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USACE / NAVFAC / AFCESA **UFGS-02522 (August 2004)**

Preparing Activity: USACE **Superseding UFGS-02522A (May 1998)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 25 June 2004
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DIVISION 02 - SITE CONSTRUCTION

SECTION 02522

GROUND-WATER MONITORING WELLS

08/04

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SECTION 02522

GROUND-WATER MONITORING WELLS
08/04

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NOTE: This guide specification covers the requirements for ground water monitoring wells for hazardous waste sites.

Comments and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents, including their organization designation and telephone number, is on the Internet.

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR).

Use of electronic communication is encouraged.

Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.
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PART 1 GENERAL

1.1 REFERENCES

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NOTE: Issue (date) of references included in project specifications need not be more current than provided by the latest guide specification. Use of SpecsIntact automated reference checking is recommended for projects based on older guide specifications.

State and/or local regulations/requirements may also need to be referenced.
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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 EWW	(1998) Standard Methods for the Examination of Water and Wastewater

ASTM INTERNATIONAL (ASTM)

ASTM A 312/A 312M	(2002) Seamless and Welded Austenitic Stainless Steel Pipes
ASTM C 136	(2001) Sieve Analysis of Fine and Coarse Aggregates
ASTM C 150	(2002ae1) Portland Cement
ASTM C 387	(2000e1) Packaged, Dry, Combined Materials for Mortar and Concrete
ASTM D 1586	(1999) Penetration Test and Split-Barrel Sampling of Soils
ASTM D 1785	(1999) Poly(Vinyl Chloride)(PVC) Plastic Pipe, Schedules 40, 80, and 120
ASTM D 2216	(1998) Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
ASTM D 2487	(2000) Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D 2488	(2000) Description and Identification of Soils (Visual-Manual Procedure)
ASTM D 4318	(2000) Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D 4750	(1987; R 2001) Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well)
ASTM D 5079	(2002) Preserving and Transporting Rock Core Samples
ASTM D 5088	(2002) Decontamination of Field Equipment Used at Nonradioactive Waste Sites
ASTM D 5092	(2002) Design and Installation of Ground Water Monitoring Wells in Aquifers
ASTM D 5299	(1999) Decommissioning of Ground Water Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities
ASTM D 5521	(1994e1) Development of Ground-Water Monitoring Wells in Granular Aquifers
ASTM D 5608	(2001)Decontamination of Field Equipment

	Used at Low Level Radioactive Waste Sites
ASTM F 480	(2002) Thermoplastic Well Casing Pipe and Couplings Made in Standard Dimension Ratios (SDR), SCH 40 and SCH 80

FORESTRY SUPPLIERS INC. (FSUP)

FSUP 77341	(1999) Munsell (R) Soil Color Charts

GEOLOGICAL SOCIETY OF AMERICA (GSA)

GSA RCC00100R	(1980) Rock Color Chart

NSF INTERNATIONAL (NSF)

NSF 14	(2003) Plastics Piping System Components and Related Materials

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

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

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

49 CFR 172	Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, and Training Requirements

1.2 SUBMITTALS

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NOTE: Submittals must be limited to those necessary for adequate quality control. The importance of an item in the project should be one of the primary factors in determining if a submittal for the item should be required.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation 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 projects.

Submittal items not designated with a "G" are considered as being for information only for Army projects and for Contractor Quality Control approval for Navy projects.

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Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.][for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation Diagrams[; G][; G, [_____]]

As-built installation diagram for each monitoring well installed, prepared by the geologist present during well installation operations, within [_____] working days of the completion of the well installation procedure.

Survey Maps and Notes

Survey maps and notes, including a tabulated list of all monitoring wells and monuments, copies of all field books, maps showing the locations, and elevations of all monitoring wells, and all computation sheets shall be submitted within [_____] working days after completion of the survey.

SD-03 Product Data

Borehole Logs

Original borehole logs, within [_____] working days after completion of the boring and well installation procedures.

Installation Diagrams

An installation diagram for each monitoring well shall be submitted within [_____] working days of the completion of the installation.

Well Development Records

A monitoring well development record, for each monitoring well, within [_____] working days of the completion of development.

Geophysical Logs

Geophysical logs shall be submitted within [_____] working days of the completion of said logging.

Well Decommissioning/Abandonment Records

A well decommissioning record, for each well, or test hole

abandoned, within [_____] working days of the completion of the abandonment procedure.

Project Photographs

Before, during, and after completion of the work, the Contractor shall take photographs of each well installation site. Photographs shall also be taken of any rock that is cored at the site.

Monitoring Wells

Catalog data for monitoring 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, and chemical specifications on drill lubricants and tracers, if used. Catalog data shall include any information, written or otherwise, supplied by the manufacturers or suppliers of the above listed items.

Qualifications

Personnel qualification documentation.

Permits

A copy of all permits, licenses, or other requirements necessary for execution of the work. Before beginning work, the local United States Geological Survey office (USGS) [and the] [State Environmental Protection office] [State Geological Agency] [state health department] [local health department] [Department of natural Resources]shall be notified of the type and location of wells to be constructed, the method of construction and anticipated schedule for construction of the wells. A copy of all such correspondence shall be furnished.

Installation Plan

A plan as specified in paragraph INSTALLATION PLAN,describing the drilling methods, sampling, and monitoring 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 shall be approved and signed by a geologist experienced in hazardous waste projects as specified in paragraph QUALIFICATIONS.

Documentation and Quality Control Reports

Reports for well construction and development.

SD-06 Test Reports

Water Source

Decontamination and drilling water source analytical test results.

Filter Pack

Filter pack material test results; sieve and chemical analyses.

Drilling Fluid Additive

Manufacturer's data, if available, including analytical test results of the additive, if not a part of the manufacturer's data.

1.3 UNIT PRICES

Payment for each specified item will be made at the contract unit price for that item. Payment will include 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. Depth, logging, installation, casing, riser pipe, and well screen shall be measured by linear distance. Payment will not be allowed for test holes or monitoring wells abandoned due to construction practices not in accordance with this specification, or for the convenience of the Contractor.

1.3.1 Test Holes

If the total depth of the test hole is greater than that specified in the contract for "Test Holes, and Samples," the additional depth will be paid for at the contract unit price for "Additional Test Hole Depth." If the test hole is developed into the permanent monitoring well, no separate payment will be made for the test hole.

1.3.2 Monitoring Well Drilling and Sampling

If the total depth of the monitoring well is greater than that specified in the contract for "Monitoring Wells and Samples," the additional depth will be paid for at the contract unit price for "Additional Monitoring Well Depth."

1.3.3 Geophysical Logging

The "Geophysical Logging" unit price will include interpretation of the logs and their delivery to the Government.

1.3.4 Casing/Riser Pipe Selection and Installation

Payment will be made for length of blank casing actually installed in the well. Payment will include compensation for decontamination and installation of the casing/riser pipe, cap, tail piece (if any), end cap and centralizers; and for the furnishing and installing of the well identification tag with information recorded thereon, or well marking as per contract.

1.3.5 Monitoring Well Screen

Payment will be made for monitoring well screen actually installed in the well.

1.3.6 Filter Pack Construction

Filter pack construction will be measured by the cubic meter. foot. Payment will include compensation for furnishing, delivering, storage, decontamination, analytical testing, and installing the filter pack.

1.3.7   Bentonite Seal

The bentonite seal will be measured by the cubic meter. foot. Payment will include full compensation for hydrating, and tremieing necessary for the work.

1.3.8   Grout Placement

The cement and/or bentonite grout used in the annulus above the bentonite seal will be paid by the cubic meter foot used. Payment will include compensation for cement, mixing of the grout, and pumping of grout, bentonite, mixing of bentonite grout, and pumping of bentonite grout, necessary for the work.

1.3.9   Monitoring Well Development

Payment for monitoring well development will be made by the hour. Payment will include compensation for pumping, surging, bailing, sample photograph, discharge water containers, and disposal.

1.3.10   Monitoring Well Completion Aboveground

Payment will include compensation for protective covers, keyed-alike padlocks, locking caps, project photographs, concrete well pads, gravel, and protective steel posts.

1.3.11   Monitoring Well or Test Hole Decommissioning/Abandonment

Permanent decommissioning/abandonment of monitoring wells or test holes will be paid for only if it becomes necessary to abandon a well or test hole as specified, and only for work completed and accepted as specified. Payment will include 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 hole and for the required well or test hole abandonment records.

1.3.12   Site Cleanup

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

1.4   SYSTEM DESCRIPTION

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NOTE: Designer must ensure that well design meets or exceeds Federal, state, and local installation requirements. Additional criteria may apply for monitoring wells at radioactive, mixed, biological, solid, or medical waste sites.

****

Each monitoring well shall be constructed to yield chemically representative ground water samples of the screened interval for chemical analysis, and to allow for the accurate measurement of ground water depths

relative to the top of the well riser, by use of electrical, wetted tape, or acoustical methods. The screened interval is that portion of a monitoring well which is directly open to the host aquifer by way of openings in the well screen and indirectly open to the aquifer by way of the filter pack (or other permeable material) extending continuously below and/or above the screen.

1.5 PERFORMANCE REQUIREMENTS

Each monitoring well shall be installed 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 monitoring well intake zone.

1.6 INSTALLATION PLAN

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NOTE: The Monitoring Well Installation Plan may need to be included as a part of the Field Sampling Plan (FSP) which is a part of the Sampling and Analysis Plan (SAP) required in Section 01450A CHEMICAL DATA QUALITY CONTROL. The FSP is described in EM 200-1-3, Requirements for the Preparation of Sampling and Analysis Plans. EM 200-1-3 outlines the SAP format requirements, which include monitoring well installation.

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The following requirements shall be incorporated into the Contractor's Monitoring Well Installation Plan and followed in the field. The plan shall include, but shall 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/rock sample disposition.

b. Description of well construction materials, including well screen, riser pipe, centralizers, tailpiece (if used), filter pack and filter pack gradation, bentonite, 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 to be used 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/features relating to frost heave prevention. The maximum frost penetration for the site shall be included in this description.

g. Description of well development methods to be used.

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/abandonment procedures.

k. Description of in-situ permeability determination techniques, if testing is required.

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

1.7 QUALIFICATIONS

A geologist with at least [3] [_____] years experience in hazardous waste projects, soil and rock logging, and monitoring well installation, registered in the state of [_____], shall be onsite and responsible for all geophysical and borehole logging, drilling, well installation, developing and testing activities. The driller shall be licensed in the state of [_____], according to the state requirements. Geophysical log interpretation shall be done by a qualified log analyst. The log analyst shall be able to demonstrate competence through background, training, and experience when so called upon. The Contractor shall have a minimum of [_____] years of monitor well installation experience. The Contractor's staff shall include appropriate health and safety personnel as specified in Section 01351 SAFETY, HEALTH AND EMERGENCY RESPONSE (HTRW/UST), and personnel qualified to perform the necessary chemical sampling as presented in the approved Sampling and Analysis Plan, prepared as specified in Section 01450A CHEMICAL DATA QUALITY CONTROL.

1.8 NOTIFICATION

The [Installation Environmental Coordinator (IEC)] [_____] and the Contracting Officer shall be notified [_____] days prior to drilling. The [Contracting Officer] [Contractor] [Installation Environmental Coordinator (IEC)] [_____] [will] [shall] be responsible for contacting the [State of [_____]] [USEPA] in accordance with the applicable reporting requirements.

1.9 DELIVERY, STORAGE, AND HANDLING

Monitoring well materials shall be stored and maintained in a clean, uncontaminated condition throughout the course of the project.

1.10 SITE CONDITIONS

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NOTE: If needed, edit and add Section 02230 CLEARING AND GRUBBING.
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Access to each monitoring 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]. Obtaining rights-of-entry is the responsibility of the [Contractor] [Government]. The Contractor shall 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 shall agree on a suitable clearing, or relocation plan and the location of any required access road.

PART 2 PRODUCTS

2.1 WELL CASING

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NOTE: The selection of well casing/riser pipe, and screen materials should be made with due consideration to geochemistry, anticipated lifetime of the monitoring program, well depth, chemical parameters to be monitored, and other site-specific factors. Normally 50 or 100 mm (2 or 4 inch) inside diameter well casing, and screen should be used; however, larger casing diameters may be necessary where dedicated purging, or sampling equipment is used, or where the well is screened in a deep formation. Schedule 40 casing is commonly used for monitoring wells, but schedule 80 is sometimes used for larger diameter PVC casing.

Welding is not a recommended procedure for the installation of a monitoring well; however, there may be occasions when it is necessary to weld outer/protective casing, or drive casing at the site. It may be unsafe to weld if certain volatile organics are present. Safety precautions should be addressed in the site safety and health plan. In addition to the safety consideration, it may be undesirable to use metal well casing if metals are the contaminants of concern, which would preclude welding of metal well pipe. Appropriate welding standards, such as AWWA C206, Field Welding of Steel Water Pipe, must be referenced if welding is anticipated.

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Monitoring well casing/riser pipe, shall be new, [102] [_____] mm [4] [_____] inch nominal internal diameter, schedule [40] [_____] flush-joint threaded [[ASTM D 1785 polyvinyl chloride (PVC)] [PTFE] [_____] pipe. This pipe shall also meet the requirements of NSF 14. Required fittings shall be ASTM F 480 flush thread male by female fittings] [Type 304 stainless steel. The minimum wall thickness shall be schedule 5S meeting the requirements of ASTM A 312/A 312M]. Pop rivets, or screws shall not be used. A [PVC] [stainless steel] [PTFE] [_____], [locking] [non-locking] cap, that threads or slips onto the top of the well casing shall be provided.

2.2 CENTRALIZERS

[Stainless steel] [PVC] [PTFE] centralizers shall be attached to the well casing when monitoring wells are over [6] [_____] meters [20] [_____] feet in length. Centralizers will not be required if the monitoring wells are installed through hollow-stem augers.

2.3 WELL SCREEN

****

NOTE: Continuous wrap screen is commonly used for monitoring wells. This type screen is not normally designated by schedule; however, the end fittings are, and must be, compatible with the schedule of the well casing. Thus the schedule of the end fittings of the screen must be specified. The schedule of the screen must be specified, however, if slotted pipe well screen is required. The screen slot size for monitor wells is commonly 0.25 mm (0.010 inch) for fine-grained formations or 0.5 mm (0.020 inch) for coarser grained formations. In most monitoring wells, because optimum yield from the well is not as critical to achieve as it is in production or extraction wells, and because extensive development is more difficult to accomplish in small diameter wells, screens are usually designed to have smaller openings, so that less formation material will be pulled into the well during the development and sampling. Monitoring well screen length is typically 1.5 to 3 meters (5 to 10 feet), but should be designed for the particular case to be monitored; however, when monitoring ground water quality at the top of the water table, screen lengths of 3 and 6 meters (10 and 20 feet) are commonly used. Screens of more than 6 meters (20 feet) are rarely used.

****

The design and construction of the monitoring well screen shall be in accordance with paragraph SYSTEM DESCRIPTION. Monitoring well screens shall consist of new commercially fabricated flush-joint threaded [102] [_____] mm [4] [_____] inch nominal internal diameter [polyvinyl chloride (PVC)] [type 304 stainless steel] [_____][continuous wrap] [schedule [40] [_____] slotted], non-clogging design. [The end fittings on the continuous wrap screen shall be schedule [40] [_____].] Required fittings shall be ASTM F 480 flush thread male by female fittings. The screen slot size shall be [determined by the Contractor, and approved by the Government] [[0.25] [0.50] [_____] mm. [0.010] [0.020] [_____] inch.] The screen length shall be [[_____] meters feet] [determined by the Contractor]. The bottom section of the screen shall be sealed watertight by means of a flush threaded end cap of the same material as the well screen and shall be within 150 mm 6 inches of the open portion of the screen.

2.4 FILTER PACK

Filter pack shall consist of clean, washed, rounded to sub-rounded siliceous material free from calcareous grains or material. Organic matter, soft, friable, thin, or elongated particles are not permissible. The gradation of the filter pack shall be determined using the grain size analysis data obtained as required in paragraph Sampling. The uniformity coefficient of the filter pack material shall not exceed 2.5. An airtight liter pint size [plastic] [glass] container shall be filled with a sample of filter pack material and furnished to the Contracting Officer for each well to serve as a quality control.

2.5 BENTONITE SEAL

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NOTE: Slurry seals can be used as when the seal location is too far below water to allow for pellet or containerized-bentonite placement, or within a narrow well-borehole annulus.

See paragraph BENTONITE SEAL note.

****

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

2.6 CEMENT AND BENTONITE GROUT

Cement grout shall be a mixture of a maximum of 26 liters of approved water per 42.6 kg7 gallons of approved water per 94 lb bag of Portland cement, which conforms to ASTM C 150, Type [I] [_____]. Not more than 5 percent by weight of bentonite powder shall be added to reduce shrinkage and to hold the cement in suspension prior to the grout set. High-solids bentonite grout shall be made from sodium bentonite powder and/or granules. Water from an approved source shall be mixed with these powders or granules to form a thick bentonite slurry. The slurry shall consist of a mixture of bentonite and the manufacturer's recommended volume of water to achieve an optimal seal. The slurry shall contain at least 20 percent solids by weight and have a density of 4.3 kg per liter 9.4 lb per gallon of water or greater. Additional construction details for grout placement above the bentonite seal for frost heave protection shall be as directed in paragraph Protective Cover Placement.

2.7 CONCRETE PAD OR GRAVEL BLANKET

A [concrete pad] [coarse gravel blanket] shall be constructed around the protective cover at the ground surface.

2.8 PROTECTIVE COVERS

Monitoring wells shall have [a steel] [a stainless steel] [a cast iron] [an aluminum] lockable protective casing/enclosure set over the well casing. The protective cover shall be set in the concrete pad or surface seal. Weather resistant padlocks which use the same key (keyed-alike) shall be provided on the protective covers, or lockable caps for all wells. Any well that is to be temporarily removed from service or left incomplete due to delay in construction shall be capped with a watertight cap and equipped with a vandal resistant cover.

2.9 PROTECTIVE POSTS

[Four] [_____] [75] [_____] mm [3] [_____] inch diameter, [schedule 40 carbon steel] [_____], [2] [_____] meter [6] [_____] foot long, primed and painted [orange] [_____] protective posts shall be placed around the monitoring well. Primer and paint shall conform to Section 09900 PAINTING, GENERAL.

2.10 CONTAINERIZATION OF DEVELOPMENT WATER, AND DRILL CUTTINGS

Water removed during development and testing operations, and cuttings from the drilling operations shall be contained in D.O.T.-approved drums, containers or vessels as specified in 49 CFR 172. The Contractor shall furnish polyethylene and steel drums with lids, lid gaskets, bolts, chain of custody forms and drum labels. The Contractor shall mark each drum label in accordance with 49 CFR 172 in addition to the following information: drum number, site name, well name and number, contents and date, approximate depth of material contained in each drum and the name and phone number of the [Installation Environmental Coordinator (IEC)] [Contracting Officer] [_____].

2.11 SAMPLE CONTAINERS

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NOTE: Delete requirements for boxing core, if rock coring is not anticipated at the site. Rock core samples should be containerized, boxed and stored in accordance with ER 1110-1-1803, EM 200-1-3, EM 1110-1-1804, and EM 1110-1-4000.
****

Cuttings and driven samples for geotechnical purposes shall be placed in air-tight liter pint size [plastic] [glass] containers and labeled with the project name, date of sample, monitoring well number and depth at which the sample was taken. Both the container and lid shall be labeled in permanent indelible ink. Jars shall be placed in partitioned [cardboard] [_____] boxes. Boxes shall be labeled with project number and well number. Containers and boxes shall be furnished by the Contractor. Core samples shall be preserved and prepared for transport as described in ASTM D 5079.Cored rock samples shall be placed in [wooden] [_____] core boxes as indicated on the drawings. Spacers shall be placed in the proper positions in the core boxes to show the location and actual extent of voids and core losses as clearly as possible. The spacers shall be made of [wood] [_____] [or some other relatively light material] which is of sufficient strength to withstand jarring and crushing in handling. Spacers shall 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 mm (6 inches), 6 inches, the spacers shall be the same width as the cores. The outside and the inside of the core box lid shall be labeled 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 shall be such that it can clearly be read in photographs of the core box. Both ends of the core box shall also be labeled with the hole number and box number. The core shall be placed in the core box starting at the left hand corner on the hinge side and running to the right. Successive cores down the hole shall be placed 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.

PART 3 EXECUTION

3.1 PROTECTION OF EXISTING CONDITIONS

The Contractor shall maintain existing survey monuments and monitoring wells, and protect them from damage from equipment and vehicular traffic.

Any items damaged by the Contractor shall be repaired by the Contractor. Monitoring wells requiring replacement due to Contractor negligence shall be re-installed according to these specifications. Wells scheduled for abandonment shall be protected from damage so that abandonment may be performed according to these specifications. Prior to excavation, the Contractor shall obtain written approval from the local utility companies to drill at each site, to avoid disturbing buried utilities.

3.2 PREPARATION

3.2.1 Decontamination

The drill rig, drill rods, drill bits, augers, temporary casing, well developing equipment, tremie pipes, grout pumping lines, and other associated equipment shall be cleaned with high-pressure hot water/steam prior to drilling at each monitoring well location. Decontamination shall be done in accordance with ASTM D 5088 ASTM D 5608. Decontamination shall be performed at a central decontamination station. Cleaning shall be performed in an area that is remote from, and cross- or down-gradient from the well being drilled. Screen and well casing shall be cleaned 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. Samplers shall be decontaminated in accordance with the Sampling and Analysis Plan. The water used for cleaning shall be from a Government approved source. The water source used for cleaning shall be sampled and tested for the constituents specified in the Sampling and Analysis Plan prior to use at the site.

3.2.2 Decontamination Station

The Contractor shall construct a temporary decontamination pad onsite. The pad shall be bermed and slightly inclined towards a sump located in one of the back corners of the pad. Plastic sheeting shall line the pads and berms to contain decontamination water. Plywood sheeting, exterior grade, shall be placed over the plastic sheeting to prevent damage to the plastic and allow the drill rig and heavy equipment to use the pad. The minimum dimensions of the pad shall be the length and width of the drill rig, plus 1.2 meters 4 feet per side to allow access and steam cleaning. Yellow ribbon shall be used to encircle the decontamination pad. Water collected in the sump shall be pumped using a "trash" pump to transfer water to a 200 liter (55 gallon) 55 gallon drum labeled "Decontamination Pad Sump Water." Solid waste shall be transferred to a separate 200 liter (55 gallon) 55 gallon drum labeled "Decontamination Pad Sump Sludge."

3.2.3 Water Source

If well drilling/installation requires the use of water, prior to its use at the site, the water source shall be sampled and tested, and approved by the Contracting Officer for the constituents specified in the Sampling and Analysis Plan. The Contractor shall be responsible for locating the source, obtaining the water from the source, transporting it to, and storing it at the site. A water sample shall be obtained from the container used in transporting the water to the site before the water is used for decontamination. This sample shall be tested and approved in accordance with the above requirements.

3.3 INSTALLATION

3.3.1 Drilling Method

****
NOTE: Delete prohibition against drilling aids where such aids are required and not otherwise prohibited.
****

The drilling method shall prevent the collapse of formation material against the well screen and casing during installation of the well. The inside diameter of any temporary casing used shall be sufficient to allow accurate placement of the screen, riser, centralizer(s), filter pack, seal and grout. The use of drilling aids such as bentonite, other clay-based agents, or any other foreign matter capable of affecting the characteristics of the ground water is prohibited. Any drilling fluid additive used shall be inorganic in nature. Grease or oil on drill rods, casing, or auger joints are not permitted; however, PTFE tape or vegetable oil (in solid phase form) are acceptable. The drill rig shall be free from leaks of fuel, hydraulic fluid, and oil which may contaminate the borehole, ground surface or drill tools. During construction of the wells, precautions shall be used to prevent tampering with the well or entrance of foreign material. Runoff shall be prevented from entering the well during construction. If there is an interruption in work, such as overnight shutdown or inclement weather, the well opening shall be closed with a watertight uncontaminated cover. The cover shall be secured in place or weighted down so that it cannot be removed except with the aid of the drilling equipment or through the use of drill tools.

3.3.2 Test Hole Requirements

One test hole shall be drilled for every monitoring well or well cluster installed. A well cluster, as defined in this specification, is two or more wells completed (screened) to different depths in a single borehole or in a series of boreholes in close proximity (3 m 10 feet or less) to each other. The test hole may be converted to the permanent monitor well. Test holes shall be logged in accordance with paragraph BOREHOLE LOGS. If temporary casing is used, it shall be in accordance with paragraph Decontamination.

3.3.3 Sampling

****
NOTE: Sampling for chemical and geotechnical analysis may be combined to allow for obtaining samples for both if that accomplishes project requirements. If this is done, however, the geotechnical sampling must be coordinated with the requirements in Section 01450 CHEMICAL DATA QUALITY CONTROL for sampling for chemical analysis. 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 1110-1-1803, and the proper storage and handling protocol for such material as may be required by other Federal, state, or local laws, regulations and permits. Sampling procedures are described in EM 200-1-3, Requirements

for the Preparation of Sampling and Analysis Plans. Guidance for preserving and preparing core samples for transport can be found in ASTM D 5079
****

3.3.3.1 Sampling for Chemical Analysis

Sampling requirements for obtaining and preserving samples for chemical analysis shall be included in the Sampling and Analysis Plan.

3.3.3.2 Sampling for Geotechnical Analysis

Samples shall be taken of all materials penetrated by each drilled well/test hole. Soil sampling shall be done with a stainless steel split tube sampler using standard sampling techniques in accordance with ASTM D 1586. Samples shall be extracted from their in-situ environment in as near an intact, minimally disturbed condition as technically practical. Samples shall be retrieved according to ASTM D 1586 at least every [1] [_____] meter [5] [_____] feet from each test hole. Samples shall be obtained continuously through the area expected to be screened. The Contractor shall provide sieve analyses of all drive sampled material. Sieve analyses shall be conducted in accordance with ASTM C 136. Drive sample tools shall be cleaned with high-pressure hot water/steam between sampling events within the same boring. Drive-sampled materials shall be placed in airtight containers and labeled as specified in paragraph SAMPLE CONTAINERS. Samples shall be delivered to the Contracting Officer designated facility. Representative soil samples shall be tested for grain-size distribution by mechanical means (sieves down to the 0.074 mm (No. 200) No. 200 size according to ASTM C 136), moisture content according to ASTM D 2216 and Atterberg limits according to ASTM D 4318. Description and identification of soils shall be done in accordance with ASTM D 2488. Laboratory classification of soils shall be done in accordance with ASTM D 2487. Sampling shall be performed to allow completion of the documents described in paragraph Borehole Logs.

3.3.4 Geophysical Logging

****
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 is not 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 D 5753.
****

The total depth of each test hole drilled shall be geophysically logged. Geophysical logging shall be documented in accordance with paragraph Geophysical Logs. The Contractor shall run [one successful natural gamma

ray or gamma-gamma for the full depth, (top to bottom of test hole);] [one successful neutron in the fluid filled portion of the hole, (top to bottom of test hole);] [one successful (top to bottom of test hole) spontaneous potential (self-potential);] [and,] [one successful (top to bottom of test hole) resistivity log], for each test hole. Log analyses and interpretations shall be made by a person qualified in accordance with paragraph QUALIFICATIONS.

3.3.5 Borehole Diameter and Depth

****
NOTE: State regulations may require more than 50 mm (2 inches) of annular space between the boring wall and the sides of the entered riser pipe and screen.
****

The borings for monitoring well installation shall be of sufficient diameter to permit at least 50 mm (2 inches) 2 inches of annular space between the boring wall and all sides of the centered riser pipe and screen. Depths of individual borings shall be [determined as specified in the approved Monitoring Well Installation Plan] [as indicated on the drawings] [_____]. The actual depth of the monitoring well shall be adequate to allow for the collection of representative ground water samples for chemical analysis at the time of initial sampling.

3.3.6 Screen, Well Casing/Riser Pipe Placement

****
NOTE: Depending on the nature of the contaminants to be sampled, the screen may be required to be placed below or across the water table. Caps for the flush-to-ground, or manhole type surface completion should not be vented, or loose fitted. Caps for these type completions should be water tight. Delete the requirements for centralizers if they are not required per paragraph CENTRALIZERS.
****

The monitoring well screen length shall be [as shown on the drawings] [[____] mm feet long] [determined by the Contractor and approved by the Government], with specified bottom cap securely attached, set to the appropriate depth. The bottom of the well screen shall be placed no more than 1 m (3 feet) 3 feet above the bottom of the drilled borehole. The well screen shall be placed in the appropriate location in the borehole so that the completed monitoring well functions in accordance with paragraphs SYSTEM DESCRIPTION and WELL ACCEPTANCE. The Contractor shall provide sieve analyses of all drive sampled material. Sieve analyses shall be conducted in accordance with ASTM C 136. The well screen shall be placed [as specified on the drawings] [at [_____]]. The screen and well casing/riser pipe sections shall be joined by flush threaded watertight joints. The well casing/riser pipe shall extend upwards from the screen to an elevation appropriate for the surface completion described in paragraph Protective Cover Placement. The well screen and riser pipe shall not be dropped or allowed to fall uncontrolled into the borehole. Screen and well casing/riser pipe shall be cleaned with high pressure hot water/steam just prior to installation; foreign material shall not remain on the screen and well casing before installation. The use of factory-sealed (plastic wrapped) screen, free from painted markings, does not waive requirements for pre-installation cleaning. Joints and fastenings shall be watertight

and flush threaded; solvent glue or set screws shall not be used. The well shall be plumb, and centered in the hole by the use of a minimum of [_____] stainless steel centralizers, in accordance with paragraph CENTRALIZERS. The centralizers shall be spaced 120 degrees apart at intervals not exceeding [6] [_____] meters [20] [_____] feet along the length of the casing. Centralizers shall not be placed on the screened interval or within the bentonite seal. The alignment of the well shall be verified by passing a 1500 mm 5 foot long section of rigid pipe 6 mm 1/4 inchsmaller in diameter than the inside diameter of the casing through the entire well. If the pipe does not pass freely, the well will not be accepted. The pipe section shall be thoroughly cleaned with high pressure hot water prior to each test. Temporary casing, hollow stem augers or other measures shall be used, as necessary, to prevent collapse of the boring against the well screen and well casing/riser pipe prior to placement of the filter pack and sealing materials. A cap shall be installed on the top of the riser pipe. Caps shall be either vented, or a telescopic fit, constructed to preclude binding to the well casing caused by tightness of fit, unclean surfaces, or weather conditions. In either case it shall be secure enough to preclude the introduction of foreign material into the well, yet allow pressure equalization between the well and the atmosphere.

3.3.7 Filter Pack Placement

After the screen and well casing have been concentrically placed in the hole, the approved filter pack shall be constructed around the screen by filling the entire space between the screen and the wall of the hole over the selected screened interval. The lowermost [300] [_____] mm [1] [_____] foot of filter pack shall be placed in the boring prior to installation of the well screen and shall serve as a base on which to place the screen. A tremie pipe having an inside nominal diameter of not less than 25 mm (1 inch), 1 inch, shall be lowered to the bottom of the annulus between the hole and well. The tremie pipe shall be cleaned with high pressure hot water/steam prior to each use. The tremie pipe shall be arranged so that water and filter pack material fed at uniform rates are discharged as the filter pack material fills the hole from the bottom up. The tremie pipe shall be raised at a rate that will keep the bottom of the pipe no more than [1500] [_____] mm [5] [_____] feet above the top of the surface of the filter pack level, and no more than [600] [_____] mm [2] [_____] feet below the surface of the filter pack level at all times. Dumping filter pack material from the surface of the ground and agitating the well in an effort to settle the filter material will not be allowed. The filter pack shall be installed continuously and without interruption until the filter pack has been placed [to a minimum of 1 meter (3 feet) 3 feet above the top of the screen in the monitoring well] [to a height equal to 20 percent of the length of the screen] [to within no more than [_____] meters feet of the top of the ground surface]. The depth to the top of the filter pack shall be directly measured, and recorded. Any water added to the filter pack material shall be obtained in accordance with paragraph Water Source. Filter pack material shall be protected 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. Filter pack material shall be transported to the well site in a manner which prevents contamination by other soils, oils, grease, and other chemicals. Temporary drill casing, if installed, or auger shall be removed simultaneously with the above operation. Lifting of the riser pipe shall be minimized when withdrawing the temporary casing/auger. Filter pack material shall be placed in no greater than 1 m (3 foot) 3 foot lifts prior to retraction of the temporary casing/auger. A minimum of 150 mm 6 inches of filter pack shall remain in the temporary casing/auger at all times

during filter pack installation. Frequent measurements shall be made inside the annulus during retraction to ensure that the filter pack is properly placed.

3.3.8 Bentonite Seal

****

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. Bentonite chips should not be placed in the vadose zone. When installing a bentonite seal in the vadose zone, potable water should be added to the bentonite for it to properly hydrate. The amount of water is dependent on the formation. It is recommended that the bentonite seal be placed in lifts, with each lift allowed to hydrate for a minimum period of time. For more guidance consult EM 1110-1-4000.

****

A minimum 1 m (3 foot) 3 foot thick hydrated bentonite seal shall be placed on top of the filter pack in a manner which prevents bridging of the bentonite in the annulus. The bottom of the bentonite seal shall be a minimum of 1 m (3 feet) 3 feet above the top of the filter pack. The depth to the top of the bentonite seal shall be directly measured, and recorded immediately after placement, without allowance for swelling. If the bentonite seal is located above any borehole fluid levels, a [300] [_____] mm [1] [_____] foot layer of fine sand shall be placed at the top of the bentonite seal.

3.3.9 Grout Placement

****

NOTE: There is a provision for placing a high-solids bentonite grout in the annulus above the bentonite seal rather than cement grout. This may be better in areas of the country where the monitoring wells will be susceptible to frost heave. If it is required that the protective casing be anchored in-place with cement grout, this should be done in accordance with paragraph Protective Cover Placement. The depth of maximum frost penetration should be determined before design of the monitoring well installation. The susceptibility of the soils to frost action should also be determined

beforehand. Guidance for determining frost penetration may be found in TM 5-852-6 or FM 5-430-00-1. 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 [non-shrinking cement] [high-solids bentonite] grout, shall be mechanically mixed in accordance with paragraph CEMENT AND BENTONITE GROUT, and placed in one continuous operation into the annulus above the bentonite seal to [within [_____] mm feet of] [the ground surface] [the maximum depth of frost penetration (frost line)]. Grout injection shall be in accordance with ASTM D 5092. If the casing interval to be grouted is less than 4.5 m (15 feet), 15 feet, and without fluids after any drill casing is removed,the grout may be placed either by pouring or pumping. The tremie pipe shall be thoroughly cleaned with high pressure hot water/steam before use in each well. The bottom of the tremie pipe shall be constructed to direct the discharge to the sides rather than downward. The discharge end of the tremie pipe shall be submerged at all times. Additional grout shall be added from the surface to maintain the level of the grout at the land surface as settlement occurs. Work shall not be conducted in the well within [24] [_____] hours after cement grouting. The alignment of the well shall be verified by passing a 1.5 m (5 foot) 5 foot long section of rigid [PVC] [stainless steel] [PTFE] [_____] pipe 6 mm (1/4 inch) 1/4 inch smaller in diameter than the inside diameter of the casing through the entire well. If the pipe does not pass freely, the well will not be accepted. The pipe section shall be thoroughly cleaned with high pressure hot water/steam prior to each test.

3.3.10 Concrete or Gravel Pad Placement

****

NOTE: Some states may require that the surface seal extend to depths of 3 m (10 feet), or greater to ensure sanitary protection of the well. The surface seal may be an extension of the annular seal installed above the filter pack or it may be a separate "surface" seal emplaced on top of the annular seal. Also, in extreme cold climates, it may be better, if allowed by state and local regulations, to fill the annular space above the bentonite well seal, or filter pack, with bentonite grout and construct the well "pad" of coarse gravel, rather than concrete. Concrete well pads sometimes have a tendency to crack and breakup in cold regions.

****

A [concrete pad with a minimum radius of [600] [_____] mm [2] [_____] feet from the protective casing and 100 mm (4 inch) 4 inch] [coarse gravel blanket with a minimum radius of [1200] [_____] mm [4] [_____] feet from the protective casing and 150 mm (6 inch) 6 inch] thick, sloped away from the well shall be constructed around the well casing at the final ground level elevation. [Prior to placement of the gravel blanket, any depression

existing around the well borehole shall be backfilled to the level of the surrounding ground surface with [near-surface drill cuttings from the well] [clay] [_____].] [Concrete for the well pads shall be furnished as pre-packaged, dry, combined materials for concrete and shall conform to ASTM C 387 normal weight, normal strength concrete. The dry materials shall be combined with potable water and mixed in an approved mixer or container until uniform in consistency and color. Water shall be limited to the minimum amount possible.]

3.3.11 Protective Cover Placement

****
NOTE: If frost heave is not a concern at the site, the requirement for the annular space between the protective casing and the well riser to be filled with dry bentonite may be deleted. The cement grout may then be placed outside of, and inside the protective casing to the ground surface as would be specified in paragraph Grout Placement.

It may be necessary to require that the protective posts be supplemented with barbed wire in livestock grazing areas. Additional guidance on monitoring well protection may be found in ASTM D 5787
****

Monitoring wells shall have a [steel] [_____] lockable protective enclosure set in the annular seal over the well casing. Keyed-alike locks shall be provided on the protective covers for all wells.

3.3.11.1 Protective Steel Casing

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

A protective steel casing shall be installed around the well casing/riser pipe by placing the protective casing into the annular seal. The protective casing shall be cleaned with high-pressure hot water/steam prior to installation to ensure that it is free of any contamination. The protective casing inside diameter shall be at least 100 mm 4 inches greater than the nominal diameter of the well riser. The protective casing shall be fitted with a locking cap and installed so that there is a maximum 61 mm 0.2 foot clearance between the top of the in-place inner well casing cap and the bottom of the protective casing locking cap when in the locked position. The protective casing shall be positioned and maintained in a plumb position. The bottom of the protective casing shall extend a minimum of 750 mm 2.5 feet below the top of the ground surface; shall extend a minimum of [750] [_____] mm [2.5] [_____] feet below the maximum depth of frost penetration (frost line); shall be anchored into the cement grout annular seal; and shall extend at least 750 mm 2.5 feet above the surface of the ground. The protective casing shall be sealed and immobilized in concrete placed around the outside of the protective casing. Dry bentonite pellets, or granules, shall then be placed in the annular space below ground level within the protective casing. The protective casing shall have a 6 mm 1/4 inch diameter drain hole installed just above the top of the [concrete pad] [gravel blanket]. Coarse sand or pea gravel shall be placed in the annular space between the protective casing and the riser

pipe, above the drain hole, to within 75 mm 3 inches from the top of the riser pipe. [Four] [_____] protective steel posts shall be installed, located 1200 mm 4 feet from the well, equally spaced around the [concrete pad] [gravel blanket]. The steel posts shall be filled with cement. The posts shall not be installed in the concrete pad, but from a 150-300 mm 0.5-1.0 foot distance from the edge of the concrete pad. The posts shall be set in cement, and shall extend a minimum of 1 m 3 feet above the ground surface. One third of the posts' total length shall be below ground surface.

3.3.11.2 Flush-to-Ground Utility Vault

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

A flush-to-ground protective steel utility vault or manhole shall be installed around the well casing/riser pipe which has been cut off below grade. The flush mounted protective utility vault or manhole shall be constructed with a concrete ground surface seal. The ground surface seal shall extend to, but not beyond, the total depth of the flush mounted protective utility vault. The ground surface seal shall be installed around the flush mounted protective utility vault and shall not be placed between the flush mounted protective utility vault and the well casing. The flush mounted protective utility vault shall not be installed in areas subject to ponding or flooding. The flush mounted protective cover's lid or manhole cover shall have the wording "ground-water monitoring well" on its outer surface. Flush mounted protective utility vaults shall be installed through an impervious surface such as asphalt or concrete. If an impervious surface does not exist, one shall be created to support the weight of the traffic in the area. The flush mounted protective utility vault shall consist of a watertight metal casing with an inside diameter at least 100 mm (4 inches) 4 inches greater than the inside diameter of the monitoring well casing. The flush mounted protective utility vault shall be one continuous metal piece or two metal pieces which are joined with a continuous weld. The flush mounted protective utility vault shall be a minimum of [300] [_____] mm [12] [_____] inches in length. There shall be no more than 200 mm (8 inches) 8 inches between the top of the monitoring well casing and the top of the flush mounted protective utility vault after installation. The flush mounted protective utility vault shall have an exterior flange or lugs. The flush mounted protective utility vault shall not extend below the top of the cement/bentonite annular space seal. To prevent damage from frost heave, the concrete surrounding the utility vault shall extend a minimum of 300 mm 1 foot below the frost line. The flush mounted protective utility vault or the monitoring well shall have a locking mechanism. The monitoring well installed within any flush mounted protective utility vault shall have a watertight cap.

3.3.12 Well Identification

****
NOTE: Local well identification requirements should be specified.
****

A corrosion resistant metal tag shall be affixed to the exterior and interior of the protective cover. The metal tag shall be stamped with the [U.S. Army Corps of Engineers CE [_____]] [_____], well identification

number, elevation of the highest point on the rim of the well casing or riser pipe, elevation of the ground surface at the well, well coordinates, date of well installation, and the top of the protective casing elevation in meters feet as determined according to paragraph SURVEYS. Monitoring wells shall be assigned the identification numbers as indicated on the drawings.

3.3.13 Well Development

****

NOTE: Well development locally improves or restores the aquifer's hydraulic conductivity and removes undesirable materials from the aquifer near the well screen, thus yielding a more representative ground water sample. The most appropriate development method and acceptance criteria to use will vary according to the hydrologic characteristics of the aquifer, the drilling method used and the type of well completion. The following specification is performance based. The designer may specify a method which has been shown to work well in the project area. In some instances, e.g., very fine-grained sediments, some karst terrains, the well development criteria may not be obtainable. Development criteria should be modified if such conditions are known or suspected to exist. The U.S. Environmental Protection Agency (EPA) may, according to their Technical Enforcement Guidance Document (TEGD), 530/R-93/001, consider a well improperly completed if a well yields turbid samples (turbidity greater than or equal to 5 NTUs) after development. If the local EPA Region enforces this criteria, it may be necessary to include a requirement that the well be developed until a turbidity of less than or equal to 5 NTUs is achieved.

****

Within 7 days of completion of each well, but no sooner than [48] [_____] hours after cement grouting is completed, the well shall be developed. Development shall be performed using only mechanical surging or over pumping or a combination thereof per ASTM D 5521. Details of the proposed development method shall be included in the Monitoring Well Installation Plan. A well development record shall be maintained in accordance with paragraph Well Development Records. Development is complete when:

a. Well water is clear to the unaided eye,

b. Sediment thickness in the well is less than [1 percent of the screen length] [30 mm (0.1 foot) 0.1 foot],

c. A minimum of three times the standing water volume in the well 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 shall mean [variation of less than

0.2 pH units, variation of ± 1 degree Celsius,1 degree Fahrenheit,; ± 3 percent change in specific conductance; ± 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] [_____]. ORP shall be determined in accordance with AWWA EWW. Temperature, specific conductance, DO, turbidity, and pH readings shall be conducted in accordance with EPA 600/4-79/020. At completion of well development, approximately 0.5 liter 1 pint of well water shall be collected in a clear glass jar. The jar shall be labeled with project name, well number and date; and photographed using 35 mm color print film. The photograph (minimally 125 x 174 mm 5 x 7 inch) shall be a suitably backlit close-up which shows the clarity of the water and any suspended sediment. The photograph and negative shall become a part of the well development record. Water removed during development and testing operations shall be [contained in D.O.T. approved drums, containers or vessels and disposed of by [_____], in accordance with paragraphs CONTAINERIZATION OF DEVELOPMENT WATER, AND DRILL CUTTINGS, and Drilling Waste Disposal] [discharged to the ground surface at least [_____] meters feet from the well in a down gradient area].

3.3.14 In-Situ Permeability Determination

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NOTE: In some fine grained aquifers, the period of time for the aquifer to reach equilibrium may exceed 24 hours and testing should be performed no sooner than 48 or more hours after the well is developed.

****

The in-situ permeability for each well shall be determined following development and shall occur no sooner than [48] [_____] hours after development. After the well is developed and allowed to equilibrate for at least 24 hours, and before in-situ permeability testing, the static water level in the well shall be measured and recorded. The Contractor shall determine, for each well installed, the in-situ permeability of the screened formation using an appropriate method after the well has been developed. The Contractor shall propose the details of the methods expected to be used and references for those methods in the Monitoring Well Installation Plan. Except for formation water from the well, no other water or liquid shall be introduced into the well.

3.3.15 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. On a remedial action project, it may be prudent to dispose of drilling and well installation waste in coordination with other project waste streams. 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.

****

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

3.4 SURVEYS

****

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

****

Coordinates and elevations shall be established for each monitoring well/test hole. Horizontal coordinates shall be determined to the closest 300 mm (1.0 foot) 1.0 foot and referenced to the State Plane Coordinate System, or Universal Transverse Mercator (UTM). If the State Plane Coordinate System/UTM is not readily available, an existing local grid system shall be used. A ground elevation to the closest 30 mm (0.1 foot) 0.1 foot shall be obtained at each well. The highest point on the top of the riser pipe will serve as a measurement point. The elevation of the monitoring well shall reference this point, and shall be surveyed to the nearest 3 mm (0.01 foot) 0.01 foot using the National Geodetic Vertical Datum of [1929] [1988]. If the datum is not readily available, the existing local vertical datum shall be used. The location, identification, coordinates, and elevations of the well and monuments shall be plotted on maps with a scale large enough to show their location with reference to other structures.

3.5 WELL DECOMMISSIONING/ABANDONMENT

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NOTE: Guidance for decommissioning of monitoring wells may also be found in EM 1110-1-4000.

****

Any well disapproved by the Contracting Officer, or any well decommissioned/abandoned by the Contractor for any reason shall be decommissioned/abandoned according to the requirements of the State of [_____], ASTM D 5299, and the requirements of these specifications. Well decommissioning/abandonment includes the removal of all materials left in the borehole/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/well. Test holes decommissioned/abandoned for any reason shall be grouted from the bottom to within [_____] mm feet of the top of the ground surface according to the protocol for grout/bentonite placement established in paragraph Grout Placement, using the grout mix specified in paragraph CEMENT AND BENTONITE

GROUT. The top [_____] mm feet shall be backfilled with [material appropriate for the intended land use] [_____]. The Contractor shall maintain a well decommissioning/abandonment record as specified in paragraph Well Decommissioning/Abandonment Records. Groundwater levels, if encountered before the decision is made for decommissioning/abandonment, shall be measured in all borings prior to backfilling. These water levels shall be included in the well decommissioning/abandonment records. No well shall be decommissioned/abandoned without the approval of the Contracting Officer.

3.6 WELL ACCEPTANCE

It is the responsibility of the Contractor to properly design, construct, install, develop, and test all monitoring wells according to the requirements of this specification so that they are suitable for the intended purpose. If the Contractor installs wells that are not functional or not in accordance with these specifications, the Contracting Officer will disapprove the well and direct the Contractor to repair or replace it, and to abandon the disapproved well in accordance with this specification.

3.7 SITE CLEANUP

After completion of the work, tools, appliances, surplus materials, temporary drainage, rubbish, and debris incidental to work shall be removed. Excavation and vehicular ruts shall be backfilled and dressed to conform with the existing landscape. Utilities, structures, roads, fences, or any other pre-existing item which must be repaired or replaced due to the Contractor's negligence shall be the Contractor's responsibility; repair or replacement shall be accomplished prior to completion of this contract.

3.8 DOCUMENTATION AND QUALITY CONTROL REPORTS

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

3.8.1 Borehole Logs

****

NOTE: Borehole logging requirements can be found in EM 1110-1-4000, Monitor Well Design, Installation, and Documentation at Hazardous and/or Toxic Waste Sites. Requirements can also be found in ASTM D 2113 and ASTM D 5434. 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 D 6032.

****

A borehole log shall be completed for each boring drilled. Borehole logs shall be prepared by the geologist present onsite during all well drilling and installation activities. The log scale shall be [10] [_____] mm equals [300] [_____] mm [1] [_____] inch equals [1] [_____] foot. Copies of complete well logs shall be kept current in the field at each well site and shall be available at all times for inspection by the Contracting Officer.

Information provided on the logs shall include, but not be limited to, the following:

a. Name of the project and site.

b. Boring/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 mm 6 inches of driven sample tubes. Information shall include hammer weight and drop distance. Information such as rod size, bit type, pump type, etc., shall be recorded. 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 shall be included. If measured, mud viscosities and weight shall be recorded.

k. Depth of each change of stratum. If location of strata change is approximate, it shall be so stated.

l. Description of the material of which each stratum is composed, in accordance with [ASTM D 2488] [_____], and/or standard rock nomenclature, as necessary. Soil parameters for logging shall include, but shall not be limited to, classification, depositional environment and formation, if known, Unified Soil Classification Symbol, secondary components and estimated percentages, color (using FSUP 77341 or GSA RCC00100R), plasticity, consistency (cohesive soil), density (non-cohesive soil), moisture content, structure and orientation, and grain angularity. Rock core parameters for logging shall include, but shall not be limited to, rock type, formation, modifier denoting variety (shaly, calcareous, siliceous, etc.), color (using GSA RCC00100R), hardness, degree of cementation, texture, crystalline structure and orientation, degree of weathering, solution or void conditions, primary and secondary permeability, and lost core. The results of any chemical field screening shall also be included on the boring log. Classification shall be prepared in the field at the time of sampling. The results of visual observation of the material encountered, and any unusual odor detected shall also be duly noted and recorded.

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. Depth to water, and any non-aqueous phase liquids (NAPLs) and date measured before, during, and after each drilling shift, and prior to well installation. The Contractor shall provide and maintain at each well under construction a portable water, and NAPL level measuring device of sufficient length to measure the water/NAPL level to [50] [_____] meter [165] [_____] foot depth. The device shall be available onsite at all times and measuring wire shall be graduated in mm . 0.01 foot. Water and NAPL level measurements shall be taken to the nearest mm . 0.01 foot.

p. Box or sample number. Depths and the number of the core boxes and/or samples shall be recorded at the proper interval.

q. Percent Rock Core Recovery. The percent core recovery for the individual drill runs, if rock is cored, shall be shown.

3.8.2 Installation Diagrams

The well will not be accepted before the geologic logs and installation diagrams are received. The diagram shall 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/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).

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/or bentonite used, mix ratios of grout, method of placement and quantities used.

k. Elevations/depths/heights of key features of the well, such as top of well casing/riser pipe, top and bottom of protective casing,

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. A plan sheet shall also be included 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.

3.8.3 Well Development Records

A monitoring well development record shall be prepared for each monitoring well installed under the supervision of the geologist present during well installation operations. Information provided on the well development record shall include, but not be limited to, the following:

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/or 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 as per ASTM D 4750 from top of the casing, immediately after pumping/development, and 24 consecutive 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/or description of the disposal facility/area, for the waters removed during development.

3.8.4 Geophysical Logs

Geophysical logs shall be prepared and completed for each monitoring well/test hole installed. Information provided on the logs shall include, as a minimum, the following:

a. Project name.

b. Test hole/monitoring well identification number.

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

d. Date test hole was drilled.

e. Fluid level in test hole 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 hole 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/min. (ft/min.). ft/min.

x. Log vert. scale m/cm (ft/in.). ft/in.

y. Module settings.

z. Recorder settings.

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

3.8.5 Well Decommissioning/Abandonment Records

Decommissioning/abandonment records shall include, as a minimum, the following:

a. Project name.

b. Well or test hole number.

c. Well/boring location, depth and diameter.

d. Date of decommissioning/abandonment.

e. Method of decommissioning/abandonment.

f. All materials used in the decommissioning/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/abandonment of the monitoring well/test hole.

3.8.6 Project Photographs

Before, during, and after completion of work, the Contractor shall take a minimum of [one view] [[_____] views] of each well installation. If rock is cored at the site, after the core has been logged the core shall be dampened, if it has dried, neatly arranged in the core box, and photographed. Photographs shall be [80] [_____] x [120] [_____] mm [3] [_____] x [5] [_____] inch color prints. The photographs shall be mounted and enclosed back-to-back in a double face clear plastic sleeve punched to fit standard three ring binders. Each color print shall show an information box, [20] [_____] x [50] [_____] mm. [1-1/2] [_____] x [3-1/2] [_____] inches. The box shall be typewritten and arranged as follows:

Project No. Contract No.

Contractor/Photographer:

Photograph No. Date/Time:

Description:

Direction of View:

3.8.7 Survey Maps and Notes

A tabulated list of all monitoring wells and monuments, copies of all field books, maps showing the locations, and elevations of all monitoring wells, and all computation sheets shall be prepared as a submittal. The tabulation shall consist of the designated number of the well or monument, the X and Y coordinates, and all the required elevations.

-- End of Section --