations at the scene. However, purposeful sampling ensures that soil sample from important features not included in the systematic approach (such as likely paths of entry and egress) are also collected (7).

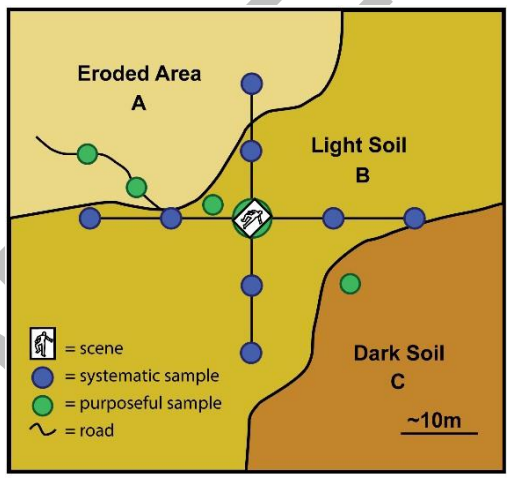

FIG. 2 Example of a combination of purposeful sampling (green circles) along a road and other areas of interest combined with systematic sampling (blue circles) around a crime scene.

8.5.2 Site- or Case-specific consideration for known surface soil sampling

8.5.2.1 *Sampling known surface soils within low variability sites*: In locations with no or low visually apparent soil variability, a number of samples should be collected in order to encompass potential variations within the soil at the site. Changes in vegetation or topography (slope position) often are associated with changes in soil characteristics, so these features may be used to guide the collection locations.

8.5.2.2 *Sampling known surface soils within high variability sites*: High levels of visual variability in a location may require the collection of a larger number of samples to capture the full range of variability present at the site. This soil spatial variability could arise from natural variations or from land-use and landscaping.

8.5.2.3 *Sampling known surface soils within complex scenes*: Complex crime scenes will require collection of a large number of known soil samples. A crime scene may have complexity arising from multiple people or vehicles leaving impressions in the soil or from other case-information indicating a large number of points of interest. When a distinct impression is present, samples should be collected from an area as close as possible to the impression (**7**). Once the impression has been documented/photographed/cast, samples can also be collected from within the area of the impression (sidewalls and floor). If necessary, to avoid any remaining casting material, collections can be made from the areas adjacent to the impression as well.

8.5.3 *Depth of collection of known surface soils:* Collect the from the surface to approximately 1 – 2 cm (1/2 to 3/4 inch) depth or to the depth of any existing impressions or features of interest, such as tire track or shoe prints (**8**).

8.6 ***Collection of known sub-surface soils*:** Soils vary with depth. Variations may be visual (color, structure, and texture) or compositional (chemical, mineralogical, physical, biological, etc.). Therefore, in locations where soil has been removed from below the surface, including, but not limited to: burial sites, holes, river banks, cut banks, deep tracks, or ruts, known soil collections should be made to encompass any variability present with increasing depth (**5**) (FIG. 3). Sub-surface soils typically should be collected from undisturbed soil horizons (8.6.3.2).

8.6.1 *Safety concerns for sub-surface soil sampling*: When digging with a spade or soil corer, consider regulations for avoiding underground hazards, like utility lines (**13**) and when excavations exceed 1.52m (5 feet) follow guidelines to avoid cave-ins (**14**).

8.6.2 *Selection of known sub-surface soils to represent soil variation with depth:* Because soil properties change with depth, known soil samples from various depths should be collected and packaged individually (FIG. 3 and FIG. 4).

8.6.2.1 *When differences can be observed between different soil horizons*, each horizon should be collected as separate known soil samples (right side of FIG. 4, FIG. 5).

8.6.2.2 *When no visually distinct layers are present*: a systematic sampling technique is recommended to make collections throughout the depth of the hole. Samples should be collected at regular intervals of approximately 15 - 30 cm (6 to 12 inches) from the greatest depth from which soil may have been transferred to the item of evidence.

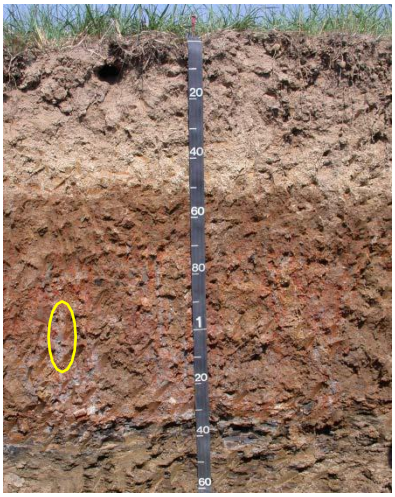

FIG. 3 An example of a soil pit with visually distinct horizons. During sampling, areas of potential mixing, such as the gray-colored krotovina (indicated by the oval) caused by crawfish burrows observed within the red-brown layer just above the shale level, should sampled separately for the adjacent material. Photograph courtesy of Dr. Brad Lee.

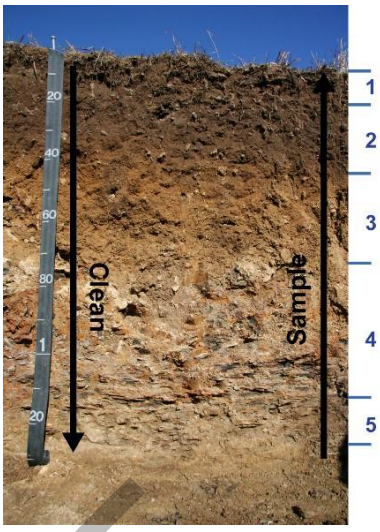

FIG. 4 An example of a soil pit with visually distinct horizons; horizons numbered to the right of the photo indicate the recommended collection areas/volumes to capture each layer and avoid disturbances of the neighboring areas. Photograph courtesy of Dr. Brad Lee.

8.6.3 Techniques and considerations for sampling sub-surface soils:

If sub-surface soils are being collected from a hole or a burial site, then consider 1) if there are impressions of digging tools in the soil, 2) if the hole has been backfilled with disturbed soil or foreign material; 3) if decomposition products have contaminated the soil.

8.6.3.1 *Collection of tool marks from intact excavation*: If an intact soil excavation at a crime scene includes tool marks or impressions that might have been made by digging tools, then these marks should be documented and, if possible, collected for potential comparison to suspected digging tools. After documentation, these tool marks can also be excised and collected from a sub-vertical soil face by careful excavation around the impression.

8.6.3.2 *Recognition and removal of disturbed soil*: If the soil horizon in the depression has been compromised, mixed, or cannot be observed, a depth profile may be observed by

excavating a soil pit in close proximity to the original site, or by digging back the side wall to an undisturbed area. This is particularly important at a clandestine grave in which products of decomposition often alter the natural soil. Known soil samples should be collected to represent: 1) the undisturbed soil throughout the depth of the profile; and 2) samples of the disturbed soil. (**12**) (FIG. 5).

8.6.3.3 *Clearing disturbed soil:* To maintain the integrity of the soil horizons, disturbed soil should be cleared from top to bottom, but soil horizons should be sampled from bottom to top (FIG. 4) to minimize contamination by soil falling from upper levels.

8.6.3.4 *Techniques for collection of sub-surface soil samples:* To obtain a representative sample from the depth profile, collect samples from each layer or horizon and package them separately. To collect a specific horizon either: 1) place a pan, or wide trowel at the bottom of the horizon and carve the horizon onto the pan using a rigid tool; or 2) take a core from the side wall of the soil pit. If a horizon includes discrete areas which are distinct from the rest of the horizon (FIG. 3), collect sufficient volume to represent those variations or collect multiple specimens from this horizon.

8.6.3.4.1 *Excavation sites on slopes:* Sub-surface soil samples from sites excavated in sloped areas should be collected from each of the walls of the excavated hole. The locations sampled should be clearly described, noting the orientation of the sampled wall relative to the slope (FIG. 5).

8.6.3.4.2 *Samples from bottom of excavation*: A representative sample should also be collected from the base of any depression or excavation. When a body is present, a sample should also be collected from the undisturbed soil at the same depth as the body but adjacent to it (FIG. 5).

8.6.3.5 *Exotic soils on buried bodies:* During excavation of a buried body, if exotic soil is observed on the body, it should be collected as a questioned soil (7.5) (**12**).

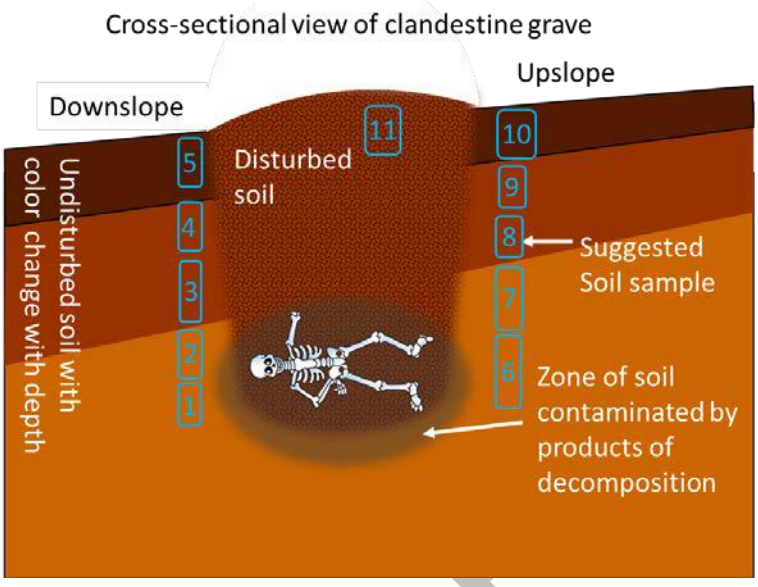

FIG.5 Schematic cross-section of a clandestine grave showing disturbed (11) and undisturbed soil (1 to 10), and soil contaminated with products of decomposition of remains. The blue boxes indicate possible soil volumes for sampling.

9. Documentation, preservation, and packaging of samples:

Proper documentation, preservation, packaging and custodial-continuity of soil samples are essential for maintaining the integrity of soil evidence. After collection, it is crucial that soil and other geological materials are submitted to the laboratory in a condition that adequately represents their original state. Samples should be handled minimally and protected from deleterious or structural changes, contamination, and inadvertent loss. To ensure maintenance of the chain of custody, sample packages should be properly sealed using tamper-evident methods. The recommendations below, specific to soil evidence, should be used with E1188 – 11, E1459 – 13, and agency-specific guidelines for documentation, collection, packaging, and preservation of evidence.

9.1 **Documentation** – Evaluation of soil or geological evidence requires an understanding of the origin and context of the individual samples. Close coordination with the laboratory receiving the evidence is highly advised to ensure that all needed information and samples are made available to the personnel conducting the examinations. Therefore, the following information should be provided whenever possible:

9.1.1 *Photographs* of the scene and evidence.

9.1.2 *Sketches* (with cardinal directions) noting the location (and depth if relevant) of evidentiary items and collected samples.

9.1.3 *Geographic coordinates* (GPS) or equivalent of collection site. When possible note the datum used and the uncertainty of the coordinates.

9.1.4 *Slope and description of topography* (flat terrace, mountain side, 5° slope to the SSW, etc.)

9.1.5 Individual sample information and documentation:

9.1.5.1 Unique sample identifier (e.g., case number and item number)

9.1.5.2 The date and time of collection.

9.1.5.3 The name of the individual who collected the sample.

9.1.5.4 Precise location and description of the sample collection and the depth from the surface. Examples of useful descriptions include: 15 to 25 cm (6 to 10 inches) below the surface from the upslope wall of clandestine grave location; front, left (driver-side) tire well; soil collected adjacent to footwear impression in photo xxx-yy, 0 to 1 cm depth.

9.2 **Preservation and packaging soil evidence:** Packaging should aim to minimize loss, contamination or alteration of soil evidence. Because evidence with adhering soil may also be

subjected to non-soil examinations (for example, finger prints or DNA), these recommendations for soil preservation should be considered along with recommendations for packaging other types of evidence.

9.2.1 *Moisture condition of soil*: In most cases, questioned and known soils should be air dried at ambient temperature prior to final packaging of evidence (**3**). Soils may be collected moist from a crime scene, but unless these soils will be transferred to the person performing the soil exam within one day, the soils should be brought to a clean location, opened and allowed to air dry. To prevent contamination during drying, clean paper may be loosely draped over the soil container (for example, butcher paper, filter paper, lint-free wipes). Do not package and submit moist soil evidence to the forensic laboratory without direct communication with the person performing the examination. The alternatives to air-drying soils are refrigeration (**7**) or freezing. If shipping moist soils, the outer-most mailing package should be labelled “keep frozen” or “keep refrigerated.” Packaging moist soil or moist evidence in paper may lead to package tearing during transport.

9.2.2 *Sample containers*: Samples should be stored in rigid containers that can be sealed tightly and which are impervious to corrosion (**3**). Suitable containers include screw-top plastic containers (plastic specimen cups), screw-top centrifuge tubes, and lined paint cans (FIG. 6.)

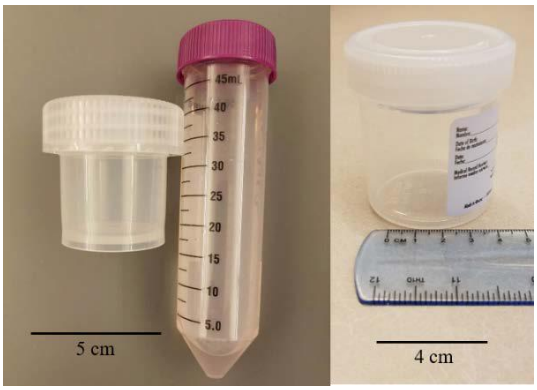

FIG. 6: Examples of possible container types that can be used to store soil evidence. (From left to right: a screw-top jar, a screw top centrifuge tube, and a urine specimen cup).

9.2.2.1 *Discouraged sample containers*: There are many sample containers commonly available to evidence recovery teams which are not appropriate for soil evidence. Paper envelopes and paper bags may rip or leak soil during transport, particularly if the evidence is moist. Unlined metal cans may rust, particularly when filled with moist soil. Plastic bags are discouraged for small quantities of soil due to particle adherence to bag sides, but may be used for larger samples. Glass containers should only be used if they are carefully padded for transport.

9.2.3 *Swabs* used for the collection of samples should be dried, if needed, and then placed in a size-appropriate, sealable container.

9.2.4 *Packaging of soil adhering to an object small enough to send to forensic laboratory*: Questioned soil on a garment, shoe, tire, or digging tool, should be packaged (ideally when dry) and shipped to the crime laboratory intact. Each item should be packaged separately. Packaging should encase the object to retain the soil in case the soil falls off during shipping. Once enclosed, the object should be packaged with padding and supports to minimize movement and abrasion during transport, which could dislodge the soil.

9.2.4.1 *Packaging large, sharp objects*, like spades or picks, present unusual problems because, unless they are well-secured and padded within the shipping container, the sharp ends may pierce the enclosing packaging material. After enclosing a large digging tool in plastic sheeting or very heavy paper, the tool can be immobilized with zip-ties to cardboard, or with a rifle evidence box.

9.2.5 *Packaging and preservation of soil aggregates with layers:* When packaging soil aggregates to preserve their layers and structures (FIG. 7), enclose the aggregate within clean paper. Use cotton balls or another filler material to pad the sample within its container to prevent breakage during transport. The filler material selected must *not* include anything containing geological materials, such as vermiculite, which may compromise analysis. Place the padded soil aggregate in a rigid container.

FIG. 7: A soil sample with multiple layers evident. Care should be taken during packaging to preserve the layer structure during shipping/transport from the field to the laboratory. Photograph courtesy of Marianne Stam.

9.2.6 *Separate boxes for questioned and known soils*: Once soil evidence is documented and sealed in individual containers, place questioned items in a separate box(es) from known soil samples prior to shipping to minimize the risk of cross contamination should one of the individual sample containers rupture during shipping.

10. References

(1) "OSAC Lexicon" http://lexicon.forensicosac.org/Term/Home/Index, accessed 2019

(2) Soil Science Glossary Terms Committee, *Glossary of Soil Science Terms*, Soil Science Society of America ,Madison, WI, 2008, p. 92. https://www.soils.org/publications/soils-glossary.

(3) Murray, R. C., "Evidence Collection", in Chapter 6 of *Evidence from the Earth: Forensic Geology and Criminal Investigation*, second edition, Mountain Press, Missoula, MT, 2004, pp. 104-111.

(4) Brown, A. G., Smith, A., and Elmhurst, O., "The Combined Use of Pollen and Soil Analyses in a Search and Subsequent Murder Investigation," *Journal of Forensic Science*, Vol 47, No. 3, 2002, pp. 614-618.

(5) Skinner, D. N. B., "Sampling Procedures in Forensic Earth Science," *New Zealand Geological Survey Report* G129, 1988.

(6) Demmelmeyer, H., and Adam, J., "Forensic Investigation of Soil and Vegetable Materials," *Forensic Science Reviews*, Vol 7, 1995, pp. 119-142.

(7) Pye, K., *Geological and Soil Evidence: Forensic Applications*, CRC Press, Boca Raton, 2007, p. 356.

(8) Ruffell, A., and Wiltshire, P., "Conjunctive Use of Quantitative and Qualitative X-Ray Diffraction Analysis of Soils and Rocks for Forensic Analysis," *Forensic Science International*, Vol 145, 2004, pp. 13-23.

(9) McKinley, J., and Ruffell, A., "Contemporaneous Spatial Sampling at Scenes of Crime: Advantages and Disadvantages," *Forensic Science International*, Vol 172, 2007, pp. 196-202.

(10) Thanasoulias, N. C., Piliouris, E. T., Kotti, M. S. E., and Evmiridis, N. P., "Application of Multivariate Chemometrics in Forensic Soil Discrimination Based on the UV-Vis Spectrum of the Acid Fraction of Humus," *Forensic Science International*, Vol 130, No. 2-3, 2002, pp. 73-82.

(11) Pye, K., Blott, S. J., Croft, D. J., and Carter, J. F., "Forensic Comparison of Soil Samples: Assessment of Small-Scale Spatial Variability in Elemental Composition, Carbon and Nitrogen Isotope Ratios, Colour, and Particle Size Distribution," *Forensic Science International*, Vol 163, No. 1-2, 2006, pp. 59-80.

(12) Brown, A. G., Smith, A., and Elmhurst, O., "The Use of Forensic Botany and Geology in War Crimes Investigations in NE Bosnia," *Forensic Science International*, Vol 163, 2006, pp. 204-210.

(13) OSHA standard 1926.651, "Specific Excavation Requirements", *Safety and Health Regulations for Construction, 1926 Subpart P, Excavations*, https://www.osha.gov/laws-regs/regulations/standardnumber/1926/1926.651, Accessed 2019

(14) OSHA standard 1926.652, "Requirements for Protective Systems", *Safety and Health Regulations for Construction, 1926 Subpart P, Excavations*, https://www.osha.gov/laws-regs/regulations/standardnumber/1926/1926.652, Accessed 2019.