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Standard Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices[1]

This standard is issued under the fixed designation D5783; 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 Scope*

1.1 This guide covers how direct (straight) rotary-drilling procedures with water-based drilling fluids may be used for geoenvironmental exploration and installation of subsurface water-quality monitoring devices.

NOTE 1—The term direct with respect to the rotary-drilling method of this guide indicates that a water-based drilling fluid is pumped through a drill-rod column to a rotating bit. The drilling fluid transports cuttings to the surface through the annulus between the drill-rod column and the borehole wall.

NOTE 2—This guide does not include considerations for geotechnical site characterization that are addressed in a separate guide.

1.2 Direct-rotary drilling for geoenvironmental exploration and monitoring-device installations will often involve safety planning, administration and documentation. This standard does not purport to specifically address exploration and site safety.

1.3 *Units*—The values stated in either SI units or inch-pound units (given in brackets) are to be regarded separately as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered stated in each system may not be exactly equivalents; therefore, each system shall be used independently of the other. Combining values from the two system may result in non-conformance with the standard.

1.4 All observed and calculated values are to conform to the guidelines for significant digits and rounding established in Practice D6026.

1.5 The procedures used to specify how data are collected/recorded or calculated in this standard are regarded as the industry standard. In addition, they are representative of the significant digits that generally should be retained. The procedures used do not consider material variation, purpose for obtaining the data, special purpose studies, or any considerations for the user's objective; and it is common practice to increase or reduce the significant digits of reported data to be commensurate with these considerations. It is beyond the scope of this standard to consider significant digits used in analysis method or engineering design.

1.6 *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 safety, health, and healthenvironmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *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.*

1.8 *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]

D653 Terminology Relating to Soil, Rock, and Contained Fluids

[1] This guide is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.21 on Groundwater and Vadose Zone Investigations.

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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.

***A Summary of Changes section appears at the end of this standard**

~~D1452~~D1452/D1452M Practice for Soil Exploration and Sampling by Auger Borings
D1586 Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils
~~D1587~~D1587/D1587M Practice for Thin-Walled Tube Sampling of Fine-Grained Soils for Geotechnical Purposes
D2113 Practice for Rock Core Drilling and Sampling of Rock for Site Exploration
~~D3550~~D3550/D3550M Practice for Thick Wall, Ring-Lined, Split Barrel, Drive Sampling of Soils
D4428/D4428M Test Methods for Crosshole Seismic Testing
D5088 Practice for Decontamination of Field Equipment Used at Waste Sites
~~D5092~~D5092/D5092M Practice for Design and Installation of Groundwater Monitoring Wells
D5099 Test Methods for Rubber—Measurement of Processing Properties Using Capillary Rheometry
D5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock
D5608 Practices for Decontamination of Sampling and Non Sample Contacting Equipment Used at Low Level Radioactive Waste Sites
~~D5784~~D5784/D5784M Guide for Use of Hollow-Stem Augers for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices
D6026 Practice for Using Significant Digits in Geotechnical Data

3. Terminology

~~3.1 *Definitions:*~~

~~3.1.1 Terminology used within this guide is in accordance with Terminology D653. Definitions of additional terms may be found in Terminology D653.~~

3.1 *Definitions:*

3.1.1 For defintions of common technical terms used in this standard, refer to Terminology D653.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 ~~*bentonite—*~~*bentonite, n—in drilling,* the common name for drilling-fluid additives and well-construction products consisting mostly of naturally-occurring montmorillonite. Some bentonite products have chemical additives that may affect water-quality analyses.

~~3.2.2 *bentonite granules and chips*—irregularly-shaped particles of bentonite (free from additives) that have been dried and separated into a specific size range.~~

~~3.2.3 *bentonite pellets*—roughly spherical- or disc-shaped units of compressed bentonite powder (some pellet manufacturers coat the bentonite with chemicals that may affect the water quality analysis).~~

3.2.2 *cleanout* ~~*depth—*~~*depth, n—in drilling,* the depth to which the end of the drill string (bit or core barrel cutting end) has reached after an interval of cutting. The cleanout depth (or drilled depth as it is referred to after cleaning out of ~~any~~ sloughed material in the bottom of the borehole) is usually recorded to the nearest ~~0.1 ft (0.03 m).~~.03 m [.1 ft].

~~3.2.5 *coefficient of uniformity*— $C_u(D)$, the ratio D_{60}/D_{10}, where D_{60} is the particle diameter corresponding to 60 % finer on the cumulative particle-size distribution curve, and D_{10} is the particle diameter corresponding to 10 % finer on the cumulative particle-size distribution curve.~~

3.2.3 ~~*drawworks—*~~*drawworks, n—in drilling,* a power-driven winch, or several winches, usually equipped with a clutch and brake system(s) for hoisting or lowering a drilling string.

3.2.4 *drill* ~~*hole—*~~*hole, n—in drilling,* a cylindrical hole advanced into the subsurface by mechanical means. Also known as a borehole or boring.

3.2.5 *drill* ~~*string—*~~*string, n—in drilling,* the complete direct rotary-drilling assembly under rotation including bit, sampler/core barrel, drill rods and connector assemblies (subs). The total length of this assembly is used to determine drilling depth by referencing the position of the top of the string to a datum near the ground surface.

3.2.6 *filter* ~~*pack—*~~*pack, n—in drilling,* also known as a gravel pack or a primary filter pack in the practice of monitoring-well installations. The gravel pack is usually granular material, having selected grain size characteristics, that is placed between a monitoring device and the borehole wall. The basic purpose of the filter pack or gravel envelope is to act as: (*1*) a non-clogging filter when the aquifer is not suited to natural development or, (*2*) act as a formation stabilizer when the aquifer is suitable for natural development.

3.2.6.1 *Discussion—*

Under most circumstances a clean, quartz sand or gravel should be used. In some cases a pre-packed screen may be used.

~~3.2.10 *grout packer*—an inflatable or expandable annular plug attached to a tremie pipe, usually just above the discharge end of the pipe.~~

~~3.2.11 *grout shoe*—a drillable plug containing a check valve positioned within the lowermost section of a casing column. Grout is injected through the check valve to fill the annular space between the casing and the borehole wall or another casing.~~

~~3.2.11.1 *Discussion*—~~

~~The composition of the drillable plug should be known and documented.~~

3.2.7 *hoisting ~~line—~~line, n—in drilling,* or drilling line, is wire rope used on the drawworks to hoist and lower the drill string.

3.2.8 *~~in-situ~~ in situ testing ~~devices—~~devices, n—in drilling,* sensors or probes, used for obtaining mechanical or chemical-test data, that are typically pushed, rotated or driven below the bottom of a borehole following completion of an increment of drilling. However, some ~~in-situ~~ in situ testing devices (such as electronic pressure transducers, gas-lift samplers, tensiometers, and so forth) may require lowering and setting of the device(s) in a pre-existing borehole by means of a suspension line or a string of lowering rods or pipe. Centralizers may be ~~required~~needed to correctly position the device(s) in the borehole.

3.2.9 *intermittent-sampling ~~devices—~~devices, n—in drilling,* usually barrel-type samplers that are driven or pushed below the bottom of a borehole following completion of an increment of drilling. The user is referred to the following ASTM standards relating to suggested sampling methods and procedures: Practice ~~D1452~~D1452/D1452M, Test Method D1586, Practice ~~D3550~~D3550/D3550M, and Practice ~~D1587~~D1587/D1587M.

~~3.2.15 *mast*—or derrick, on a drilling rig is used for supporting the crown block, top drive, pulldown chains, hoisting lines, etc. It must be constructed to safely carry the expected loads encountered in drilling and completion of wells of the diameter and depth for which the rig manufacturer specifies the equipment.~~

~~3.2.15.1 *Discussion*—~~

~~To allow for contingencies, it is recommended that the rated capacity of the mast should be at least twice the anticipated weight load or normal pulling load.~~

~~3.2.16 *piezometer*—an instrument for measuring pressure head.~~

3.2.10 *subsurface water-quality monitoring ~~device—~~device, n—in drilling,* an instrument placed below ground surface to obtain a sample for analysis of the chemical, biological or radiological characteristics of subsurface-pore water or to make ~~in-situ~~ in situ measurements.

4. Significance and Use

4.1 Direct-rotary drilling may be used in support of geoenvironmental exploration and for installation of subsurface water-quality monitoring devices in unconsolidated and consolidated materials. Direct-rotary drilling may be selected over other methods based on advantages over other methods. In drilling unconsolidated sediments and hard rock, other than cavernous limestones and basalts where circulation cannot be maintained, the direct-rotary method is a faster drilling method than the cable-tool method. The cutting samples from direct-rotary drilled holes are usually as representative as those obtained from cable-tool drilled holes however, direct-rotary drilled holes usually require more well-development effort. If ~~however,~~ drilling of water-sensitive materials (that is, friable sandstones or collapsible soils) is anticipated, it may preclude use of water-based rotary-drilling methods and other drilling methods should be considered.

4.1.1 The application of direct-rotary drilling to geoenvironmental exploration may involve sampling, coring, ~~in-situ~~ in situ or pore-fluid testing, or installation of casing for subsequent drilling activities in unconsolidated or consolidated materials. Several advantages of using the direct-rotary drilling method are stability of the borehole wall in drilling unconsolidated formations due to the buildup of a filter cake on the wall. The method can also be used in drilling consolidated formations. Disadvantages to using the direct-rotary drilling method include the introduction of fluids to the subsurface, and creation of the filter cake on the wall of the borehole that may alter the natural hydraulic characteristics of the borehole.

NOTE 3—The user may install a monitoring device within the same borehole wherein sampling, ~~in-situ~~ in situ or pore-fluid testing, or coring was performed.

4.2 The subsurface water-quality monitoring devices that are addressed in this guide consist generally of a screened or porous intake and riser pipe(s) that are usually installed with a filter pack to enhance the longevity of the intake unit, and with isolation seals and low-permeability backfill to deter the movement of fluids or infiltration of surface water between hydrologic units penetrated by the borehole (see Practice ~~D5092~~D5092/D5092M). ~~Inasmuch as~~ Since a piezometer is primarily a device used for measuring subsurface hydraulic heads, the conversion of a piezometer to a water-quality monitoring device should be made only after consideration of the overall quality of the installation, including the quality of materials that will contact sampled water or gas.

NOTE 4—Both water-quality monitoring devices and piezometers should have adequate casing seals, annular isolation seals and backfills to deter movement of contaminants between hydrologic units.

5. Apparatus

5.1 Direct-rotary drilling systems consist of mechanical components and the drilling fluid.

5.1.1 The basic mechanical components of a direct-rotary drilling system include the drill rig with derrick, rotary table and kelly or top-head drive unit, drill rods, bit or core barrel, casing (when ~~required~~needed to protect the hole and prevent wall collapse when drilling unconsolidated deposits), mud pit, suction hose, cyclone desander(s), drilling-fluid circulation pump, pressure hose, and swivel.

NOTE 5—In general, in North America, the sizes of casings, casing bits, drill rods, and core barrels are usually standardized by manufacturers according to size designations set forth by the American Petroleum Institute (API) and the Diamond Drill Core Manufacturers Association (DCDMA). Refer to the DCDMA technical manual and to published materials of API for available sizes and capacities of drilling tools equipment.

5.1.1.1 *Drill Rig,* with rotary table and kelly or top-head drive unit should have the ability to rotate a drill-rod column and apply a controllable axial force on the drill bit appropriate to the drilling and sampling requirements and the geologic conditions.

5.1.1.2 *Kelly,* a formed or machined section of hollow drill steel, used with some rotary-drilling systems, that is joined to the swivel at the top and the drill rods below. Flat surfaces or splines of the kelly engage the rotary table so that rotation is transmitted to the drill rods.

5.1.1.3 *Drill Rods,* (that is, drill stems, drill string, drill pipe) transfer force and rotation from the drill rig to the bit or core barrel. Drill rods conduct drilling fluid to the bit or core barrel. Individual drill rods should be straight so they do not contribute to excessive vibrations or "whipping" of the drill-rod column. ~~All threaded~~ Threaded connections should be in good repair and not leak significantly at the internal fluid pressure ~~required~~used for drilling. Drill rods should be made up ~~securely~~ and kept secure by wrench tightening at the threaded joint(s) ~~at all times~~ to prevent rod damage.

NOTE 6—Drill rods usually require lubricants on the threads to allow easy unthreading of the drill-rod tool joints. Some lubricants have organic or metallic constituents, or both, that could be interpreted as contaminants if detected in a sample. Various lubricants are available that have components of known chemistry. The effect of drill-rod lubricants on chemical analyses of samples should be considered and documented when using direct-rotary drilling. The same consideration and documentation should be given to lubricants used with water swivels, hoisting swivels, or other devices used near the drilling axis.

5.1.1.4 *Rotary Bit or Core Bit,* provides the material cutting capability. Therefore, a core barrel can also be used to advance the hole.

NOTE 7—The bit is usually selected to provide a borehole of sufficient diameter for insertion of monitoring-device components such as the screened intake and filter pack and installation devices such as a tremie pipe. It should be noted that if bottom-discharge bits are used in loose cohesionless materials, jetting or erosion of test intervals could occur. The borehole opening should permit easy insertion and retraction of a sampler, or easy insertion of a pipe with an inside diameter large enough for placing completion materials adjacent to the screened intake and riser of a monitoring device. Core barrels may also be used to advance the hole. Coring bits are selected to provide the hole diameter or core diameter ~~required.~~needed. Coring of rock should be performed in accordance with Practice D2113. The user is referred to Test Method D1586, Practice ~~D1587~~D1587/D1587M, and Practice ~~D3550~~D3550/D3550M for techniques and soil-sampling equipment to be used in sampling unconsolidated materials. Consult the DCDMA technical manual and published materials of API for matching sets of nested casings and rods if nested casings must be used for drilling in incompetent formation materials.

5.1.1.5 *Mud Pit,* is a reservoir for the drilling fluid and, if ~~properly~~correctly designed and utilized, provides sufficient flow-velocity reduction to allow separation of drill cuttings from the fluid before recirculation. The mud pit is usually a shallow, open metal tank with baffles; however, for some circumstances, an excavated pit with some type of liner, designed to prevent loss of drilling fluid and to contain potential contaminants that may be present in the cuttings and recirculated fluids may be used. The mud pit can be used as a mixing reservoir for the initial quantity of drilling fluid and, in some circumstances, for adding water and additives to the drilling fluid as drilling progresses.

NOTE 8—Some drilling-fluid components ~~must~~ will need to be added to the composite mixture before other components; consequently, an auxiliary mixing reservoir may be ~~required~~needed to premix these components with water before adding to the mud pit. ~~All~~The quantities, chemical composition and types of drilling-fluid components and additives used in the composite drilling-fluid mixture should be documented.

5.1.1.6 *Suction Hose,* sometimes equipped with a foot valve or strainer, or both, conducts the drilling fluid from the mud pit to the drilling-fluid circulation pump.

5.1.1.7 *Drilling-Fluid Circulation Pump,* ~~must have~~ having the capability to lift the drilling fluid from the mud pit and move it through the system against variable pumping heads and provide an annular velocity adequate to transport drill cuttings out of the borehole.

NOTE 9—Drilling-fluid pressures at the bit should be low to prevent fracturing of the surrounding material. ~~All drilling-fluid~~ Drilling-fluid pressures should be monitored during drilling. Any abrupt changes or anomalies in the drilling-fluid pressure should be duly noted and documented including the depth(s) of occurrence(s).

5.1.1.8 *Pressure Hose,* conducts the drilling fluid from the circulation pump to the swivel.

5.1.1.9 *Swivel,* directs the drilling fluid to the rotating kelly or drill-rod column.

5.1.2 *Drilling Fluid,* usually consists of a water base and one or more additives that increase viscosity or provide other desirable physical or chemical properties. Principal functions of drilling fluid include: (*1*) sealing the borehole wall to ~~minimize~~ reduce potential loss of drilling fluid, (*2*) providing a hydraulic pressure against the borehole wall to support the open borehole, (*3*) removing cuttings generated at the bit and (*4*) lubricating and cooling of the bit.

NOTE 10—Particular attention should be given to the drilling-fluid makeup-water source and the means used to transport the makeup water to the drilling site as potential sources of contamination to the drilling fluid. If the chemical makeup of the water is determined the test results should be documented.

5.1.3 Some commonly used additives for water base drilling fluids are listed below:

5.1.3.1 Beneficiated bentonite, a primary viscosifier and borehole sealer, consists of montmorillonite with other naturally-occurring minerals and various additives such as sodium carbonate or polyacrylates, or both.

5.1.3.2 Unbeneficiated bentonite, a primary viscosifier and borehole sealer, consists of montmorillonite with other naturally-occurring minerals but without additives such as sodium carbonate or polyacrylates.

5.1.3.3 Sodium carbonate powder (soda ash) is used to precipitate calcium carbonate hardness from the drilling fluid water base before adding other components. An increase in pH will occur with the addition of sodium carbonate. Sodium hydroxide (caustic soda) generally should not be used in this application.

5.1.3.4 Carboxylmethylcellulose powder (CMC) is sometimes used in a water based fluid as a viscosifier and as an inhibitor to clay hydration.

NOTE 11—Some additives to water-based drilling fluid systems retard clay hydration, inhibiting swelling of clays on the borehole wall and inhibiting “balling” or “smearing” of the bit.

5.1.3.5 Potassium chloride (muriated potash) or diammonium phosphate can be used as an inhibitor to clay hydration.

5.1.3.6 Polyacrylamide, a primary viscosifier and clay-hydration inhibitor, is a polymer that is mixed with water to create a drilling fluid.

5.1.3.7 Barium sulfate increases the density of water-based drilling fluids. It is a naturally occurring high specific gravity mineral processed to a powder for rotary drilling-fluid applications.

5.1.3.8 Lost-circulation materials are used to seal the borehole wall when fluids are being lost through large pores, cracks or joints. These additives usually consist of various coarse textured materials such as shredded paper or plastic, bentonite chips, wood fibers, or mica.

5.1.3.9 Attapulgite, a primary viscosifier for rotary drilling in high-salinity environments, is a clay mineral drilling-fluid additive.

NOTE 12—The listing and discussion of the above drilling-fluid additives does not imply general acceptance for geoenvironmental exploration. Some of the additives listed above may impact water-quality analyses. Some ~~readily~~ may be available, but not as common, drilling-fluid additives, not listed above, or could cause significant contamination in a borehole or hydrologic unit. Each additive should be evaluated for each specific application. The types, amounts, and chemical compositions of ~~all~~ additives used should be documented. In addition, a hole log should document the depths where ~~any~~ new additives were introduced. Methods to break revertible fluids should be documented.

6. Drilling Procedures

6.1 As a prelude to and throughout the drilling process stabilize the drill rig and raise the drill-rig mast. Position the mud pit and install surface casing and seal at the ground surface.

NOTE 13—Under some circumstances, surface casing may be ~~required~~needed to prevent hole collapse. Deeper casing(s) (nested casings) may also be ~~required~~needed to facilitate adequate downhole fluid circulation and hole control. ~~All casing~~ Casing used should first be decontaminated according to Practice D5088 or D5608 prior to use and the casing information documented.

6.2 Mix an initial quantity of drilling fluid, usually using the mud pit as the primary mixing reservoir.

NOTE 14—The need for chemical analysis of samples of each drilling-fluid component and the final mixture should be documented.

6.3 Drilling usually progresses as follows:

6.3.1 Attach an initial assembly of a bit or core barrel, often with a single section of drill rod, below the rotary table or top-head drive unit with the bit or drill head placed within the top of the surface casing.

NOTE 15—The drill rig, drilling, hoisting and sampling tools, the rotary gear or chain case, the spindle and ~~all~~other components of the rotary drive above the drilling axis should be cleaned and decontaminated according to Practice D5088 or D5608 prior to commencing drilling and sampling operations.

6.3.2 Activate the drilling-fluid circulation pump, causing drilling fluid to circulate through the system.

6.3.3 Initiate rotation of the bit and apply axial force to the bit.

6.3.4 Continue drilling-fluid circulation as rotation and axial force are applied to the bit until drilling progresses to a depth where: (*1*) sampling or ~~in-situ~~ in situ testing will be performed, (*2*) the length of the drill-rod column limits further penetration, or (*3*) (when core drilling) the core specimen has entered the core barrel.

6.3.5 Stop rotation. Lift the bit slightly off hole bottom while drilling-fluid circulation is continued to facilitate removal of the drill cuttings from the borehole annulus. If sampling is to be done, stop drilling-fluid circulation and rest the bit on the hole bottom to ascertain hole depth. If, after making a depth measurement, it is apparent that caving has caused hole-depth loss, document the hole depth and amount of caving that had occurred. If caving has occurred, set decontaminated casing to support the boring.

NOTE 16—The time ~~required~~ to remove the cuttings from the borehole will depend mainly upon the pumping rate, the cross-sectional area of the borehole annulus, the borehole depth, the viscosity of the drilling fluid, and the size of the cuttings. If determined that caving occurred and casing had to be set, this information should be documented.

6.3.6 Increase drilling depth by attaching an additional drill-rod section to the top of the previously advanced drill-rod column and resuming drilling operations according to 6.3.2 through 6.3.5. Drilling behavior should be documented as drilling progresses. This recorded information should include (as a minimum): drilling-fluid circulation pressures, depth(s) of occurrence of low or lost drilling-fluid circulation, drill-cuttings description, depths of and type of sample(s)/core(s) taken from the hole, and any other data identified as necessary and pertinent to the needs of the exploration program. Record to two significant digits.

NOTE 17—Drilling rates depend on many factors such as the density or stiffness of unconsolidated material and the existence of cobbles or boulders, the hardness or durability of the rock, or both, the swelling activity of clays or shales encountered in the borehole and the erosiveness of the borehole wall. Drilling rates can vary from a few mm (less than an in./min) to about 1 m (3 ft)/min,[3 ft]/min, depending on subsurface conditions. Other factors influencing drilling rates include the weight of the drill string, collar(s) weight and size of drill pipe, and the rig pulldown or holdback pressure. These data as well as any and other drilling-rate information should be recorded.

6.3.7 Perform sampling or in-situ in situ testing at any depth by interrupting the advance of the bit, cleaning the hole of cuttings according to 6.3.5, stopping the fluid circulation, and removing the drill-rod column from the borehole. Drill-rod removal is not necessary when a sample can be obtained or an in-situ in situ test can be performed through the hollow axis of the drill rods and bit. Sampling depth should be compared to the cleanout depth. Verify the depth-comparison data by first resting the sampler on the bottom of the hole and comparing that measurement with the cleanout-depth measurement. This should be done before every sampling or in-situ in situ testing is performed in the hole. If bottom-hole sloughing is apparent from a depth measurement made prior to sampling (determined by comparing the hole-cleanout depth with the sampling depth) it is recommended that the hole be cleaned in order that a minimum depth of undisturbed intact material extend at least 18-in. a minimum of .5 m [18-in.] below the sampler/bit for testing. Record the depth of in-situ in situ testing or sampling as well as the depth below the sampler/bit for evaluation of data quality for later evaluation of sample quality or in-situ in situ testing data validity. Decontaminate sampling and testing devices according to Practice D5088 prior to testing.

6.4 When drilling must progress through material suspected of being contaminated, installation of single or multiple (nested) casings may be requiredneeded to isolate zones of suspected contamination. Isolation casings are usually installed in a predrilled borehole or by using a casing-advancement method. A grout seal is then installed, usually by applying the grout at the bottom of the annulus with the aid of a grout shoe or a grout packer and a tremie pipe. Allow the grout to set before drilling activities are continued. Document complete casing and grouting records, including location(s) of nested casings for the hole.

7. Installation of Monitoring Devices

7.1 Subsurface water-quality monitoring devices are generally installed in boreholes drilled by direct-rotary methods using the three-step procedure shown on Fig. 1. The three steps are: (*1*) drilling, with or without sampling, (*2*) removal of the drill-rod

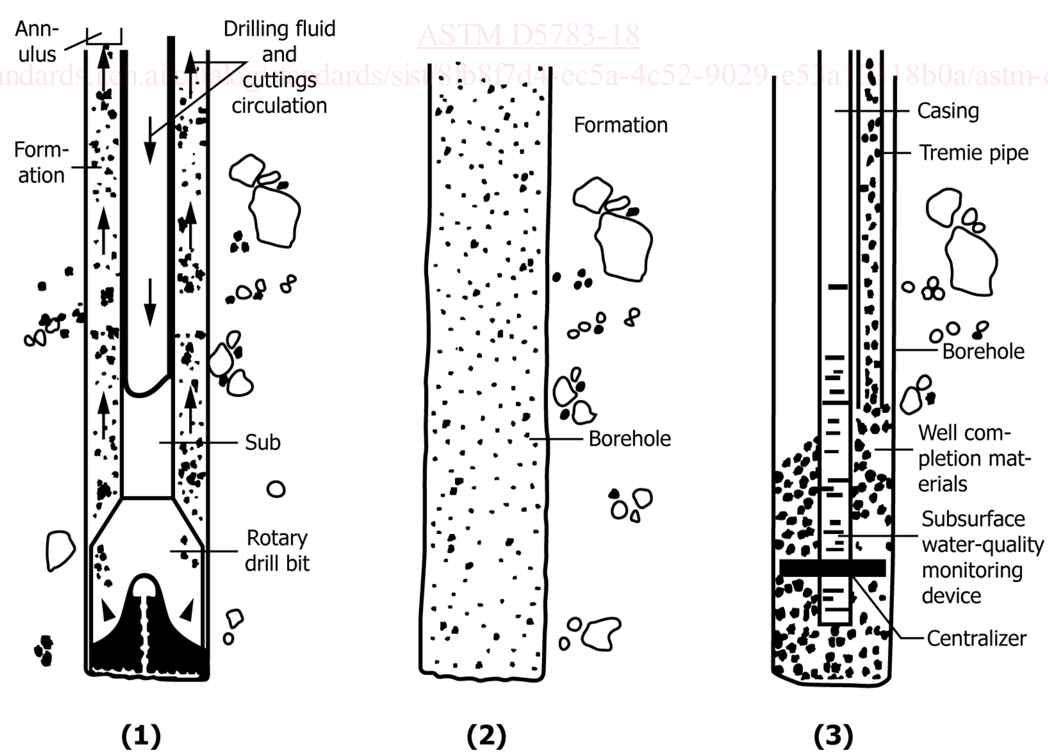

FIG. 1 Sketch Showing Basic Three-Step Procedure for Installation of Subsurface Water-Quality Monitoring Device Using Direct-Rotary Drilling With Water-Based Drilling Fluid