



Standard Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices¹

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

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 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.4 *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.*

1.5 *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.

2. Referenced Documents

2.1 ASTM Standards:²

- D653 Terminology Relating to Soil, Rock, and Contained Fluids
- D1452 Practice for Soil Exploration and Sampling by Auger Borings
- D1586 Test Method for Penetration Test (SPT) and Split-Barrel Sampling of Soils
- D1587 Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes
- D2113 Practice for Rock Core Drilling and Sampling of Rock for Site Exploration
- D3550 Practice for Thick Wall, Ring-Lined, Split Barrel, Drive Sampling of Soils
- D5088 Practice for Decontamination of Field Equipment Used at Waste Sites
- D5092 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
- D5784 Guide for Use of Hollow-Stem Augers for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices

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.

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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.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *bentonite*—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).

3.2.4 *cleanout depth*—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).

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.

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

3.2.7 *drill hole*—a cylindrical hole advanced into the subsurface by mechanical means. Also known as a borehole or boring.

3.2.8 *drill string*—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.

3.2.9 *filter pack*—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.

3.2.9.1 *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.

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

3.2.13 *in-situ testing devices*—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 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 to correctly position the device(s) in the borehole.

3.2.14 *intermittent-sampling devices*—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](#), Test Method [D1586](#), Practice [D3550](#), and Practice [D1587](#).

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.

3.2.17 *subsurface water-quality monitoring device*—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 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 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 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**). Inasmuch as 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 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 connections should be in good repair and not leak significantly at the internal fluid pressure required for drilling. Drill rods should be made up securely 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. Coring of rock should be performed in accordance with Practice **D2113**. The user is referred to Test Method **D1586**, Practice **D1587**, and Practice **D3550** 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 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 be added to the composite mixture before other components; consequently, an auxiliary mixing reservoir may be required to pre-mix these components with water before adding to the mud pit. All 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 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 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 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 Carboxymethylcellulose 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 Attapulgit, 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 available, but not as common, drilling-fluid additives, not listed above, 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 to prevent hole collapse. Deeper casing(s) (nested casings) may also be required to facilitate adequate downhole fluid circulation and hole control. All casing used should first be decontaminated according to Practice **D5088** 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 components of the rotary drive above the drilling axis should be cleaned and decontaminated according to Practice **D5088** 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 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.

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, 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 pull-down or holdback pressure. These data as well as any other drilling-rate information should be recorded.

6.3.7 Perform sampling or 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 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 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 material extend at least 18-in. below the sampler/bit for testing. Record the depth of 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 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 required 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

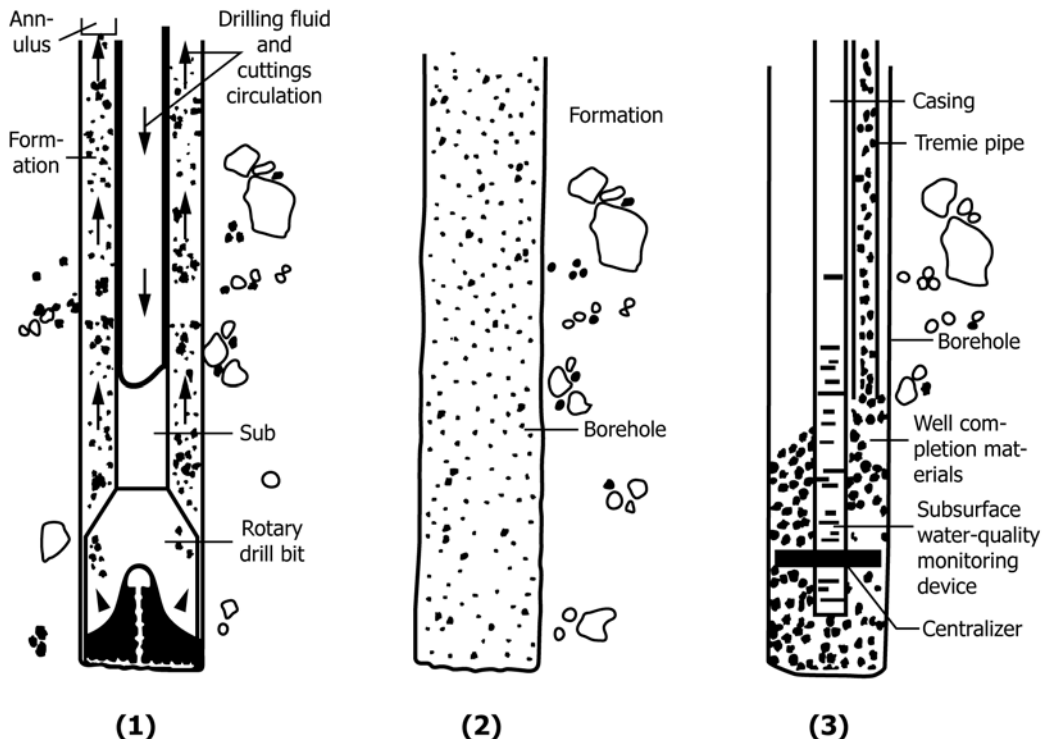


FIG. 1 Sketch Showing Basic Three-Step Procedure for Installation of Subsurface Water-Quality Monitoring Device Using Direct-Rotary Drilling With Water-Based Drilling Fluid

are: (1) drilling, with or without sampling, (2) removal of the drill-rod column assembly and placement of the monitoring device, and (3) addition of other materials such as filter packs, seals and grouts. If protective casings are present in the borehole they are usually removed in incremental fashion as completion materials are added.

NOTE 18—The volumes of sand packs and seals should be documented and compared to calculated values based on hole diameter for evaluation of hole quality.

7.2 Assemble water-quality monitoring devices, with attached fluid conductors (risers), and insert into the borehole with the least possible addition of contaminants. The user is referred to Practice **D5092** for monitoring-well installation methods and Practice **D5088** for suggested methods of field-equipment decontamination.

NOTE 19—If the integrity of the borehole wall will not be compromised by removing the wall cake from the borehole in the vicinity of the screened intake, the drilling mud should be removed using a well-development procedure as suggested in Guide **D5784** prior to inserting a monitoring well or a water-quality monitoring device in the borehole.

7.2.1 Some materials, such as screens and risers, require cleaning or decontamination, or both, at the job site (see Practice **D5088**).

7.2.2 Prior to installation, store all monitoring-device materials undercover and place upwind and well away from the drill rig and any other sources of contamination such as electrical generators, air compressors, or industrial machinery.

7.2.3 Clean hoisting tools, particularly wire rope and hoisting swivels, and decontaminate according to Practice **D5088** before using.

7.3 Select filter materials, bentonite pellets, granules and chips and grouts and install according to specific subsurface-monitoring requirements. Document this information.

NOTE 20—Filter packs for monitoring devices are usually installed in rotary-drilled holes using a tremie pipe inserted in the annulus between the borehole wall and the monitoring device (minimum annulus between riser pipe and hole wall should be about 1 in. (25 mm) completely around the riser pipe). Monitoring devices installed in a saturated zone typically have sand-sized filter packs selected on the basis of the grain-size characteristics of the hydrologic unit adjacent to the screened intake. Filter-pack sands are usually selected with a coefficient of uniformity of less than 2.5. Filter packs for vadose-zone monitoring devices may be predominantly silt sized (however, soil-gas monitoring devices should not use silt-sized filter packs but typically use coarse sand or gravel filter packs). These filter materials are often mixed with water of known quality and then inserted through a tremie pipe and tamped into place around the device. The type(s) and volumes of filter materials used and the quality and quantities of mixing water should be documented. In most cases, a centralizer should be used to position the monitoring device in the borehole. The intake device and riser(s) should be suspended above the bottom of the borehole during installation of the filter pack(s), seal(s) and backfill to keep the riser(s) as straight as possible. Care should be taken when adding backfill or filter material(s), or both, so that the materials do not bridge. However, if bridging does occur during the installation procedure, tamping rods or other tamping devices may be used to dislodge the “bridge”.

7.4 Sealing materials, consisting of either bentonite pellets, chips, or granules, are usually placed directly above the filter pack.

NOTE 21—It may be effective, when granular filter packs are used, to install a thin, fine sand, secondary filter either below the annular seal or both above and below the seal. These secondary filters protect both the

monitoring device filter and the seal from intrusion of grout installed above the seal.

7.5 The backfill that is placed above the annular seal is usually a bentonite or cement-base grout.

NOTE 22—Grouts should be designed and installed in consideration of the ambient hydrogeologic conditions. The constituents should be selected according to specific performance requirements and these data documented.

7.5.1 In most cases, the grout should be pumped into the annulus using a tremie pipe.

NOTE 23—Grouting equipment should be cleaned and decontaminated prior to use according to Practice **D5088**. Also, the equipment used for grouting should be constructed from materials that do not “leach” significant amounts of contaminants to the grout.

7.5.2 Control the initial position of the tremie pipe and grouting pressures to prevent materials from being jetted into underlying seal(s) and filter(s) (use of a tremie pipe having a plugged bottom and side-discharge ports should be considered to minimize bottom-jetting problems).

7.5.3 In most cases, the grout should be discharged at a depth of approximately 5 to 10 ft (1.5 to 3 m) below the grout surface within the annulus (after the placement of the initial 5 to 10 ft (1.5 to 3 m) of grout above the underlying filter or seal). Discharge additional grout at a depth of approximately 5 to 10 ft (1.5 to 3 m) below the grout surface within the annulus. Raise the tremie pipe periodically as grout is discharged to maintain the appropriate depth below the grout surface.

NOTE 24—The need for chemical analysis of samples of each grout component and the final mixture should be documented. Also, it should be noted that if cements are used for grouting, they generate hydroxides and thereby, can cause a localized increase in the alkalinity and pH of the surrounding groundwater.

7.5.4 Install the grout in such a manner as to displace fluids in the borehole.

8. Development

8.1 Most monitoring-device installations should be developed to remove suspended solids from drilling fluids and disturbance of geologic materials during installation and to improve the hydraulic characteristics of the filter pack and the geologic unit adjacent to the intake. For suggested well-development methods and techniques the user is referred to Test Method **D5099**. The method(s) selected and time expended to develop the installation and the changes in water quality discharged at the surface should be carefully observed and documented. For suggested well-development methods and techniques the user is referred to Test Method **D5099**.

NOTE 25—Under most circumstances, development should be initiated as soon as possible following completion, however, time should be allowed for setting of grout.

9. Field Report and Project Control

9.1 The field report should include information recommended under Guide **D5434**, and identified as necessary and pertinent to the needs of the exploration program.

9.2 Other information in addition to Guide **D5434** should be considered if deemed appropriate and necessary to the needs of

the exploration program. Additional information should be considered as follows:

9.2.1 *Drilling Methods:*

9.2.1.1 Description of the direct-rotary system,

9.2.1.2 Type, quantities, and locations in the borehole of use of additives added to the circulation media,

9.2.1.3 Description of circulation rates, cuttings return, including quantities, over intervals used. Locations and probable cause of loss of circulation in the borehole. Drilling-fluid loss quantities should be documented, and

9.2.1.4 Descriptions of drilling conditions related to drilling pressures, rotation rates, and general ease of drilling as related to subsurface materials encountered.

9.2.2 *Sampling*—Document conditions of the bottom of the borehole prior to sampling and report any slough or cuttings present in the recovered sample.

9.2.3 *In-situ Testing:*

9.2.3.1 For devices inserted below the bottom of the borehole document the depths below the bottom of the hole and any unusual conditions during testing.

9.2.3.2 For devices testing or seating at the borehole wall, report any unusual conditions of the borehole wall such as inability to seat borehole packers.

9.2.4 *Installations*—A description of well-completion materials and placement methods, approximate volumes placed, depth intervals of placement, methods of confirming placement, and areas of difficulty of material placement or unusual occurrences.

10. Keywords

10.1 direct-rotary drilling method; drilling; geoenvironmental exploration; groundwater; vadose zone

APPENDIX

(Nonmandatory Information)

X1. ADDITIONAL REFERENCES

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