INTERNATIONAL

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Standard Practice for Detecting Hot Spots Using Point-Net (Grid) Search Patterns[1]

This standard is issued under the fixed designation D6982; 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 practice provides equations and nomographs, and a reference to a computer program, for calculating probabilities of detecting hot spots (that is, localized areas of soil or groundwater contamination) using point-net (that is, grid) search patterns. Hot spots, more generally referred to as targets, are presumed to be invisible on the ground surface. Hot spots may include former surface impoundments and waste disposal pits, as well as contaminant plumes in groundwater or the vadose zone.

1.2 For purposes of calculating detection probabilities, hot spots or buried contaminants are presumed to be elliptically shaped when projected vertically to the ground surface, and search patterns are square, rectangular, or rhombic. Assumptions about the size and shape of suspected hot spots are the primary limitations of this practice, and must be judged by historical information. A further limitation is that hot spot boundaries are usually not clear and distinct.

1.3 In general, this practice should not be used in lieu of surface geophysical methods for detecting buried objects, including underground utilities, where such buried objects can be detected by these methods (see Guide D6429).

1.4 Search sampling would normally be conducted during preliminary investigations of hazardous waste sites or hazardous waste management facilities (see Guide D5730). Sampling may be conducted by drilling or by direct-push methods. In contrast, guidance on sampling for the purpose of making statistical inferences about population characteristics (for example, contaminant concentrations) can be found in Guide D6311.

1.5 *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.*

1.6 *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:*[2]

D5730 Guide for Site Characterization for Environmental Purposes With Emphasis on Soil, Rock, the Vadose Zone and Groundwater (Withdrawn 2013)[3]

D6051 Guide for Composite Sampling and Field Subsampling for Environmental Waste Management Activities

D6311 Guide for Generation of Environmental Data Related to Waste Management Activities: Selection and Optimization of Sampling Design

D6429 Guide for Selecting Surface Geophysical Methods

3. Terminology

3.1 *Definitions:*

3.1.1 *hot spot*—a localized area of soil or groundwater contamination.

3.1.1.1 *Discussion*—A hot spot may be considered as a discrete volume of buried waste or contaminated soil where the concentration of a contaminant of interest exceeds some prespecified threshold value. Although hot spots are more likely to have variable sizes and shapes and not have clear and distinct boundaries, ellipitically shaped hot spots or targets with well-defined edges are assumed for the purposes of calculating detection probabilities. The assumption that hot spots have elliptical shapes is not inconsistent with known historical patterns of contaminant distribution.

3.1.2 *sampling density*—the number of soil borings (that is, sampling points) per unit area.

3.1.3 *semi-major axis, a*—one half the length of the long axis of an ellipse. For a circle, this distance is simply the radius.

[1] This practice is under the jurisdiction of ASTM Committee D34 on Waste Management and is the direct responsibility of Subcommittee D34.01.01 on Planning for Sampling.

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[2] 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] The last approved version of this historical standard is referenced on www.astm.org.

3.1.4 *semi-minor axis, b*—one half the length of the short axis of an ellipse.

3.1.5 *target*—the object or "hot spot" that is being searched for.

3.1.6 *threshold concentration*—the concentration of a contaminant above which a hot spot is considered to be detected.

3.1.7 *unit cell*—the smallest area into which a grid can be divided so that these areas have the same shape, size, and orientation. For a triangular grid, the unit cell is a 60°/120° rhombus comprised of two equilateral triangles with a common side.

3.2 *Symbols:*

3.2.1 a—length of the semi-major axis of an ellipse

3.2.2 b—length of the semi-minor axis of an ellipse

3.2.3 A_T—area of target or hot spot. For an ellipse, $A_T = \pi ab$.

3.2.4 A_S—search area

3.2.5 S—the "shape" of an elliptical target (that is, the ratio of the length of the semi-minor axis to the length of the semi-major axis of an ellipse, b/a)

3.2.6 G—the distance between nearest grid nodes of a unit cell

3.2.7 Q—the ratio of the length of the long side of a rectangular grid cell to the length of the short side

3.2.8 A_C—the area of the unit cell. For a square, $A_{sq} = G^2$. For a rectangle $A_{re} = Q \cdot G^2$. For a 60°/120° rhombus, $A_{rh} = [(\sqrt{3})/2]G^2$. The inverse of A_C is the sampling density

3.2.9 β—the probability of not detecting a hot spot

3.2.10 $P(hit)$—probability of detection (that is, $1 - \beta$)

4. Significance and Use

4.1 Search sampling strategies have found wide utility in geologic exploration where drilling is required to detect subsurface mineral deposits, such as when drilling for oil and gas. Using such strategies to search for buried wastes and subsurface contaminants, including volatile organic compounds, is a logical extension of these strategies.

4.2 Systematic sampling strategies are often the most cost-effective method for searching for hot spots.

4.3 This practice may be used to determine the risk of missing a hot spot of specified size and shape given a specified sampling pattern and sampling density.

4.4 This practice may be used to determine the smallest hot spot that can be detected with a specified probability and given sampling density.

4.5 This practice may be used to select the optimum grid sampling strategy (that is, sampling pattern and density) for a specified risk of not detecting a hot spot.

4.6 By using the algorithms given in this practice, one can balance the cost of sampling versus the risk of missing a hot spot.

4.7 Search sampling patterns may also be used to optimize the locations of additional groundwater monitoring wells or vadose zone monitoring devices.

5. Assumptions

5.1 One or more targets or hot spots exist and are equally likely to occur in any part of the search area.

5.2 When projected vertically upward to a level ground surface, the target appears as an ellipse or a circle (Fig. 1). The probable size and shape of a hot spot can only be guessed from past site or facility records, known layout of the site or facility, and personal knowledge.

5.3 The search pattern is either a square, a rectangular, or an equilateral triangular grid. Borings are made at the intersections of grid lines (that is, nodes) (Fig. 2).

5.4 Borings or direct-push devices are directed downward vertically and the detection of the target is unambiguous. Such an assumption presumes that the full length of a boring would be subject to analysis as contiguous intervals of the boring. If sampling intervals are discontinuous, then contamination might be missed if it occurred between sampled intervals. If sampling intervals are too long, then a hot spot may not be detected because of dilution of a hot spot with less contaminated portions of the sampled interval. The criteria for detection of contaminants may be prespecified threshold concentrations (for example, screening levels) that would trigger further investigation of sites or facilities.

5.5 The area of the bore hole or direct-push device is infinitely small compared to the target area. The algorithms used in this practice assume that bore holes or direct-push devices have no area, but rather are vertical lines projected downward from grid nodes.

6. Preliminary Considerations

6.1 Before designing a hot spot detection strategy, a preliminary investigation of the area containing possible hot spots or targets should be conducted. From historical records, physical layout of buildings and equipment, known transportation pathways, landscape features, and eyewitness accounts, one

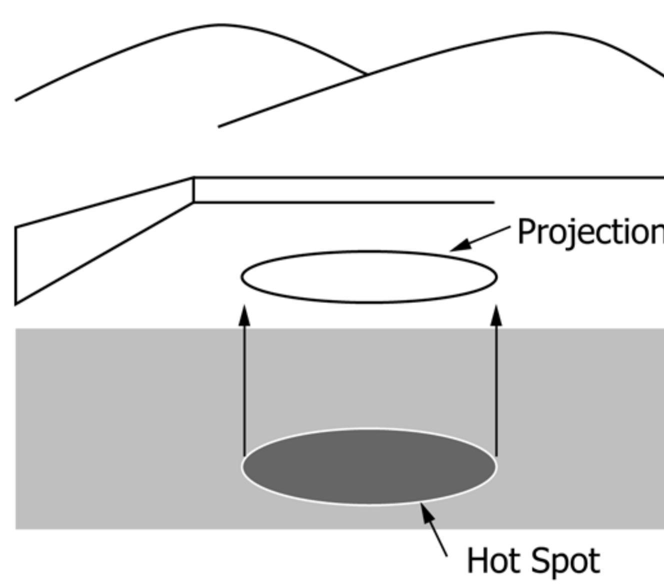

FIG. 1 Projection of Boundaries of Subsurface Contamination to the Ground Surface