Standard Guide for Environmental Site Characterization in Cold Regions[1]

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INTRODUCTION

Understanding environmental processes that occur in soil and rock systems in cold regions of the world depends on adequate characterization of not only the physical, chemical, and biological properties of soil and rock but also the climatic factors under which they exist. Processes of interest may include, but are not limited to, surface and subsurface hydrology, contaminant mobilization, distribution, fate and transport, chemical and biological degradation of wastes, geomorphological, and ecological processes in general.

1. Scope

1.1 Use this guide in conjunction with Guide D 5730.

1.2 This guide describes special problems to be considered when planning field investigations in cold regions. The primary focus of this guide is presenting the special problems and concerns of site characterization in the cold regions of the world.

1.3 Laboratory testing of soil, rock, and ground-water samples is specified by other ASTM standards that are not specifically discussed in this guide. Laboratory methods for measurement of physical properties relevant to environmental investigations are included in Guide D 5730.

1.4 The values stated in SI units are to be regarded as the standard.

1.5 This guide emphasizes the care that must be taken by all field personnel during operations in tundra and permafrost areas of the world.

1.6 *This guide offers an organized collection of information or a series of options and does not recommend a specific course of action. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this guide may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

1.7 *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:* [2]

D 653 Terminology Relating to Soil, Rock, and Contained Fluids

D 4083 Practice for Description of Frozen Soils (Visual-Manual Procedure)

D 5254 Practice for the Minimum Set of Data Elements to Identify a Ground-Water Site

D 5408 Guide for Set of Data Elements to Describe a Ground-Water Site; Part One—Additional Identification Descriptors

D 5409 Guide for Set of Data Elements to Describe a Ground-Water Site; Part Two—Physical Descriptors

D 5410 Guide for Set of Data Elements to Describe a Ground-Water Site; Part Three—Usage Descriptors

D 5730 Guide to Site Characterization for Environmental Purposes with Emphasis on Soil, Rock, the Vadose Zone and Ground Water

D 5781 Guide for Use of Dual-Wall Reverse-Circulation Drilling for Geoenvironmental Exploration and Installation of Subsurface Water-Quality Monitoring Devices

D 5783 Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and Installation of Subsurface Water-Quality Monitoring Devices

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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.

D 6001 Guide for Direct Push Water Sampling for Geoenvironmental Investigations

3. Terminology

3.1 *Definitions*—Definitions of terms used in this guide are in accordance with Terminology D 653.

3.1.1 Guide D 5730 identifies major references from a range of disciplines that can be used as additional sources for definitions of terms that are related to environmental site characterization.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *active layer*, *n*—the top layer of ground above the permafrost table that thaws each summer and refreezes each fall.

3.2.2 *alpine permafrost*, *n*—permafrost developed in temperate climate mountainous areas of the world.

3.2.3 *continuous permafrost*, *n*—permafrost occurring everywhere beneath the exposed land surface throughout a geographic regional zone, with the exception of widely scattered sites, such as newly deposited unconsolidated sediments, where the climate has just begun to impose its influence on the ground thermal regime that will cause the formation of continuous permafrost.

3.2.4 *discontinuous permafrost*, *n*—permafrost occurring in some areas beneath the ground surface throughout a geographic regional zone where other areas are free of permafrost.

3.2.5 *icing, n*—a sheet-like mass of layered ice, either on the ground surface or on the surface of river ice. Aufeis (German), Naled (Russian).

3.2.6 *permafrost*, *n*—the thermal condition in earth materials where temperatures below 0°C persist over at least two consecutive winters and the intervening summer; moisture in the form of water and ground ice may or may not be present. Earth materials in this thermal condition may be described as perennially frozen, irrespective of their water and ice content.

4. Significance and Use

4.1 This guide, when used in conjunction with Guide D 5730, provides direction to the selection of the various ASTM standards that are available for the investigation of soil, rock, the vadose zone, ground-water, and other media where the investigations have an environmental purpose and are conducted in cold regions of the world. It is intended to improve consistency of practice and to encourage rational planning of a site characterization program by providing information to assist in the design of an environmental reconnaissance or investigation plans. This guide is intended to provide information that will help minimize the effect of site characterization operations on areas of frozen ground or permafrost and increase the safety of environmental operations in cold regions.

4.2 This guide presents information and references for site characterization for environmental purposes in cold regions of the world.

5. Special Problems of Cold Regions

5.1 *Safety*—When working in very cold temperatures safety is of utmost importance. Weather is volatile and unpredictable. The difficulty of working under arctic conditions tends to cause frustration and increases the chance of injury. Freezing of exposed flesh and hypothermia can occur very quickly under winter conditions. Specific training in arctic survival techniques in accordance with the Department of the Army or comparable training is recommended for anyone expected to work in these conditions.

5.2 *Tundra*—All operations in areas of tundra must be undertaken with special care. What causes a minor impact in a temperate region from a small environmental site characterization study will have a greater impact on tundra or areas underlain by permafrost. Special care and attention during the planning process must be given to field operations to prevent damage to the tundra surface and vegetation. Winter field operations when tundra is protected by snow and ice are less damaging than summer operations but increase difficulties created by very cold temperatures (see 5.3).

5.2.1 Give special attention to all operations using any form of vehicle in tundra areas. Because of the fragile nature of tundra only a single vehicle pass or aircraft landing may be all that is required to cause uncontrolled degradation of the vegetation and underlying permafrost.

5.2.2 Give special attention to any operation using a motorized or heat producing unit (for example, drilling equipment). These items must be insulated in order to protect permafrost or frozen surface layers against heat transfer, which can result in irreversible degradation of the vegetation and underlying permafrost.

5.3 *Very Cold Temperatures*—Field operations during seasons of very cold temperatures require special planning and concern. Work elements that would require only an hour or so to perform in temperate climates may require several days to perform under the winter temperatures of cold regions. Site investigation planning should take into consideration and allow sufficient time to perform all steps of the investigation. Some procedures, such as tactile methods for visual-manual classification of soils, may not be feasible during cold weather.

5.4 *Permafrost*—The cold winters and short summers of the polar regions produce a layer of frozen ground or permafrost that remains frozen through the summer. Permafrost is a phenomenon of the polar and subpolar regions of the world. About 20 % of the world's land is underlain by permafrost. Permafrost and permafrost hazards uniquely affect most activities in the cold regions, and permafrost and associated hazards must be considered in the planning of all environmental site characterization operations.

5.4.1 Many permafrost areas of the world are not in equilibrium with the existing climate. Any small disturbance of the thermal regime of the permafrost, such as a tire track or drill hole, may result in a drastic change in the underlying permafrost. Therefore, extreme care must be given to prevent damage to the environment when conducting characterization operations in areas underlain by permafrost.

5.4.2 Permafrost acts as a natural barrier in some areas, containing aquifers not usually exposed to surface conditions. Penetration of the permafrost layer into underlying ground water during installation of monitoring wells or collection of deep core samples can increase and exacerbate the fate and transport of environmental contaminants. This can, in turn, change a relatively small, contained site into a much larger area of contamination with greater environmental impact in a region with fragile, highly specialized flora and fauna.

5.5 *Seepage Icings*—Ground-water that seeps or flows at ground surface often results in the formation of disruptive icings. Because many of these seepage sites are located along road cuts the icings may result in loss of use of the roadway. Seepage icings from uncontrolled artesian well flow have been known to cause disruptions. Seasonal frost moves downward more quickly along roadways than it does adjacent undisturbed areas. At times, seasonal frost will move downward to contact the underlying permafrost and form a frost dam within the soil that impedes the flow of ground-water. Hydrostatic pressure will then increase, forcing water to the surface forming an icing. Special attention must be given when undertaking environmental site investigations in cold regions to prevent the occurrence of icings, unless specifically created by design for construction of winter haul roads.

5.6 *Frost Heaving*—In areas of fine-grained sediments, such as silt and clay, frost heaving along with loss of bearing strength is a major problem that must be considered when installing recorder sites for monitoring operations in cold regions. Frost heaving may distort structures, collapse well casings, and cause changes in casing elevations of wells. If not corrected, changes in casing elevation may result in water level measurements that are not correct. During design, siting or construction of structures, frost heaving must be considered and taken into account.

5.7 *Transient Artesian Conditions*—During drilling operations, special attention must be given to possible artesian ground-water conditions below any existing permafrost layers. Drilling operations in cold regions must include plans for dealing with the artesian pressures and blow-out prevention. This may require the use of forward rotary drilling equipment and mud additives to increase the specific weight of the drilling fluid during drilling. Guide D 5783 on direct rotary drilling should be consulted for information on use of drilling fluid additives.

6. Site Investigation Plan

6.1 Review objectives of the investigation prior to final development of a detailed site investigation plan. In cold regions this requires the involvement of individuals or organizations with experience working in such regions. The detailed site investigation plan should clearly identify the types of data that are required to meet the objectives of the investigation. Considerations for identifying data requirements include:

6.1.1 Data required to comply with applicable federal, state, or local regulatory programs.

6.1.2 Data required as inputs to computer models expected to be used.

6.1.3 Data required for selection and design of any implementation measures (that is, protective measures at controlled waste disposal sites, remediation options at contaminated sites).

6.1.4 Data and information on any known geologic or hydrologic hazards at the site.

6.1.5 Data required for risk assessment or to propose alternative cleanup levels.

6.2 A site visit prior to extensive collection of existing data should be made unless the limited scope of a project does not allow multiple visits. The advantage of such a visit is that it may prevent preconceived ideas derived from inaccurate existing information from influencing initial conceptual site model development. A complete environmental site investigation will usually encompass the following activities:

6.2.1 Review available information, both regional and local, on the geologic history (including seismic activity and other potential geologic hazards), rock, soil, ground-water, surface water, and other significant environmental and anthropogenic features (for example, buried utilities) occurring at the proposed location and in the immediate vicinity of the site.

6.2.2 In cold regions, the site investigation plan should include information as to study site selection, routes of access to the site with minimum environmental damage, type and number of tests to be performed at the site, and disposal of waste produced by tests and personnel along with any special requirements needed to reduce the effects of the testing on the surrounding environment. Nonintrusive, nondestructive geophysical testing methods, such as seismic refraction, electromagnetic induction, and ground-penetrating radar may help optimize sampling programs and selection of locations for monitoring well installations.

6.2.3 A site investigation plan in cold regions usually will require a subsurface temperature monitoring system to help assess natural seasonal changes in ground conditions and document impacts of disturbance on tundra ecosystems.

7. Field Methods

7.1 All field procedures should be documented by identifying time, date, location, meteorological conditions, and personnel involved. Practice D 5254 and Guides D 5408, D 5409, and D 5410 identify minimum and additional data elements for identifying a ground-water site, and can serve as checklists to ensure that important information is not omitted. Samples collected should be assigned a unique descriptor number to specifically identify sample location and for reference to field log data.

7.2 Practice D 4083 presents a procedure for the description of frozen soils based on visual examination and simple manual tests.

7.3 *Equipment Selection*—When several alternatives are available to achieve a given objective, all factors should be considered in selecting equipment or a method. Equipment available from commercial sources generally is preferable to homemade equipment because specifications can be documented readily and replacement parts usually can be obtained quickly and used without affecting the comparability of results secured with the defective equipment. Equipment specifications should be checked for operation under cold temperatures. Equipment with the greatest durability and reliability is preferable. ASTM test methods or standard operating procedures and protocols established by government agencies should be used whenever applicable. The timeliness of results is an important consideration when selecting equipment or methods.

Methods that provide real-time data that fulfill data quality requirements are preferable to methods that require use of remote laboratories.

7.3.1 Special circumstances in cold regions may require use of uncommon or nonstandard equipment, methods, or procedures. The rationale for use of such equipment and procedures should be given in the detailed site investigation plan.

7.4 *Drilling Operations*:

7.4.1 *Drilling Operations Using Water-Based Drilling Fluids*—It is not practical in many areas of frozen ground or permafrost to use drilling methods that use water-based drilling fluids because special heat maintenance operations have to be formed to keep the drilling fluid from freezing in the pipes of the drilling rig and other areas where the drilling fluids are stored for use, such as mud pits.

7.4.2 *Direct Push and Vibratory Technology*—Truck or tractor mounted hydraulic-push or vibratory equipment may be useful for ground-water sampling in cold regions. This equipment has an overall depth capability exceeding 100 ft (30 m) under suitable geologic conditions of unconsolidated sediments. The frozen ground of the cold regions, however, may limit the use of the equipment. The technology should be useful in discontinuous permafrost areas and in areas where there is a layer of unfrozen material above the permafrost. The hydraulic hammer included with the push equipment may be used to penetrate relative thin frozen units encountered during drilling. With the use of direct push equipment and a mobile laboratory, ground-water samples can be collected and analyzed in relatively large numbers within a short time (see Guide D 6001). Direct push technology does not generate drill cuttings, and therefore, eliminates the need for disposal of any cuttings. The use of rotation with flighted augers is possible with many direct push systems currently available. Augers may provide an access hole through permafrost allowing direct push tools to be used in the penetrable soils underneath.

7.4.3 *Reverse Rotary with Multiple Well Casings*—Reverse-circulation drilling with dual-wall drill stem is a drilling method where the flow of drilling fluid (air or water) down the borehole occurs between the outer and inner casing of a dual-wall drill stem rather than between an uncased borehole and the drill stem (See Guide D 5781). Otherwise, multiple well casing drilling is similar to reverse circulation rotary drilling. Usually the drill bit is very close to the inside diameter of the outer casing. Consequently, the outer casing partially or completely supports the borehole wall. A major advantage of using dual-wall reverse-circulation drilling over other rotary drilling methods in cold regions is that drilling is readily accomplished in frozen ground conditions with minimum drilling fluid contact with the frozen material thereby reducing the amount of melting. Also, the presence of a casing minimizes the problem of loss of circulation in porous formations or hole collapse in unconsolidated sediments.

8. Keywords

8.1 antarctic; arctic; cold regions; drilling; environmental site characterization; ground-water

APPENDIX

(Nonmandatory Information)

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