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USACE / NAVFAC / AFCEC / NASA **UFGS-33 11 13 (August 2017)**

Preparing Activity: USACE **Superseding**
UFGS-33 20 00 (April 2008)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2021
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DIVISION 33 - UTILITIES

SECTION 33 11 13

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08/17

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-- End of Section Table of Contents --

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SECTION 33 11 13

POTABLE WATER SUPPLY WELLS
08/17

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NOTE: This guide specification covers the requirements for drilling of water supply wells, furnishing and installing the pump, and associated testing.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).

****

PART 1 GENERAL

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DRAWINGS

Drawings should include the following and any other information necessary to indicate layout and general configuration of the well.

Diameter of drilled hole

Casing sizes - outside casing, inside casing

Well screen size

Minimum depth of outer casing and minimum depth of well screen

Limits of gravel envelope around inside casing and screens

Limits of neat cement grout around outer casing

Location of air line and altitude gage

Type of cap, cover, or seal required at top of well

Required well capacity in gallons per minute.

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1.1 UNIT PRICES

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NOTE: Separate pay items for test holes and water wells must be included in the contract.

If Section 01 20 00 PRICE AND PAYMENT PROCEDURES is included in the project specifications, appropriately edit this subpart and move into Section 01 20 00.

****

Payment for each specified item will be made at the contract unit price for that item. Payment includes full compensation for equipment, materials and labor for drilling; removal and disposal of temporary casing, cuttings, and drill fluid; preparation of borehole logs; and sample handling, containers, storage, and testing. Measure depth, logging, installation, casing, riser pipe, and well screen by linear distance. Payment is not allowed for test wells or wells abandoned due to construction practices not in accordance with this specification, faulty construction practices or for the convenience of the Contractor.

1.1.1 Test Well

Compensation for the test well will be made at the contract unit price and includes material, equipment, and labor required to drill and perform tests on the test well. Measure depth as the total linear distance between ground surface and bottom of hole. If the total depth of hole is greater than that specified on the contract for "Test Well," the additional depth will be paid for at the contract unit price for "Additional Test Well Depth." If the test well is developed into the permanent well with no increase in diameter, compensation will be as described below, and separate payment will not be made for the test well.

1.1.2 Water Well

Compensation for the water well will be made at the contract unit price and includes material, equipment, and labor required to drill, develop, perform tests, and complete the permanent well. Measure depth as the total linear distance between ground surface and bottom of hole. If the total depth of well is greater than that specified in the contract for "Water Well," the additional depth will be paid for at the contract unit price for "Additional Water Well Depth."

1.1.3 Observation Well

Compensation for an observation well will be made at the contract unit price and includes material, equipment and labor required to drill, install, and complete the observation well, as well as perform tests and permanently grout it after use. Measure depth as the total linear distance between ground surface and bottom of hole. If the total combined depth of observation wells is greater than that specified in the contract for "Observation Wells," the additional depth will be paid for at the contract unit price for "Additional Observation Well Depth."

[1.1.4 Geophysical Logging

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NOTE: Delete this paragraph if not applicable for the project.
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The "Geophysical Logging" unit price will include interpretation of the logs and their delivery to the Government.

]1.1.5 Well or Test Well Decommissioning or Abandonment

Permanent decommissioning or abandonment of wells or test wells will be paid for only if it becomes necessary to abandon a well or test well as specified, and only for work completed and accepted as specified. Payment includes compensation for drilling, casing removal, well sampling, materials, cement, mixing of cement, bentonite, and water, pumping of grout, equipment, removal of foreign objects, and transportation necessary to abandon the well or test well and for the required well or test well abandonment records.

1.1.6 Cleanup

Separate payment will not be made for cleanup of the site. Cleanup means restoring the site to its pre-construction condition, in accordance with paragraph SITE CLEANUP. Cleanup is considered part of and incidental to the drilling, construction, or decommissioning of the well.

1.2 REFERENCES

****
NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile

references in the publish print process.
****

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA 10084	(2017) Standard Methods for the Examination of Water and Wastewater
AWWA A100	(2020) Water Wells
AWWA B300	(2018) Hypochlorites
AWWA B301	(2010) Liquid Chlorine
AWWA C200	(2012) Steel Water Pipe - 6 In. (150 mm) and Larger
AWWA C206	(2017) Field Welding of Steel Water Pipe
AWWA C654	(2013) Disinfection of Wells

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A139/A139M	(2016) Standard Specification for Electric-Fusion (ARC)-Welded Steel Pipe (NPS 4 and over)
ASTM A312/A312M	(2019) Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
ASTM C136/C136M	(2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C150/C150M	(2020) Standard Specification for Portland Cement
ASTM D1586/D1586M	(2018) Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils
ASTM D1587/D1587M	(2015) Thin-Walled Tube Sampling of Soils for Geotechnical Purposes
ASTM D1784	(2020) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D1785	(2015; E 2018) Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe,

	Schedules 40, 80, and 120
ASTM D2216	(2019) Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
ASTM D2239	(2012) Standard Specification for Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter
ASTM D2487	(2017; E 2020) Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D2488	(2017; E 2018) Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)
ASTM D4318	(2017; E 2018) Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D5088	(2020) Decontamination of Field Equipment Used at Nonradioactive Waste Sites
ASTM D5299/D5299M	(2017) Standard Guide for Decommissioning of Ground Water Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities
ASTM D5521/D5521M	(2013) Standard Guide for Development of Ground-Water Monitoring Wells in Granular Aquifers
ASTM D5608	(2016) Decontamination of Field Equipment Used at Low Level Radioactive Waste Sites
ASTM F480	(2014) Thermoplastic Well Casing Pipe and Couplings Made in Standard Dimension Ratios (SDR), SCH 40 and SCH 80

U.S. ARMY CORPS OF ENGINEERS (USACE)

CED TR GL-85-3	(1985) Geotechnical Descriptions of Rock and Rock Masses

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA 600/4-79/020	(1983) Methods for Chemical Analysis of Water and Wastes

1.3 ADMINISTRATIVE REQUIREMENTS

1.3.1 Notification

Notify the [Installation Environmental Coordinator (IEC)][_____][and the] Contracting Officer [21][_____] days prior to drilling. The [Contracting Officer][Contractor][Installation Environmental Coordinator

(IEC)][_____] is responsible for contacting the [State of [_____]][USEPA] in accordance with the applicable reporting requirements. Before beginning work, notify the local United States Geological Survey office (USGS)[and the][State Environmental Protection office][State Geological Agency][state health department][local health department] of the type and location of wells to be constructed, the method of construction and anticipated schedule for construction of the wells.

1.3.2 Delivery, Storage, and Handling

Store and maintain well materials in a clean, uncontaminated condition throughout the course of the project. Do not allow filter pack material to freeze before installation.

1.3.3 Project and Site Conditions

Access to each well site, including any utility clearance, permits, licenses, or other requirements and the payment thereof necessary for execution of the work, is the responsibility of the [Contractor][Government]. Furnish a copy of all permits, licenses, and other legal requirements necessary for execution of the work [30][_____] working days before commencement of the work. Obtaining rights-of-entry is the responsibility of the [Contractor][Government]. Visit each proposed well location to observe any condition that may hamper transporting equipment or personnel to the site. [If clearing, or relocation is necessary, the Contractor, [Installation Environmental Coordinator,]and the Contracting Officer must agree on a suitable clearing, or relocation plan, and the location of any required access road.]

1.3.4 Water Well Design Requirements

1.3.4.1 Well Installation Plan

Submit a plan as specified herein describing the drilling methods, sampling, and well construction and well development [30][_____] calendar days prior to beginning drilling operations. Mobilization activities may start prior to submittal of the plan. The plan must be approved and signed by an experienced geologist as specified in paragraph QUALIFICATIONS. Incorporate the following requirements into the Well Installation Plan and follow them in the field. the design of the well is to be based on the various aspects analyzed and contained in this plan (boring log, geophysical log, geotechnical report, sieve analysis, etc.). The plan must include, but not be limited to, a discussion of the following:

a. Description of well drilling methods, and installation procedures, including any temporary casing used, placement of filter pack and seal materials, drill cuttings and fluids disposal, and soil and rock sample disposition.

b. Description of well construction materials, including well screen, riser pipe, centralizers, air line and gauge, tailpiece (if used), filter pack and filter pack gradation, bentonite or drilling mud, drilling fluid additives (if used), drilling water, cement, and well protective measures.

c. Description of quality control procedures to be used for placement of filter pack and seals in the boring, including depth measurements.

d. Forms intended for written boring logs, installation diagrams of wells, geophysical logs, well development records, well sampling data records, state well registration forms, and well abandonment records.

e. Description of contamination prevention and well materials and equipment decontamination procedures.

f. Description of protective cover surface completion procedures, including any special design criteria or features relating to frost heave prevention. Include the maximum frost penetration for the site in this description.

g. Description of intended well development methods.

h. List of applicable publications, including state and local regulations and standards.

i. List of personnel assignments for this project, and personnel qualifications.

j. Description of well decommissioning or abandonment procedures.

k. Description of well capacity testing techniques.

l. Description and discussion of geophysical techniques to be employed at the site.

m. Description of permanent pump to be installed, and discussion of pump operating tests to be employed at the site.

n. Description of specific methods to be employed to control potential contamination or pollution arising from well installation activities.

o. Description of plumbness and alignment testing.

p. Description of specific methods employed to test for sand.

1.3.4.2 Test Wells

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NOTE: The test well and capacity test should be specified if there is reason to believe that the well may not produce the required yield at the design depth. If the required yield is not obtained, the test well may be drilled deeper or the location changed before the complete well is constructed. Requirements for the test well may be deleted if the well is to be constructed in an area where other wells of similar depth and design are performing adequately. However, a drill log should be made and capacity test should be performed for all wells to provide an "as-built" record.
****

Before starting construction of the well, drill a test well of at least [100][_____] mm[4][_____] inches in diameter at the location of the well into the target water bearing [stratum][strata]. Drill test wells in a manner to protect the subsurface from surface contamination. Carefully

advance test wells and sample to determine the presence of the upper aquiclude if one exists. Properly case, grout and seal the boring into the aquiclude before the boring is advanced through the aquiclude into the aquifer. Use the test well to determine the expected flow, optimum depth for flow, water quality, and to identify the strata encountered. Before conducting a capacity test, case the well, and screen in accordance with these specifications. Log test wells in accordance with paragraph BOREHOLE LOGS. A temporary casing [may][must] be used. If used, seat the temporary casing [into the top of the rock][at the top of the stratum being tested]. The test well may be converted to the permanent well, in accordance with these specifications. If the test well is not used for the permanent well, abandon the test well as specified in paragraph WELL DECOMMISSIONING OR ABANDONMENT.

1.3.4.3 Sampling for Geotechnical Analysis

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NOTE: Sampling for chemical and geotechnical analysis may be combined to allow for obtaining samples for both if that accomplishes project requirements. If rock is cored at the site, and it is determined that it should be retained, it should be boxed, and photographed. Its storage, and later disposal should be in accordance with ER 1110-1-1901, and the proper storage and handling protocol for such material as may be required by other Federal, state, or local laws, regulations and permits.

****

Take samples of all materials penetrated by each drilled well or test well. Obtain soil samples with a [split][thin-walled] tube sampler using standard sampling techniques in accordance with [ASTM D1586/D1586M][ASTM D1587/D1587M]. Extract samples from their in-situ environment in as near an intact, minimally disturbed condition as technically practical. Obtain samples continuously through the area expected to be screened. Provide sieve analyses of all drive-sampled material. Conduct sieve analyses in accordance with ASTM C136/C136M. Determine the gradation of the natural formation through the use of sieve analyses performed on formation samples taken from the areas to be screened. Place drive-sampled materials in airtight containers and label as specified in paragraph SAMPLE CONTAINERS. Deliver samples to the [Contracting Officer][designated facility]. Test representative soil samples for grain-size distribution by mechanical means (sieves down to the 0.074 mm No. 200 size according to ASTM C136/C136M), moisture content according to ASTM D2216 and Atterberg limits according to ASTM D4318. Describe and identify soils in accordance with ASTM D2488. Perform laboratory classification of soils in accordance with ASTM D2487. Perform sampling to allow completion of the documents described in paragraph BOREHOLE LOGS.

1.3.4.4 Observation Wells

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NOTE: In some cases an observation well or wells should be drilled an appropriate distance from the test hole or pump well. The observation wells (piezometers) should be monitored during the yield test of the test hole and/or capacity test of the pump well so that valid information of aquifer

potential and character may be obtained. The observation wells must be designed, installed and removed from service in a manner that precludes the possibility of future groundwater contamination resulting from their existence. If the decision is made to keep the observation well for future sampling, or for use in future pumping tests, the observation wells must be properly completed as specified in this section, or other USACE guidance, such as Section 33 51 39 GROUND-WATER MONITORING WELLS.

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After completion of the [test well][pump well][_____], drill [one][_____] observation well(s)[, or more as directed], at least [45][_____] mm [1-3/4][_____] inches in diameter to the target water bearing stratum, [at the location(s) indicated][at a location [_____] mfeet from][at an appropriate location near] the [test well][pump well][_____]. Use the observation well[s] in conjunction with the [yield test of the test well][and][capacity test of the pump well]. After final acceptance of the pump well by the Contracting Officer, the observation well must be [abandoned as specified in paragraph WELL DECOMMISSIONING OR ABANDONMENT][left in place for future monitoring of the well system].

[1.3.4.5 Geophysical Logging

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NOTE: The requirement to obtain borehole geophysical surveys is optional. While it may not be necessary to require a borehole geophysical survey at a site where a great deal is known about the subsurface, at another site, where very little, or nothing is known, it may be prudent to require a borehole geophysical survey. When it is deemed necessary to require a borehole geophysical survey, the specific type of survey should be specified. This recommendation is made by the project geologist. The project geologist should also determine what geophysical logging may not be allowed by state regulations, before specifying them. See EM 1110-1-1802, Geophysical Exploration. Guidance for planning and conducting borehole geophysical logging may be found in ASTM D5753.

****

Geophysically log the total depth of each test well drilled. Document geophysical logging in accordance with paragraph GEOPHYSICAL LOGS. Run [one successful natural gamma ray or gamma-gamma for the full depth, (top to bottom of test well);][one successful neutron in the fluid filled portion of the well, (top to bottom of test well);][one successful (top to bottom of test well) spontaneous potential (self-potential);][and,][one successful (top to bottom of test well) resistivity log], for each test well. Log analyses and interpretations must be made by a person qualified in accordance with paragraph QUALIFICATIONS.

]1.3.5 Qualifications

Submit personnel qualification documentation. A geologist with at least [3][_____] years experience in soil and rock logging, and well

installation, [registered in the state of [_____],]must be on site during drilling, installation, and testing activities, and be responsible for all geophysical and borehole logging, drilling, well installation, developing and testing activities. Employ a driller licensed in the state of [_____], according to the state requirements. Geophysical logs must be interpreted by a qualified log analyst. Demonstrate the log analyst competence through background, training, and experience when so called upon. Document a minimum of [_____] years of well installation experience. [Have on staff appropriate health and safety personnel as specified in Section 01 35 29.13 HEALTH, SAFETY, AND EMERGENCY RESPONSE PROCEDURES FOR CONTAMINATED SITES, and personnel qualified to perform the necessary chemical sampling as presented in the approved Sampling and Analysis Plan.]

1.4 SUBMITTALS

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NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a “G” to an item, if the submittal is sufficiently important or complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

****

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation Diagrams; G[, [_____]].

SD-03 Product Data

Well Material

Geophysical Logging

Cement and Bentonite Grout

Drilling Mud

Well Screens

SD-05 Design Data

Well Installation Plan; G[, [_____]]l

SD-06 Test Reports

Water Source; G[, [_____]].

Filter Pack

Capacity Test

Test For Plumbness And Alignment

Water Quality Test

Sand Test

Tests

SD-07 Certificates

Site Conditions

Project Photographs

Qualifications

Casing

Air Line and Gauge

Graveling Equipment list

Construction of Filter Pack

SD-11 Closeout Submittals

Survey Maps And Notes; G

Well Development Records

Geophysical Logs

Decommissioning or Abandonment Record

PART 2 PRODUCTS

2.1 CASING

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NOTE: Well components do not have to be made of the same materials to be compatible. With the proper connectors, different materials can be used together without causing detrimental results. When using different materials together, the manufacturer should be consulted.

Edit the submittal requirements based on the type of well (consolidated or unconsolidated). If the specification is written for a consolidated well, delete the well components which are not normally required in consolidated formations, such as inner casing, well screen, and gravel fill.
****

All casing, screen, and other well material must be of compatible materials to prevent galvanic reaction between components of the completed well. Submit catalog data, and name of supplier, for well screens (to include the screen slot size), casing, riser pipe, filter pack material, bentonite, cement, centralizers, surface protective covers, well vaults, locking caps, airline oil filters for pneumatic drilling, dedicated sampling equipment, pumps, and chemical specifications on drill lubricants, tracers, disinfecting agents, and drill fluid additives, if used. Catalog data must include any information, supplied by the manufacturers or suppliers of the above listed items.

2.1.1 Steel Casing and Couplings

Steel casing must be new [carbon steel, conforming to ASTM A139/A139M Grade B][standard weight [galvanized][black]steel pipe, conforming to ASTM A53/A53M][steel pipe conforming to AWWA C200][[type 304][or][type 316] stainless steel] and nominal [_____] mminch diameter, [_____] mminch wall thickness [schedule 5S meeting the requirements of ASTM A312/A312M], as applicable. Joints must be either threaded and coupled, or field welded in accordance with AWWA C206. [Provide casings with [drive shoes][_____].]

2.1.2 Plastic Casing and Couplings

****
NOTE: ASTM F480 covers several different types of pipe materials and coupling configurations. If any of these materials or couplings are to be prohibited, this paragraph should clearly point out which are or are not allowed.
****

Plastic casing pipe and couplings must be schedule [80][___], threaded flush joint[or other joint type as approved by the Contracting Officer]and conform to ASTM F480 and ASTM D1785.

2.2 WELL SCREENS

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NOTE: Well screens will be specified when the developed well requires assurance of relatively free entry of water into the casing at low velocity, when surrounding sand from the unconsolidated formation must be prevented from entering the intake, or when a structural retainer is required to support the borehole in the unconsolidated material. Type of screen and casing will be designer's option and nonapplicable type of screen will be deleted. Metal screens and casings will be specified when strength of screen and casing must be greater than that provided by plastic or when maximum open area for the screen diameter is required. Plastic screens and casing may be specified when water quality is such that screen selection requires corrosive-resistant materials, or when economy is of prime importance. Blanks in the well screen may be appropriate if more than one water bearing zone is encountered in an aquifer, or when it is necessary to place a centering device (centralizer) in the screened area. However, screening more than one aquifer in the same well should be avoided whenever possible due to the possibility of cross-contamination.

****

a. Well Screens must be a minimum of [100][_____] mm[4][_____] inches nominal diameter, and must be directly connected to the bottom of the inner casing by an approved method. The length of the screen must be sufficient to provide an intake area capable of passing not less than the minimum required yield of the well, at an entrance velocity not exceeding 30.5 mm/s0.1 fps.

b. The opening, or slot size of the screen, must be [[_____] mminch][determined by the Contractor][designed based on analysis of the distribution of the grain size of the[aquifer materials encountered during drilling][artificial filter pack]], be compatible with the material surrounding the screen. Submit as part of the well installation plan.

c. The well screen must be of sufficient size and design to hold back and support the [gravel used in the filter pack envelope][and][in-situ material surrounding the screen].

d. Use screen and all accessories required for satisfactory operation that are standard products of manufacturers regularly engaged in the production of such equipment. Field constructed screen is not acceptable.

e. "Blanks" in the well screen may be utilized in nonproductive zones, or where centering devices are needed in the screened area, and area considered "casing."

f. Seal the bottom section, below the screen, watertight by means of a [flush threaded][welded] end cap of the same material as the well

screen.

2.2.1 Metal Screen

Metal screen must be an approved wire-wound type of [type 304][or][type 316]stainless steel, conforming to the applicable requirements of AWWA A100. A wire-wound screen manufactured with supporting bars or core of material different from the wire will not be acceptable. Make joints of threaded couplings of the same material as the screens or by brazing or welding in accordance with AWWA C206.

2.2.2 Plastic Screen

2.2.2.1 Plastic Pipe

Plastic pipe, and screen material must conform to ASTM F480. All PVC plastic pipe must conform to ASTM D1785.

2.2.2.2 Bonding Materials

****

NOTE: When sampling for trace level contaminants in a well, the use of any solvents to join casing should not be allowed.

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Bonding materials, proportions and preparation of adhesives, the method of application, and the procedure used for making and curing the connections must conform to the recommendations of the plastic pipe manufacturer and ASTM F480. The pot life, initial setting time and external heating requirements for curing of the adhesive must be suitable for the procedure and climatic and other conditions and must be varied as required to suit changes in climatic and other conditions. Use a system for making joints at the well site that provides a curing period adequate to develop the ultimate strength of the completed joint. Self-tapping screws or other devices for holding adhesive-coated pipe in the couplings during the setting period [may][must not] be utilized. Do not stress newly-made joints in the casing, lower into the well, or submerge in water prior to complete curing of the adhesive.

2.2.2.3 Plastic Well Screen

Provide plastic well screen with perforations consisting of either machine-sawed slots, continuous wrap or wound, or drilled, formed, or molded openings, and have smooth, sharp-edged openings free of burns, chipped edges, or broken pieces on the interior and exterior surfaces of the pipe. The pattern of the openings must be uniformly spaced around the periphery of the well screen. Design and submit compatible slot sizes of screens and [filter-pack gradations][surrounding material] to the Contracting Officer[, with a representative sample of materials in which the screen is to be placed]. The plastic pipe screen strength properties must be equivalent to those for the plastic casing with which the screen is used. Plastic well screen is to be ASTM D1784 compliant.

2.3 FILTER PACK

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NOTE: The use of artificial filter-pack construction is recommended in formations where the

screen slot opening, selected on the basis of a naturally developed well, is smaller than 0.25 mm 0.010 inch (No. 10 slot). Artificial filter-pack material should also be specified when fine uniform material, or extensively laminated, non-homogenous formations are encountered. Guidance for designing and selecting the screen slot size, and filter pack gradation may be found in EPA's "Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells", (EPA document number 160014-891034); or "Groundwater and Wells", by Fletcher G. Driscoll, published by Johnson Well Screens, 1986.

If the well is not a filter pack type, this paragraph should be deleted in its entirety, along with other references to filter pack wells throughout the specification. When requiring sterilization, the strength of the sterilizing agent should be stated, and how much is required per cubic yard of filter pack.

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Provide filter pack material that is a product of a commercial sand and gravel supplier, sized and graded for the surrounding soil encountered, and composed of clean, round, hard, waterborne siliceous material, free of flat or elongated pieces, organic matter, or other foreign matter. Submit filter pack material test results; sieve and chemical analyses, within [5][_____] working days after completion of the test well. Size the filter material which will allow the maximum flow of water into the well and prevent the infiltration of sand and silt. The gradation of the filter material must have a uniformity coefficient of not more than 2.5. The filter material must be [thoroughly sterilized with chlorine or hypochlorite immediately before being placed][placed as directed]. Manufactured glass beads made of soda lime glass, SiLi beads, or similar products designed for use in potable water wells may be used as filter pack in lieu of natural quartz sand.

2.4 BENTONITE SEAL

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NOTE: Before installing an annular seal, the state regulatory agency should be consulted. The state, or local municipality, where the well is being installed, may have specific requirements for sanitary, and/or wellhead protection.

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Provide bentonite seal, intended to keep grout from entering the filter pack, consisting of hydrated granular, or pelletized, sodium montmorillonite furnished in sacks or buckets from a commercial source, and free of impurities which adversely impact the water quality. If the bentonite seal is located above any borehole fluid levels, place a layer of fine sand at the top of the bentonite seal, to provide an additional barrier to any downward migration of grout.

2.5 CEMENT AND BENTONITE GROUT

2.5.1 Cement Grout

Provide cement grout consisting of Portland cement conforming to ASTM C150/C150M, Type I or II, sand and water. Proportion cement grout not to exceed 2 parts, by weight, of sand to 1 part of cement with not more than 23 liters6 gallons of water per 42.6 kg94 lb bag of Portland cement, with a mixture of such consistency that the well can be properly grouted. No more than 5 percent by weight of bentonite powder may be added to reduce shrinkage.

2.5.2 Bentonite Grout

Make high-solids bentonite grout from sodium bentonite powder, granules, or a combination of the two. Mix water from an approved source with these powders or granules to form a thick bentonite slurry. The slurry must consist of a mixture of bentonite and the manufacturer's recommended volume of water to achieve an optimal seal. The slurry must contain at least 20 percent solids by weight and have a density of 4.3 kg/L9.4 lb/gallon of water or greater.

2.6 PERMANENT PUMP

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NOTE: The pump and motor diameter should be at least 25 mm1 inch smaller than the inside diameter of the well screen or casing, whichever is smaller, in order to allow it to be removed for servicing after buildup of scale on the outside of the pump and inside of the well screen and casing. A permanent pump should not be specified until it is known how much the well will produce. The installation of the permanent pump may need to be in a separate section, (refer to Section 23 21 23 HYDRONIC PUMPS).

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Permanent pump must be an approved [submersible][jet][or][_____]type with a capacity sufficient to deliver [_____] L/sgpm. Connect the pump to the pump controls by a three-wire drop line. Provide [polyethylene plastic pipe conforming to ASTM D2239][galvanized steel pipe conforming to ASTM A53/A53M] piping for the well drop line. Operate the pump on [208][_____] volts, 60 Hz,[3][single]-phase power, with the motor of sufficient size to operate the pump under the maximum operating conditions without exceeding its rating. Equip the pump with necessary controls to provide for automatic operation of the pump. The pump and motor unit must be no larger than [_____] mminches in diameter at any point.

2.7 CONTAINERS FOR DRILL CUTTINGS AND CORED ROCK SAMPLES

2.7.1 Containers for Drill Cuttings

Drill cuttings and driven samples required for geotechnical purposes are to be sealed in air-tight literpint size [plastic][glass] containers. Place individual sample containers in partitioned [cardboard][_____] boxes.

2.7.2 Labelling of Drill Cutting Containers

Label individual sample containers with the project name, date of sample, well number and depth at which the sample was taken. Label both the container and lid in permanent indelible ink. Label partitioned cardboard box with project number and well number.

2.7.3 Packaging of Cored Rock Samples

Place cored rock samples in [wooden][_____] core boxes as indicated. Place spacers in the proper positions in the core boxes to show the location and actual extent of voids and core losses as clearly as possible. Make the spacers of [wood][_____] [or some other relatively light material] which is of sufficient strength to withstand jarring and crushing in handling. Spacers must be of a strongly contrasting color pattern so that core losses will be accented either by direct observation or in photographs. In the smaller sizes, up to and including 150 mm6 inches, provide spacers the same width as the cores. Place the core in the core box starting at the left hand corner on the hinge side and running to the right. Place successive cores down the hole in successive troughs, starting from the back and working toward the front of the box so that the core can be read in the same manner as a printed page, from left to right, when standing in front of the open box.

2.7.4 Labeling of Cored Rock Sample Containers

Label the outside and the inside of the core box lid with the project name, hole number, date sampled, location, surface elevation, core box number, and interval of depth of core. The information on the label must be such that it can clearly be read in photographs of the core box. Also, label both ends of the core box with the hole number and box number.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Protection of Existing Conditions

Maintain existing survey monuments and wells, and protect them from damage from equipment and vehicular traffic. Repair any items damaged during this work. Reinstall wells requiring replacement due to Contractor negligence according to these specifications. Protect wells scheduled for abandonment from damage so that abandonment may be performed according to these specifications. Prior to commencement of drilling, obtain written approval from the local utility companies to drill at each site, to avoid disturbing buried utilities.

[3.1.2 Decontamination

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NOTE: It may not be necessary to decontaminate the drilling equipment but the designer should consider whether it is prudent to require that the equipment be decontaminated before use since this well will be used for potable water. Delete this paragraph if it is not applicable for this project .

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Clean the drill rig, drill rods, drill bits, augers, temporary casing,

well developing equipment, tremie pipes, grout pumping lines, and other associated equipment with high-pressure hot water/steam prior to drilling at each well location. Decontaminate in accordance with ASTM D5088 or ASTM D5608. Decontaminate at a central decontamination station in an area that is remote from, and cross- or down-gradient from the well being drilled. Clean screen and well casing with high-pressure hot water immediately prior to installation in the well. The use of factory sealed (plastic wrapped) screen and well casing does not waive this requirement for pre-installation cleaning. Decontaminate samplers in accordance with the Sampling and Analysis Plan. Use water for cleaning from a Government approved source. Sample and test the water source used for cleaning for the constituents specified in the Sampling and Analysis Plan prior to use at the site.

3.1.3 Water Source

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NOTE: Delete this paragraph if not applicable for the project.

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Submit decontamination and drilling water source analytical test results obtained from the Sampling and Analysis Plan, within [_____] working days before beginning drilling operations. The Contractor is responsible for locating the source, obtaining the water from the source, transporting it to, and storing it at the site.

]3.2 DRILLING, CONSTRUCTION AND TESTING

3.2.1 Well Drilling and Construction

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NOTE: The geologist must be aware of the approximate depth of well and length of screen required to provide sufficient water to fulfill project requirements and the quality of water to be expected at that depth. (The Post, or Resident Engineers office, or local USGS office is a good source for this information.) This knowledge is necessary to estimate well drilling costs and to determine what type of treatment is required to make the water usable. Any such site-specific conditions or criteria for individual projects should be included in this paragraph. The geologist must ensure that well design meets or exceeds Federal, state, and local installation requirements. Guidance on water well construction may be found in Environmental Protection Agency (EPA) Manual of Water Well Construction Practices (570/9-75/001).

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Locate the well [as indicated][where directed], and construct in accordance with these specifications. Install each well to prevent aquifer contamination by the drilling operation and equipment, intra- and inter-aquifer contamination, and vertical seepage of surface water adjacent to the well into the subsurface, especially the well intake zone.

If a well of the required capacity is not constructed, or if the well is abandoned because of loss of tools, or for any other cause, abandon the

hole as specified in paragraph WELL DECOMMISSIONING OR ABANDONMENT.

3.2.1.1 General

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NOTE: Delete prohibition against organic drilling fluid, and grease, oil, and fuel leaks on equipment if not installing wells at an HTRW site, or if not applicable for the project.

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a. Use the drilling method approved by the Contracting Officer and in conformance with all state and local standards for water well construction. Execute the work under the direct supervision of an experienced well driller. The drilling method must prevent the collapse of formation material against the well screen and casing during installation of the well.

b. The inside diameter of any temporary casing used must be sufficient to allow accurate placement of the screen, riser, centralizer(s), filter pack, seal and grout. [Any drilling fluid additive used must be inorganic in nature, but phosphate free. Grease or oil on drill rods, casing, or auger joints is not permitted; however, PTFE tape or vegetable oil (in solid phase form) are acceptable. The drill rig must be free from leaks of fuel, hydraulic fluid, and oil which could contaminate the borehole, ground surface or drill tools.]

c. Use casing pipe, well screens, and joint couplings of compatible materials throughout each well.

d. The well must be a [filter pack well][naturally developed well] activated in the [overburden][water-bearing stratum][stratum based on test well data].

e. Drill the well straight, plumb, and circular from top to bottom. Initially drill the well from the ground surface to the [uppermost level of the water bearing strata][top of rock][_____] and the bottom of the outer casing set at this elevation. The hole below the outer casing must penetrate the water bearing stratum a sufficient depth to produce the required amount of water without causing excessive velocities through the aquifer.

f. During construction of the wells, use precautions to prevent tampering with the well or entrance of foreign material. Prevent runoff from entering the well during construction.

g. If there is an interruption in work, such as overnight shutdown or inclement weather, close the well opening with a watertight uncontaminated cover. Secure the cover in place or weigh down so that it cannot be removed except with the aid of the drilling equipment or through the use of drill tools.

3.2.1.2 Setting Outer Casing

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NOTE: There is a provision for temporary casing, as extraction and/or injection wells may not require a permanent outer casing.

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The outer casing must not be less than [200][_____] mm[8][_____] inches in diameter. The hole must be of sufficient size to leave a concentric annular space of not less than [65][_____] mm[2-1/2][_____]inches and not more than [150][_____] mm[6][_____]inches between the outside of the outer casing and the walls of the hole. Fill the annular space between the outer casing and the walls of the holes with cement grout. Acceptable methods of grouting are detailed in AWWA A100; select a method specifying the forcing of grout from the bottom of the space to be grouted towards the surface. Provide a suitable grout retainer, packer, or plug at the bottom of the outer casing so that grout will not leak into the bottom of the well. Continuously grout to ensure that the entire annular space is filled in one operation. After grouting is completed, do not resume drilling operations for at least [72][_____] hours to allow proper setting of the grout.

3.2.1.3 Temporary Casing

Have temporary well casing available at the construction site of either iron or steel of sufficient length to case to the bottom of all borings. The Contracting Officer will direct the use of a temporary casing to the bottom of the boring during drilling and placement of screen, riser, and filter pack when determined it is necessary to provide adequate support to the sides of the hole. When the walls of the boring require support only during development operations, provide a temporary casing to extend only to a depth 1 m3 feet below the top of the filter pack. The temporary casing, must have an inside diameter of not less than [_____] mminches, of sufficient thickness to retain its shape and maintain a true section throughout its depth, and in sections of any convenient length. The temporary casing must permit its removal without disturbing the filter pack, riser, or well screen. Set the temporary casing so that no cavity will be created outside of it at any point along its length. In the event the temporary casing should become unduly distorted or bent, discard it and use new casing during installation of any additional well.

3.2.1.4 Construction of Inner Casing and Screen

After the grout has set, ream the hole below the outer casing at the required diameter, to the required depth, by an approved method which prevents caving of the hole before or during installation of the filter pack, well screen and inner casing. Contractor may elect to increase the size of the outer casing and drill to the diameter of the filter pack with an annular space between the inner casing and outer casing equal to the thickness of the filter pack. Firmly attach the well screen and inner casing, and lower into the hole by a method which allows for control of the rate of fall of the well screen and inner casing at all times. Do not drop well screen and inner casing, or allow to fall uncontrolled into the hole. Extend the inner casing up through the outer casing to [_____] metersfeet [above][below] the ground surface. Install 3 approved centering devices spaced at 120 degrees between the outer casing and inner casing prior to well construction at [intervals not exceeding [8][_____] m [25][_____]feet along the length][the top of the inner casing and the bottom of the outer casing]. If the screen length is greater than [8][_____] meters[25][_____] feet, place a [1][_____] meter[3][_____] foot length of blank casing in the middle of the screen interval for placement of centering devices. Do not place centering devices on the screened interval, or within the bentonite seal, if used.

3.2.1.5 Construction of Filter Pack

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NOTE: If the natural formation is developed as the well filter, then this paragraph may be deleted. If development of the well is done after the filter pack is installed, but before the bentonite, or annular seal is installed, additional filter pack material may have to be added, if the level of the top of the filter pack drops below the specified elevation for the top of the filter pack.

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a. After the screen and inner casing have been concentrically set in the hole below the outer casing, construct the approved filter pack around the screen by filling the entire space (annulus) between the screen and the wall of the hole in the water bearing stratum with filter pack material.

b. Obtain any water added to the filter pack material in accordance with paragraph WATER SOURCE.

c. Lower a tremie pipe having an inside nominal diameter of not less than [40][_____] mm[1-1/2][_____] inches to the bottom of the well between the hole and screen (i.e., the annulus). Arrange and connect the tremie pipe, at the surface of the ground, to water pumping and graveling equipment so that water and filter material, fed at uniform rates, are discharged as the filter material fills the hole from the bottom up. Raise the tremie pipe at a rate that will keep the bottom of the pipe no more than [1][_____] m[3][_____] feet above the filter material level at all times.

d. If there is a desire to use methods of placing filter material other than those specified, submit the details of the method and equipment proposed to the Contracting Officer, before filter pack placement begins; however, dumping filter pack material from the surface of the ground and agitating the well in an effort to settle the filter will not be allowed.

e. Install the filter pack continuously and without interruption until the filter pack has been placed to within [300 mm1 foot of the top of the inner casing][1.5 m5 feet of the ground surface][[10][_____] m [30][_____] feet above the top of the screen]. Directly measure and record the depth to the top of the filter pack.

f. Protect filter pack material from contamination prior to placement by either storing it in plastic lined bags, or in a location protected from the weather and contamination on plastic sheeting. Do not allow filter pack material to freeze before installation. Transport filter pack material to the well site in a manner which prevents contamination by other soils, oils, grease, and other chemicals.

g. Temporary drill casing, if installed, or hollow stem auger, must be removed simultaneously with the above operation.

h. Place filter pack material in no greater than 1 m3 foot lifts prior to retraction of the temporary casing or auger. A minimum of 150 mm6 inches of filter pack must remain in the temporary casing or auger at all times during filter pack installation. Make frequent measurements

inside the annulus during retraction to ensure that the filter pack is properly placed.

3.2.1.6 Bentonite Seal Placement

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NOTE: Sufficient time should be allowed for the bentonite seal to hydrate and form a low permeable seal before grout is placed in the annular space above the bentonite seal. By not allowing enough time, grout material could infiltrate into the seal and possibly into the filter pack. It is recommended waiting a minimum of 3 to 4 hours for hydration of bentonite pellets, or tablets. If bentonite chips are used, the minimum hydration time could be twice as long. Normally bentonite chips should only be used if it is necessary to install a seal in a deep water column. Because of their high moisture content and slow swelling tendencies, chips can be dropped through a water column more readily than a material with low moisture content, such as pellets or tablets. It is recommended that the bentonite seal be placed in lifts, with each lift allowed to hydrate for a minimum period of time. Slurry seals may be used when the seal location is too far below water to allow for pellet or other containerized-bentonite placement, or within a narrow well-borehole annulus. For more guidance consult EM 1110-1-4000.

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After the inner casing and [well screen][and filter pack]have been installed,[and after predevelopment of the well,] seal the annular space between the inner and outer casings by use of a bentonite seal. Place a minimum 1 m3 foot thick hydrated bentonite seal on top of the filter pack in a manner which prevents bridging of the bentonite in the annulus. The bottom of the bentonite seal must be a minimum of 2 m5 feet above the top of the well screen. Directly measure the depth to the top of the bentonite seal, and record immediately after placement, without allowance for swelling. If the bentonite seal is located above any borehole fluid levels, place a [300][_____] mm[1][_____] foot layer of fine sand at the top of the bentonite seal. Wait a minimum of [3][4][____] hours for hydration of bentonite pellets before proceeding.

3.2.1.7 Grout Placement

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NOTE: Before installing an annular seal, the state regulatory agency should be consulted. The state, or local municipality, where the well is being installed, may have specific requirements for sanitary, and/or wellhead protection. There is a provision for placing a high-solids bentonite grout in the annulus above the bentonite seal rather than cement grout. Advantages and disadvantages of using a bentonite grout instead of cement grout are discussed in EM 1110-1-4000. There may be a need for a provision to grout the annular space in lifts in deep wells to ensure that any PVC or other type

casing will not be collapsed by the weight and/or heat created by the chemical reaction of cement grout. If grouting in lifts is for some reason not acceptable, the well should be designed to withstand greater external pressures. This may mean using higher schedule casing, or steel instead of PVC, for example.

****

a. After the inner casing and [well screen][filter pack][bentonite seal] have been installed, mechanically mix a [non-shrinking cement][high-solids bentonite] grout in accordance with paragraph CEMENT AND BENTONITE GROUT, and place by tremie pipe, in one continuous operation without damaging the well casing into the annulus between the inner and outer casings above the bentonite seal to [within [_____] mmfeet of][the ground surface][the maximum depth of frost penetration (frost line)]. Grout injection must be in accordance with AWWA A100.

b. If the casing interval to be grouted is less than 4.5 m15 feet, and without fluids after any drill casing is removed, the grout may be placed either by pouring or pumping.

c. Thoroughly clean the tremie pipe with high pressure hot water or steam before use in each well. Configure the bottom of the tremie pipe to direct the discharge to the sides rather than downward. Submerge the discharge end of the tremie pipe at all times.

d. Add additional grout from the surface to maintain the level of the grout [within [_____] mmfeet of the ground surface][at the land surface] as settlement occurs. Do not conduct work in the well within [24][_____] hours after cement grouting.

e. Verify the alignment of the well by passing a 1.5 m5 foot long section of rigid [PVC][stainless steel][PTFE][_____] pipe 6 mm1/4 inch smaller in diameter than the inside diameter of the casing through the entire well. The well will not be accepted if the pipe does not pass freely. Thoroughly clean the pipe section with high pressure hot water or steam prior to each test.

3.2.2 Well Development

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NOTE: There is a provision for predevelopment, or development after the filter pack is installed, but before the bentonite seal is installed.

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Develop the well within 7 days of completion of each well, but no sooner than [48][_____] hours after cement grouting is completed. The 48 hour period does not apply to well predevelopment or development after the filter pack has been installed, but before the annular seal is installed. Develop the well in accordance with the Well Installation Plan, by approved methods until the water pumped from the well is substantially free from sand, and until the turbidity is less than 5 on the Jackson Turbidity Scale specified in AWWA 10084. Developing equipment must be of an approved type and of sufficient capacity to remove all cutting fluids, sand, rock cuttings, and any other foreign material.

Thoroughly clean the well from top to bottom before beginning the well tests. Perform development using only mechanical surging, over pumping, or jetting, or a combination thereof in accordance with ASTM D5521/D5521M. Include details of the proposed development method in the Well Installation Plan. The well must be free of drawdown or surcharge effects due to pump testing, developing or drilling at another location at the time of development of any well.

3.2.2.1 Site Access and Predevelopment

Maintain the needed access and work area and clearance, necessary to accomplish development at the well site. Furnish, install, or construct the necessary discharge line and troughs to conduct and dispose of the discharge [a sufficient distance from the work areas to prevent damage]. Conduct development to achieve a stable well of maximum efficiency and continue until a satisfactory sand test, as specified in paragraph SAND TEST, is obtained. During predevelopment of the well, add filter pack material to the annular space around the screen to maintain the top elevation of the filter pack to the specified elevation. Provide an open tube or other approved means for accurately determining the water level in the well under all conditions. If, at any time during the development process it becomes apparent in the opinion of the Contracting Officer that the well may be damaged, immediately terminate development operations. The Contracting Officer may require a change in method if the method selected does not accomplish the desired results. The Contracting Officer may order that wells which continue to produce excessive amounts of fines after development for [6][___] hours be abandoned, plugged, and backfilled, and may require the Contractor to construct new wells nearby. Remove all materials pulled into the well by the development process prior to performing the pumping test.

3.2.2.2 Jetting

a. Perform jetting using either a single or double ring jet. If a double ring jet is used the rings should be 600 mm2 feet apart.

b. Construct the jetting tool of high-strength material and conservatively designed and proportioned so that it will withstand high pressures. The jetting tool must have [two [7][8][10] mm [3/16][1/4][3/8] inch diameter hydraulically balanced nozzles spaced 180 degrees][four [7][8][10] mm[3/16][1/4][3/8] inch diameter holes spaced 90 degrees] apart and exert the jetting force horizontally through the screen slots.

c. Construct the rings such that the tips of the jets are within 13 mm 1/2 inch from the inner surface of the well screen.

d. The pump used in conjunction with the jetting tool must be capable of providing [pressures up to [1700][_____] kPa[250][_____] psi.] [a minimum jetting fluid exit velocity of 45 m/s150 f/s].

e. Prior to commencing jetting, and following each jetting cycle, remove all sand and other materials from inside the screen. Start the jetting process at the bottom of the screen and rotate the jetting tool [slowly][1 cycle per 30 seconds][[_____] cycles per [_____] seconds] while rotating the pipe [180][90] degrees for two minutes at each location then raise the pipe [150][_____] mm[6][_____] inches.

f. Pump all wells, more than 100 mm4 inches in diameter, during the jetting cycle to remove incoming sand and other material. Pump at a rate not less than 115 percent of the rate at which fluid is introduced through the jetting tool. This will allow a flow of material into the well as it is being developed.

g. Ensure water introduced into the well during this jetting process is free of sand.

h. The Contracting Officer may require other means of developing the well such as intermittent pumping method, variation of the intermittent pumping method, or surge block if it appears that the development of the well is not producing the desired results.

3.2.2.3 Intermittent Pumping

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NOTE: Backflow through the pump, while starting and stopping a pump intermittently, with the check valve removed, to produce rapid changes in the pressure head within the well during development, called "rawhiding," is allowed for developing wells. The alternate lifting and dropping of a column of water in the pump discharge pipe creates a surging action in the well. For more information on this development process, consult ASTM D5521/D5521M. Delete this requirement if it is not needed.

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Pump the well at a capacity sufficient to produce a rapid drawdown of approximately [_____] mfeet stopping the pump (backflow through pump will not be permitted) to permit the water surface to rise to its former elevation, and repeat this procedure. Cycle time for this procedure will vary as directed but will not be more than 3 cycles per minute. A pump discharge in excess of [_____] L/sgpm is required. Use a deep well turbine pump, or electric submersible pump with check valve, with any attachment necessary to accomplish rapid starting and stopping for intermittent pumping. Set the intake at least 3 m10 feet below the maximum expected drawdown in the well. Prior to commencing intermittent pumping, and periodically during development by this method, remove all sand and other materials from inside the screen. The amount of drawdown may be decreased if, in the opinion of the Contracting Officer, the efficiency of the well might otherwise be impaired.

3.2.2.4 Surging

Surging of the well requires use of a circular block, or multiple blocks, which are approximately 25 mm1 inch smaller in diameter than the inside diameter of the well and is constructed of a material which will not damage the screen if the block comes in contact with the screen, and a bailer or pump to remove materials drawn into the well. Continue the surging for a period of approximately [one][_____] hour, or until little or no additional material from the foundation or filter pack can be pulled through the screen. Move the surge block by a steady motion up and down the full length of the well screen. Prior to commencing surging, and periodically during development by this method, remove all sand and other materials from inside the screen. Remove all materials pulled into the well by the surging process.

3.2.2.5 Well Development Criteria

Maintain a well development record in accordance with paragraph WELL DEVELOPMENT RECORDS. Development is complete when all of the following criteria are met:

a. Well water is clear to the unaided eye[, and turbidity less than or equal to [5][_____] Nephelometric Turbidity Units (NTUs)],

b. Sediment thickness in the well is less than [1 percent of the screen length][30 mm0.1 foot],

c. A minimum of three times the standing water volume in the well is removed plus three times the volume of all added water and drilling fluid lost during drilling and installation of the well is removed, and

d. [Temperature, specific conductivity, pH, oxidation-reduction potential (ORP), dissolved oxygen (DO), and turbidity readings, measured before, twice during and after development operations, have stabilized. Stabilization is defined as [variation of less than 0.2 pH units, variation of plus or minus ±0.5 degrees C1 degree F, ±3 percent change in specific conductance; and less than a ±10mV for ORP; and ±10 percent for DO, and turbidity, measured between three consecutive readings with one casing volume of water removed between each reading] [_____]. Determine ORP in accordance with AWWA 10084. Conduct temperature, specific conductance, DO, turbidity, and pH readings in accordance with EPA 600/4-79/020. At completion of well development, collect approximately 0.5 liter1 pint of well water in a clear glass jar. Label the jar with project name, well number and date; and digital photograph. The photograph (minimally 125 x 174 mm5 x 7 inch) must be a suitably backlit close-up which shows the clarity of the water and any suspended sediment. The photograph and digital copy become a part of the well development record. Water removed during development and testing operations must be [contained in D.O.T. approved drums, containers or vessels and disposed of by [_____], in accordance with paragraph Drilling Waste Disposal] [discharged to the ground surface at least [_____] mfeet from the well in a down gradient area].]

3.2.3 Tests

After the wells have been developed, notify the Government and make the necessary arrangements for conducting the capacity tests. The well must be free of drawdown or surcharge effects caused by pumping tests, well development, or well drilling at another location during capacity testing and the recovery testing after completion of capacity testing. If the capacity test indicates that the required capacity can be obtained, perform the tests for quality of water. If the capacity and quality tests indicate that the required capacity and quality can be obtained, complete the permanent well, as specified, at that depth. Submit Test Reports within [_____][24] hours following the conclusion of each test. Prior to making quality tests, clean drilling equipment, tools and pumps contacting well water with live steam.

3.2.3.1 Capacity Test

****

NOTE: This test should be used to verify that the

well is developed properly and will produce the required yield. Test pump should be capable of a range of pumping rates, varying from about 50 percent to about 200 percent of the design capacity of the well. Since there are a wide variety of pump test methods, the designer should refer to a good water wells reference book (such as "Ground Water and Wells," by Fletcher G. Driscoll, published by Johnson Well Screens, 1986) for test procedures which best apply.

****

a. Provide an approved temporary test pump, with discharge piping of sufficient size and length to conduct the water being pumped to [point of discharge][_____], and equipment necessary for measuring the rate of flow and water level in the well.

b. Run an [8][_____] hour [constant-rate][step-drawdown] capacity test with the pumping rate and drawdown at the pump well and observation wells recorded every [[30][_____] minutes][1/2 minute during the first 5 minutes after starting the pump; then every 5 minutes for an hour; then every 20 minutes for 2 hours].

c. [From this point on, readings taken at hourly intervals, until the water level stabilizes, are sufficient.] [Read observation wells (piezometers) on the same schedule as the pump well.] [During the step-drawdown test, increase the pumping rate in steps at [regular][[2][_____] hour] intervals. Measure specific capacity for each step.]

d. Begin the test at the rate of [the expected capacity of well] [[_____] L/sgpm] and at least that rate maintained throughout the duration of the [test][step interval]. [The well must be "step" tested at rates of approximately [1/2, 3/4, 1 and 1 1/2][_____] times the design capacity of [_____] L/sgpm.]

e. If this capacity cannot be maintained for the test period, terminate the capacity test and drill the test well deeper or relocate as directed.

f. When the pump is shut off, take water level readings during the rebound period for the same intervals of time as the drawdown test until static water level is reached.

g. Submit the record of the test.

3.2.3.2 Test for Plumbness and Alignment

Upon completion of the permanent well, test for plumbness and alignment by lowering into the well, to the total depth of the well, a plumb [12][_____] m[40][_____] feet long or a dummy of the same length. The outer diameter of the plumb must not be more than 13 mm1/2 inch smaller than the diameter of that part of the hole being tested. If a dummy is used, it must consist of a rigid spindle with three rings, each ring being [300][_____] mm[12][_____] inches wide. Use cylindrical rings spaced one at each end of the dummy and one in the center. The central member of the dummy must be rigid so that it will maintain the alignment of the axis of the rings. Decontaminate the dummy as specified in paragraph DECONTAMINATION, before use. If the plumb or dummy fail to move freely

throughout the length of the casing or well screen for the depth of well or should the well vary from the vertical in excess of two-thirds the inside diameter of that part of the well being tested for each 30 m100 feet of depth, correct the plumbness and alignment of the well. If the faulty alignment and plumbness is not correctable, as determined by the Contracting Officer, abandon the well as specified in paragraph WELL DECOMMISSIONING OR ABANDONMENT and drill a new well at no additional cost to the Government.

3.2.3.3 Water Quality Test

****

NOTE: The Post, or Resident Engineer, or the USGS should be consulted to determine if any additions or deletions should be made to the Water Quality Analysis table.

****

When the capacity test in the test well has been completed, and again after the yield in the permanent well and drawdown test or capacity test have been completed, secure samples of the water in suitable containers, and of sufficient quantity, to have bacterial, physical, and chemical analyses made by [a recognized testing laboratory][_____], except that the bacterial analysis may be made by the applicable State Board of Health, if desired. Water Quality Analysis must address each item specified in the Water Quality Analysis Table at the end of this specification. Expenses incident to these analyses are borne by the Contractor and the results of the analyses submitted to the Contracting Officer. Perform all sampling and analyses using EPA and State approved methods, procedures, and holding times.

3.2.3.4 Sand Test

As part of each capacity test, or at the end of each intermittent pumping, perform a determination of the amount of sand (filter pack and foundation material) a well is producing. Remove all material from the bottom of the tailpipe prior to starting the sand test. Test each well by pumping at a rate [of [_____] L/sgpm] [sufficient to produce approximately [_____] mfeet of draw-down]. After the pump is at the desired pumping rate, divert the flow from the discharge [into a container that will collect all the sand being carried by the water][through a Rossum Sand Tester]. Development of the well is satisfactory if the amount of sand collected is less than 0.5 L per 100,000 L1 pint per 25,000 gallons of water pumped at the specified rate. Upon completion of the test, determine the amount of sand in the tailpipe to verify that no material is being deposited in the bottom of the well.

3.3 REQUIREMENTS AFTER TESTING

3.3.1 Installation of Permanent Pump

****

NOTE: The yearly change in the regional water table should be determined before specifying the minimum pump depth.

****

Install the permanent well pump in the well at a minimum depth of [8][_____] m[25][_____] feet below the maximum drawdown groundwater level

after the drawdown test has been completed. Secure the pump at the required elevation as recommended by the pump manufacturer. After installation of the pumping units and appurtenances is complete, carry out operating tests to assure that the pumping installation operates properly. Tests must assure that the pumping units and appurtenances have been installed correctly, that there is no objectionable heating, vibration, or noise from any parts, and that all manual and automatic controls function properly.

3.3.2 Disinfecting

a. After completion of tests of well, or installation of permanent pump, or at time of tests for yield and drawdown test, whichever is later, disinfect the wells by adding chlorine, conforming to AWWA B301, or hypochlorite, conforming to AWWA B300, in sufficient quantity so that a concentration of at least 50 ppm of chlorine is obtained in all parts of the well.

b. Prepare chlorine solution and introduce into the well in an approved manner, and leave in the well for period of at least 12 hours but not more than 24 hours. Information on methods for preparing chlorine solution and introducing it into the well can be found in AWWA C654.

c. After the contact period, pump the well until the residual chlorine content is not greater than 1.0 ppm.

d. Pump the well to waste for an additional 15 minutes with less than 1 ppm chlorine residual, after which take two samples not less than 30 minutes apart and test for the presence of coliform bacteria.

e. Disinfect and re-disinfect the well as required until two consecutive samples are free from coliform bacteria.

3.3.3 Pumphouse and Slab

****

NOTE: In some instances, a pumphouse and base slab may not be appropriate. In such cases, alternate designs must ensure that surface water cannot infiltrate into the well and that the pump and well head are protected.

****

Provide a pumphouse and slab preventing the infiltration of surface water or precipitation into the well. The slab must be [1.2][_____] m square by [150][_____] mm thick[4][_____] feet square by [6][_____] inches thick and constructed of reinforced concrete. Extend the top of the outer casing [300][_____] mm[12][_____] inches above the top of the slab. The top of the slab must be at elevation [_____] or higher. Construct the pumphouse on the slab and thermally insulate.

3.3.4 Site Clean-up

After completion of the work, remove tools, appliances, surplus materials, temporary drainage, rubbish, and debris incidental to work. Backfill and dress excavation and vehicular ruts to conform with the existing landscape. Repair of replace utilities, structures, roads, fences, or any other pre-existing item damaged due to the Contractor's negligence; this must be accomplished prior to completion of this contract.

3.3.5 Drilling Waste Disposal

****

NOTE: The designer must address disposal of drill cuttings, rock core, grout or bentonite slurry, and other solid or liquid materials bailed, pumped, or otherwise removed from the borehole during drilling, well installation, completion, and well development procedures within all appropriate regulatory requirements. The nature of these wastes (whether hazardous or not) will potentially vary between well sites on a single project. In some instances, rock core may be determined to be contaminated and must be handled accordingly. Refer to EPA/540/G-91/009, Management of Investigation-Derived Waste From Site Investigations and EPA OSWER Directive 9345.3-03FS, April 1992, Guide to Management of Investigation-Derived Wastes, for discussion of some issues relevant to Superfund projects. State/local regulations must also be considered.

****

Dispose of slurry, drill cuttings, rock core; other solid or liquid material bailed, pumped, or otherwise removed from the borehole during drilling, installation, completion, well development procedures and testing; and fluids from material and equipment decontamination activities by [_____].

3.3.6 Surveys

****

NOTE: Guidance for installing survey markers can be found in EM 1110-1-1002 Survey Markers and Monumentation.

****

Establish coordinates and elevations for each well or test well. Determine horizontal coordinates to the closest 300 mm1.0 foot and referenced to the State Plane Coordinate System, or Universal Transverse Mercator (UTM). If the State Plane Coordinate System or UTM is not readily available, use an existing local grid system. Obtain a ground elevation to the closest 30 mm 0.1 foot at each well. Use the highest point on the top of the riser pipe as a measurement point. The elevation of the well must reference this point, and be surveyed to the nearest 3 mm 0.01 foot using the [National Geodetic Vertical Datum of 1929] [North American Vertical Datum of 1988]. If the datum is not readily available, use the existing local vertical datum. Plot the location, identification, coordinates, and elevations of the well and monuments on maps with a scale large enough to show their location with reference to other structures.

3.4 FIELD QUALITY CONTROL

3.4.1 Well Decommissioning or Abandonment

a. Any well disapproved by the Contracting Officer, or any well decommissioned or abandoned by the Contractor for any reason must be decommissioned or abandoned according to the requirements of the State of [_____], [ASTM D5299/D5299M,] and the requirements of these

specifications.

b. Well decommissioning or abandonment includes the removal of all materials left in the borehole or well, excluding the filter pack, and including backfill materials, casing, screen, and any other material placed into the hole before the decision was made to abandon the borehole or well.

c. Grout test wells decommissioned or abandoned for any reason from the bottom to within [_____] mmfeet of the top of the ground surface according to the protocol for grout or bentonite placement established in paragraph GROUT PLACEMENT, using the grout mix specified in paragraph CEMENT AND BENTONITE GROUT. Backfill the top [_____] mmfeet with [material appropriate for the intended land use][_____].

d. Maintain a well decommissioning or abandonment record as specified herein.

e. If encountered before the decision is made for decommissioning or abandonment, measure groundwater levels in all borings prior to backfilling. Include these water levels in the well decommissioning or abandonment records.

f. No well may be decommissioned or abandoned without the approval of the Contracting Officer.

3.4.2 Documentation and Quality Control Reports

Establish and maintain documentation and quality control reports for well construction, development, and testing to record the desired information and to assure compliance with contract requirements, including, but not limited to, the following:

3.4.2.1 Borehole Logs

****

NOTE: Borehole logging requirements can be found in EM 1110-1-4000. Requirements can also be found in ASTM D2113 and ASTM D5434. If rock is cored at the site, and it is deemed necessary to determine the rock quality designation (RQD) of the core for design purposes, the RQD should also be shown on the boring log. Guidance for determining the RQD may be found in ASTM D6032. Item o. has a provision for recording the level of non-aqueous phase liquids (NAPLs).

****

Complete a borehole log for each boring drilled. Borehole logs must be prepared by the geologist present onsite during all well drilling and installation activities. Use a log scale of [10][_____] mm equals [300][_____] mm[1][_____] inch equals [1][_____] foot. Keep copies of complete well logs current in the field at each well site and make available at all times for inspection by the Contracting Officer. As a minimum, provide the follow information on the logs:

a. Name of the project and site.

b. Boring or well identification number.

c. Location of boring (coordinates, if available).

d. Make and manufacturer's model designation of drilling equipment and name of drilling firm.

e. Date boring was drilled.

f. Reference data for all depth measurements.

g. Name of driller and name and signature of geologist preparing log.

h. Nominal hole diameter and depth at which hole diameter changes.

i. Total depth of boring.

j. Method of drilling, including sampling methods and sample depths, including those attempted with no recovery. Indication of penetration resistance such as drive hammer blows given in blows per 150 mm6 inches of driven sample tubes. Information must include hammer weight and drop distance. Record information such as rod size, bit type, and pump type. Include a description of any temporary casing used, drill fluids and fluid additives used, if any, including brand name and amount used, along with the reason for and start (by depth) of its use. If measured, record mud viscosities and weight.

k. Depth of each change of stratum. State if location of strata change is approximate.

l. Description of the material of which each stratum is composed, in accordance with [ASTM D2488][_____], or standard rock nomenclature in accordance with [CED TR GL-85-3][_____], as necessary. Soil parameters for logging must include, but not be limited to, classification, depositional environment and formation, if known, Unified Soil Classification Symbol, secondary components and estimated percentages, color, plasticity, consistency (cohesive soil), density (non-cohesive soil), moisture content, structure and orientation, and grain angularity. Rock core parameters for logging must include, but not be limited to, rock type, formation, modifier denoting variety (shaly, calcareous, siliceous, etc.), color, hardness, degree of cementation, texture, crystalline structure and orientation, degree of weathering, solution or void conditions, primary and secondary permeability, and lost core. Include the results of any chemical field screening on the boring log. Prepare classification in the field at the time of sampling. Also, duly note and record the results of visual observation of the material encountered, and any unusual odor detected.

m. Depth of any observed fractures, weathered zones, or any abnormalities encountered.

n. Depth and estimated percent of drill fluid loss or lost circulation. Measures taken to regain drill water circulation. Significant color changes in the drilling fluid return.

o. Box or sample number. Record depths and the number of the core boxes and samples at the proper interval.

p. Percent Rock Core Recovery. Show the percent core recovery for the

individual drill runs, if rock is cored.

q. Submit [five][_____] prints of the graphic boring log prepared to scale showing the required details, within [_____] working days after completion of the test well. Use this drawing to aid in determining the well design, design of the filter pack, well screen location and screen openings.

3.4.2.2 Installation Diagrams

The well will not be accepted before the geologic logs and installation diagrams are received. Submit As-built installation diagram for each well installed, prepared by the geologist present during well installation operations, within [_____] working days of the completion of the well installation procedure. The diagram must illustrate the as-built condition of the well and include, but not be limited to, the following items:

a. Name of the project and site.

b. Well identification number.

c. Name of driller and name and signature of the geologist preparing diagram.

d. Date of well installation.

e. Description of material from which the well is constructed, including well casing or riser pipe and screen material, centralizer composition, if used, diameter and schedule of casing and screen, gradation of filter pack, lithologic description, brand name (if any), source, and processing method, and method of placement of the filter pack, bentonite seal type (pellets, granules, chips, or slurry), grout type (cement or high-solids bentonite) and type of protective cover (protective casing or flush-to-ground),if used.

f. Total depth of well.

g. Nominal hole diameter.

h. Depth to top and bottom of screen, and filter pack.

i. Depth to top and bottom of any seals installed in the well boring (grout or bentonite).

j. Type of cement and bentonite used, mix ratios of grout, method of placement and quantities used.

k. Elevations, depths, and heights of key features of the well, such as top of well casing or riser pipe, top and bottom of protective casing (if used), ground surface, the depth of maximum frost penetration (frost line), bottom of well screen, top and bottom of filter pack, and top and bottom of seal.

l. Other pertinent construction details, such as slot size and percent open area of screen, type of screen, and manufacturer of screen.

m. Well location by coordinates. Include a plan sheet showing the coordinate system used and the location of each well. A plan sheet is

not required for each well installation diagram; multiple wells may be shown on the same sheet.

n. Static water level upon completion of the well.

o. Special problems and their resolutions; e.g., grout in wells, lost casing, or screens, bridging, etc.

p. Description of surface completion.

3.4.2.3 Well Development Records

****
NOTE: Delete item k. if not applicable for the project.
****

Prepare a well development record for each well, within [_____] working days of the completion of development under the supervision of the geologist present during well installation operations. Include, as a minimum, the following information on the well development record:

a. Date, time, and elevation of water level in the well, before development.

b. Depth to bottom of well, name of project and site, well identification number, and date of development.

c. Method used for development, to include size, type and make of equipment, bailer, and pump used during development.

d. Time spent developing the well by each method, to include typical pumping rate, if pump is used in development.

e. Volume and physical character of water removed, to include changes during development in clarity, color, particulates, and odor.

f. Volume of water added to the well, if any.

g. Volume and physical character of sediment removed, to include changes during development in color, and odor.

h. Source of any water added to the well.

i. Clarity of water before, during, and after development. Nephelometric turbidity unit (NTU) measurements.

j. Total depth of well and the static water level from top of the casing, immediately after pumping or development, and 24 hours after development.

[k. Readings of pH, specific conductance, DO, ORP, and temperature taken before, during, and after development.

] l. Name and job title of individual developing well.

m. Name and description of the disposal facility or area, for the waters removed during development.

[3.4.2.4 Geophysical Logs

****
NOTE: Delete this paragraph if not applicable for the project.
****

Prepare and complete geophysical logs for each well or test well installed. Submit interpreted geophysical logs, within [_____] working days of the completion of said logging. As a minimum, include the following information on the logs:

a. Project name.

b. Test well or well identification number.

c. Location of test well (coordinates, and state, and county name).

d. Date test well was drilled.

e. Fluid level in test well before logging.

f. Fluid type and temperature.

g. Fluid resistance in ohm-m.

h. Casing type, diameter, and elevation (top and bottom).

i. Cement type and elevation (top and bottom).

j. Screen type, diameter, and elevation (top and bottom).

k. Date and time test well was logged.

l. Reference elevation for all depth measurements.

m. Operator's name.

n. Equipment name and address.

o. Logger type and number.

p. Tool type.

q. Detector type (Nuclear Log only).

r. Source type (Nuclear Log only).

s. Source size (Nuclear Log only).

t. Source spacing (Nuclear Log only).

u. Tool length, cable head to detector.

v. Calibration.

w. Logging speed cm/minft/min.

x. Log vert. scale m/cmft/in.

y. Module settings.

z. Recorder settings.

aa. Document all field problems, including equipment malfunctions. Include the steps taken to solve the problem and how the log might have been affected.

]3.4.2.5 Well Decommissioning or Abandonment Records

As a minimum, include the following in the decommissioning or abandonment records:

a. Project name.

b. Well or test well number.

c. Well or boring location, depth and diameter.

d. Date of decommissioning or abandonment.

e. Method of decommissioning or abandonment.

f. All materials used in the decommissioning or abandonment procedure and the interval in which test materials were placed.

g. Casing, and or other items left in hole by depth, description, and composition.

h. Description and total quantity of grout used initially.

i. Description and daily quantities of grout used to compensate for settlement.

j. Water or mud level (specify) prior to grouting and date measured.

k. The reason for decommissioning or abandonment of the well or test well.

3.4.2.6 Tests

Prepare and submit a copy of all testing results from the well installation process. Include results of drawdown, well yield, sand, plumbness or alignment, etc. as well as any other test results in this submittal.

3.4.2.7 Project Photographs

Before, during, and after completion of work, take a minimum of [one view] [[_____] views] of each well installation. If rock is cored at the site, after the core has been logged, dampen the core if it has dried, arrange neatly in the core box, and photograph. Photographs must be [80][_____] by [120][_____] mm[3][_____] by [5][_____] inch color prints. Mount the photographs and enclose back-to-back in a double face clear plastic sleeve punched to fit standard three ring binders. Each color print must show an information box, [20][_____] by [50][_____] mm[1-1/2][_____] by [3-1/2][_____] inches. Submit digital copy of all photographs as well as color copy. The box must be labeled and arranged as follows:

Project No.	Contract No.
Contractor/Photographer:	
Photograph No.	Date/Time
Description:	
Direction of View:	

3.4.2.8 Survey Maps and Notes

Submit Survey maps and notes, including a tabulated list of all wells and monuments, copies of all field books, maps showing the locations, and elevations of all wells, datum used (e.g. state plane NAD27, NAD83, UTM, etc.), elevation datum, units of measurement, and all computation sheets, within [_____] working days after completion of the survey. Also, submit a diagram showing where on the top of the well the elevation was determined by the surveyor. The tabulation must consist of the designated number of the well or monument, the X and Y coordinates, and all the required elevations. Also, provide a diagram showing where on the top of the well the elevation was determined by the surveyor.

WATER QUALITY ANALYSIS TABLE	
Physical Characteristics	
_____	
Color	
Taste	
Threshold odor number	
Turbidity	
Resistivity in ohms per cubic centimeter and 25 degrees C	
pH value	
Temperature	

WATER QUALITY ANALYSIS TABLE	
Chemical Characteristics (Expressed as mg/L)	
_____	
Arsenic	
Barium	
Cadmium	
Chromium	
Copper	
Lead	
Mercury	
Selenium	
Silver	
Zinc	
Fluoride as F	
Manganese as Mn (dissolved and total)	
Iron as Fe (dissolved and total)	
Suspended Solids	
Total Dissolved Solids	
Calcium as Ca	
Magnesium as Mg	
Sodium and Potassium as Na	

Total Hardness as CaCO(3)	
Endrin	
Lindane	
Methoxychlor	
Toxaphene	
2-4-D	
2, 4, 5 TP Silvex	
Total Organic Halogens	
TOC	
Sulphates as SO(4)	
Chlorides as C1	
Bicarbonates as HCO(3)	
Carbonates as CO(3)	
Nitrates as NO(3)	
Alkalinity (methyl-orange)	
Phenolphthalein as CaCO(3)	
Silica as SiO(2)	
Carbonate Hardness	
Non-Carbonate Hardness	
H2S	
Total Ammonia	
Silt Density Index	
Langelier Saturation Index	

-- End of Section --