Designation: D5521/D5521M – 18

Standard Guide for Development of Groundwater Monitoring Wells in Granular Aquifers[1]

This standard is issued under the fixed designation D5521/D5521M; 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 the development of screened wells installed for the purpose of obtaining representative groundwater information and water quality samples from granular aquifers, though the methods described herein could also be applied to wells used for other purposes. Other well-development methods that are used exclusively in open-borehole bedrock wells are not described in this guide.

1.2 The applications and limitations of the methods described in this guide are based on the assumption that the primary objective of the monitoring wells to which the methods are applied is to obtain representative water quality samples from aquifers. Screened monitoring wells developed using the methods described in this guide should yield relatively sediment-free samples from granular aquifer materials, ranging from gravels to silty sands. While many monitoring wells are considered "small-diameter" wells (that is, less than 10 cm [4 in.] inside diameter), some of the techniques described in this guide will be more easily applied to large-diameter wells (that is, 10 cm [4 in.] or greater inside diameter).

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the 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, health, and environmental 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 needs to 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.*

1.6 *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]

D653 Terminology Relating to Soil, Rock, and Contained Fluids

D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

D5088 Practice for Decontamination of Field Equipment Used at Waste Sites

D5092 Practice for Design and Installation of Groundwater Monitoring Wells

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of common terminology terms used within this standard, refer to Terminology D653.

3.1.2 *annular seal, n—in groundwater*, material used to provide a seal between the borehole and the casing of a well. The annular seal should have a hydraulic conductivity less than that of the surrounding geologic materials, be resistant to chemical or physical deterioration.

[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.

Current edition approved June 1, 2018. Published July 2018. Originally approved in 1994. Last previous edition approved in 2013 as D5521 – 13. DOI: 10.1520/D5521_D5521M-18.

[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

3.1.3 *backwashing, n—in groundwater*, the reversal of water flow caused by the addition of water to a well that is designed to loosen or break sediment bridges within the filter pack and well screen and facilitate the removal of fine-grained sediment from the formation surrounding the borehole.

3.1.4 *bailing (development), n—in groundwater*, a development technique using a bailer which is raised and lowered in the well to create a strong inward and outward movement of water from the well to the formation and vice versa to loosen or break sediment bridges within the filter pack and well screen and to remove fine-grained sediment from the well.

3.1.4.1 *Discussion*—In unconsolidated formations, casing is usually driven as drilling proceeds to prevent collapse of non-cohesive materials (that is, sand) into the borehole.

3.1.5 *filter-packed well, n—in groundwater*, a well where the in situ geologic materials adjacent to the well screen has been replaced by an engineered or processed filter pack material.

3.1.6 *formation damage, n—in groundwater*, disturbance or reduction of in situ aquifer hydrogeologic parameters at the borehole wall caused by the drilling process, the well installation process, or destructive, subsurface geoengineering/geotechnical testing. May consist of sediment compaction, clay smearing, clogging of pores with drilling mud filtrate, or other drilling/testing-related damage.

3.1.7 *overpumping, n—in groundwater*, a well development technique that involves pumping the well at a rate that exceeds the design capacity of the well.

3.1.8 *rawhiding—in groundwater*, starting and stopping a pump intermittently to produce rapid changes in the pressure head in the well.

3.1.9 *sandlocking*—refers to the accumulation of sand and other sediment on development tools while they are working in the well screen, resulting in the tools becoming lodged in the screen.

3.1.9.1 *Discussion*—This refers to the accumulation of sand and other sediment in the impeller section of a submersible pump, resulting in the impellers binding.

3.1.10 *spudding, n—in drilling*, the operation, in cable-tool drilling, of drilling a collar hole and advancing a casing through overburden. Also a general term in rotary or diamond core drilling applied to drilling through overburden.

3.1.11 *well sump, n—in groundwater*, a blank extension of easing beneath the well screen that provides a space for fine-grain sediment introduced into the well during development or groundwater sampling to accumulate.

3.1.12 *surge block, n—in groundwater*, a plunger-like tool consisting of disks of flexible material (that is, neoprene) sandwiched between rigid (that is, metal) disks that may be solid or valved, and used in well development. See *surging.*

3.1.13 *surging, n—in groundwater*, a well development technique where a surge block is alternately raised and lowered within the well casing or screen, or both, to induce a strong inward and outward movement of water through the well screen.

3.1.14 *well development, n—in groundwater*, the act of addressing potential formation damage caused by the drilling and well installation process by removing fine-grained sediment or drilling fluids, or both, from in situ geologic formation and filter pack such that the evaluated in situ aquifer hydrogeologic parameters are more likely to be representative of the assumed pre-drilling/monitor well installation conditions and overall well yields are enhanced.

4. Significance and Use

4.1 A correctly designed, installed, and developed groundwater monitoring well, constructed in accordance with Practice D5092 should provide the following: representative samples of groundwater that can be analyzed to determine physical properties and water quality parameters of the sample or potentiometric levels that are representative of the total hydraulic head of that portion of the aquifer screened by the well, or both. The well may also be utilized for conducting aquifer performance tests used for the purpose of determining the hydrogeologic properties of the targeted hydrostratigraphic unit in which the well has been completed.

NOTE 1—An extensive research program on annular sealants was conducted from 2001 through 2009 and in subsequent years by the Nebraska Grout Task Force (Lackey et al., 2009 and State of California, 2015). This research included cement and bentonite grouts and the use of pellets and chips. The general finding of the study indicates all sealing methods suffer from some shrinkage in the portion of the well in the unsaturated zone. The best grouts were cement-sand, bentonite chips, neat cements, and bentonite slurries with more than 20 percent solids. Especially problematic is the use of low solids content bentonite slurries in the unsaturated zone leading to a prohibition on their use in California (State of California, 2015). It is also highly recommended that State and Federal codes/regulations regarding seals within the unsaturated zone be evaluated prior to design to ensure codes are met.

4.2 Well development is an important component of monitoring well completions. Monitoring wells installed in aquifers should be sufficiently developed to such that they serve their intended objectives. Well development methods vary with the physical characteristics of the targeted hydrostratigraphic unit in which the monitoring well is screened, the construction details of the well, the drilling method utilized during the construction of the borehole prior to well installation, and the quality of the groundwater. The development method for each individual monitoring well should be selected from among the several methods described in this guide and should be employed by the well construction contractor or the qualified personnel in responsible charge of the monitoring well completion.

4.3 The importance of well development in monitoring wells cannot be overestimated. If a monitoring well is inherited with a project, it is best for the well construction contractor or the qualified personnel to consider the possibility that well development was not performed or was carried out inadequately, which may influence both previous and future sampling results if the wells were not redeveloped and/or appropriate documentation of well development cannot be obtained. Proper and careful well development will improve the ability of most monitoring wells to provide representative, unbiased chemical and hydraulic data. The additional time and money spent performing this important step in monitoring well completion or maintenance will reduce the potential for damaging pumping equipment and in situ sensors, and increase the probability that groundwater samples are representative of the targeted formation water monitored. Practice D3740 provides evaluation factors for the activities in this guide.

NOTE 2—The quality of the result produced by this standard is dependent on the competence of the personnel performing it, and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D3740 are generally considered capable of competent and objective testing/sampling/evaluation/and the like. Users of this standard are cautioned that compliance with Practice D3740 does not in itself assure reliable results. Reliable results depend on many factors. Practice D3740 provides a means of evaluating some of those factors.

5. Purposes of Monitoring Well Development

5.1 Monitoring wells are developed primarily for the following reasons:

5.1.1 To address potential damage, which may occur during the drilling and monitoring well installation processes at the borehole wall and the adjacent geologic formation (that is, clogging, smearing, or compaction of geologic materials comprising the formation or targeted hydrostratigraphic unit). This may potentially result in localized alterations of the hydrogeologic characteristics of the formation near the borehole (see Fig. 1);

NOTE 3—One of the purposes of development is to address the potential damage done to the borehole wall during drilling and monitoring well installation processes. The "skin" of fine-grained sediment that accumulates along the borehole wall during mud-rotary drilling is an example of the potential distress.

5.1.2 To remove fine-grained sediment from the formation and filter pack (where applicable) that may result in the acquisition of turbid, sediment-laden samples;

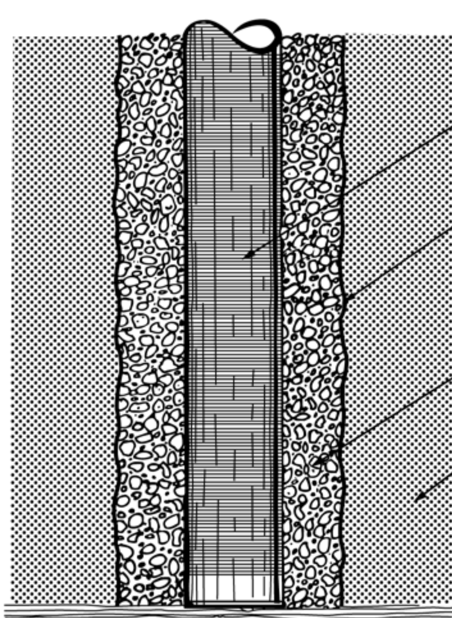

FIG. 1 Example of Rectifying Damage Done During Drilling

5.1.3 To stabilize formation and artificial filter pack materials (where applicable) adjacent to the well screen (see Fig. 2[3]);

NOTE 4—After well development, formation materials in "naturally developed" wells (left) and filter packed wells (right) should be stabilized such that potential entry of fine-grained materials into the well is reduced, little settlement occurs, and groundwater flow to and from the well is not significantly hindered or impaired.

5.1.4 To retrieve potentially lost drilling fluid (if drilling fluid was used in the borehole installation process) that may alter the quality of groundwater in the vicinity of the well and interfere with groundwater quality analysis (see Fig. 3[3]); and

NOTE 5—When drilling with water-based drilling fluids, some drilling fluid will infiltrate beyond the borehole into the most permeable zones. This creates the mud cake effect desired by well drillers as one of the means of keeping a borehole open during the drilling process. One of the purposes of development is to remove this drilling fluid from the formation adjacent to the open interval of the well.

5.1.5 To increase the potential well efficiency and hydraulic communication between the well and the adjacent formation to provide for the acquisition of representative groundwater samples and conduct aquifer performance tests.

6. Conducting a Monitoring Well Development Program

6.1 *Well Development Process*—The well development process consists of three phases: predevelopment, preliminary development, and development. If a monitoring well is inherited with a project, the three well development phases should be evaluated by the well construction contractor and/or qualified personnel prior to groundwater sampling or completing aquifer performance tests.

6.1.1 Predevelopment refers to techniques used to mitigate potential formation damage during the drilling and well construction processes. This is particularly important when using direct or reverse rotary drilling systems that depend on drilling fluid to carry cuttings to the surface and support an open borehole. Control and monitoring of drilling fluid properties, during the drilling operation and immediately prior to the installation of screen, casing, and filter pack, is very crucial and should be documented during the drilling process.

6.1.2 Preliminary development takes place after the screen, casing, and filter pack have been installed. Methods used to accomplish this task include surging, bailing, hydraulic jetting, and air lifting. The primary purpose of this operation is to apply sufficient energy in the well to address potential formation damage from the drilling process; removal of fine-grained sediment from the screen, filter pack, and geologic formation adjacent to the filter pack; stabilization and overall consolidation of the filter pack; retrieval of drilling fluid (if used); and creation of an effective hydraulic interface between the well and the geologic formation through the filter pack.

6.1.2.1 During this phase of well development, the preferred technique is to gradually apply the selected well development method, increasing intensity as long as the well responds to treatment. Response generally is indicated by increased yields of water and sediment, typically fine-grained. Intensive development of a well that appears to be plugged should not be

[3] Figure adapted from *Ground Water and Wells*, Second edition, 1986.