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USACE / NAVFAC / AFCEC / NASA	**UFGS 33 51 39 (August 2017)**

Preparing Activity: NASA	**Superseding**
	UFGS 33 24 00.00 20 (March 2006)
	UFGS 33 24 13 August 2008)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2021

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SECTION TABLE OF CONTENTS

DIVISION 33 - UTILITIES

SECTION 33 51 39

MONITORING WELLS

08/17

PART 1 GENERAL

1.1 UNIT PRICES
1.1.1 Test Holes
1.1.2 Well Drilling and Sampling
1.1.3 Geophysical Logging
1.1.4 Well Casing and Riser Pipe Selection and Installation
1.1.5 Monitoring Well Screen
1.1.6 Filter Pack Construction
1.1.7 Bentonite Seal
1.1.8 Grout Placement
1.1.9 Monitoring Well Development
1.1.10 Monitoring Well Completion Aboveground
1.1.11 Monitoring Well or Test Hole Decommissioning/Abandonment
1.1.12 Site Cleanup
1.2 REFERENCES
1.3 ADMINISTRATIVE REQUIREMENTS
1.3.1 Notification
1.4 SUBMITTALS
1.5 QUALITY CONTROL
1.5.1 Qualifications
1.5.2 Required Drawings
1.5.3 Investigation-derived Waste Management Plan
1.5.4 Health and Safety Plan (HASP)
1.5.5 Sampling and Analysis Plan (SAP)
1.5.6 Installation Plan
1.5.7 Treatment Facility Permit
1.5.8 Well Development Report
1.5.9 Well Construction Permit
1.5.10 Shipment Manifests
1.5.11 Delivery Certificates
1.5.12 Treatment and Disposal Certificates
1.6 DELIVERY, STORAGE, AND HANDLING
1.7 PROJECTS/SITE CONDITIONS

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION
2.2 COMPONENTS
2.2.1 Well Casing
2.2.1.1 Stainless Steel Pipe
2.2.1.2 PVC Pipe
2.2.2 Well Screen
2.2.2.1 Stainless Steel Screens
2.2.2.2 PVC Screens
2.2.2.3 Prepacked Screen Monitoring Wells
2.2.3 Primary Filter Pack
2.2.3.1 Secondary Filter Pack
2.2.4 Annular Sealants
2.2.4.1 Bentonite Seal
2.2.4.2 Neat Cement Grout
2.2.4.3 Cement And Bentonite Grout
2.2.5 Bottom Plugs
2.2.6 Locking Well Cap
2.2.7 Protective Outer Casing [and Bollards]
2.2.8 Polyethylene Sheeting

PART 3 EXECUTION

3.1 PREPARATION
3.1.1 Water Source
3.1.2 Decontamination
3.1.3 Decontamination Station
3.1.4 Containerization Of Development Water, And Drill Cuttings
3.2 INSTALLATION
3.2.1 Drilling Method
3.2.2 Test Hole Requirements
3.2.3 Borehole Diameter and Depth
3.2.4 Screen, Well Casing And Riser Pipe Placement
3.2.5 Filter Pack Placement
3.2.6 Bentonite Seal
3.2.6.1 Bentonite Pellets
3.2.6.2 Bentonite Chips
3.2.6.3 Bentonite Slurry
3.2.6.4 Bentonite Seal Thickness And Replacement
3.2.7 Grout Placement
3.2.8 Concrete or Gravel Pad Placement
3.2.9 Protective Cover Placement
3.2.9.1 Aboveground Completions
3.2.9.2 At-Grade Completions
3.2.9.3 Protective Steel Casing
3.2.9.4 Flush-to-Ground Utility Vault
3.2.10 Well Identification
3.3 FIELD QUALITY CONTROL
3.3.1 Temporary Containment of Soil Removed from the Borehole
3.3.2 Well Alignment
3.3.3 Sampling
3.3.4 Sampling for Chemical Analysis
3.3.5 Sampling for Geotechnical Analysis
3.3.5.1 Geophysical Logging
3.3.6 In-Situ Permeability Determination
3.3.7 Well Development
3.3.7.1 Well Development Records
3.3.8 Surveys

3.3.8.1 Survey Maps and Notes
3.3.9 Project Photographs
3.4 ADJUSTING AND CLEANING
3.4.1 Site Cleanup
3.4.2 Water From Well Development Operations
3.4.2.1 Disposal of Containerized Water
3.4.3 Drilling Waste Disposal
3.4.4 Transportation Of Contaminated Soil And Water
3.4.5 Disposal of Contaminated Soil And Water
3.5 CLOSEOUT ACTIVITIES
3.5.1 Well Acceptance
3.5.2 Documentation Reports
3.5.2.1 Borehole Logs
3.5.2.2 Installation Diagrams
3.5.3 Geophysical Logs
3.5.4 Well Decommissioning/Abandonment Records

-- End of Section Table of Contents --

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SECTION 33 51 39

MONITORING WELLS
08/17

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NOTE: This specification covers the requirements for monitoring well installation and testing at hazardous and non-hazardous waste sites.

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).

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NOTE: This guide specification is not appropriate for vapor extraction and two phase extraction wells.

****

PART 1 GENERAL

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NOTE: 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 is pulled into the well during the development and sampling.

Use Section 33 11 13 WATER SUPPLY WELLS for water

supply wells and associated testing.

Use Section 33 26 00.00 10 RELIEF WELLS for projects relating to the relief of excess hydrostatic pressures adjacent to dams, locks, levees or other water retaining structures.

Coordinate and specify the appropriate pump for the specified well in a separate section.

Include the following in the drawings, and any other information necessary to indicate layout and general configuration of the well:

1. Diameter of drilled hole

2. Casing diameter

3. Well screen diameter, length, location, and slotted opening size

4. Minimum depth of casing and minimum depth well screen

5. Depth to primary and secondary filter packs

6. Depth to bentonite seal and grout seal

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

Include the applicable state and local regulatory references where appropriate in the body of the specification.

Use the following specifications in conjunction with this section:

00 22 13.00 20 SUPPLEMENTARY INSTRUCTIONS TO OFFERORS

01 35 26 GOVERNMENTAL SAFETY REQUIREMENTS

01 35 29.13 HEALTH, SAFETY, AND EMERGENCY RESPONSE PROCEDURES FOR CONTAMINATED SITES

01 32 01.00 10 PROJECT SCHEDULE

01 32 16.00 20 SMALL PROJECT CONSTRUCTION PROGRESS SCHEDULES] or

[01 32 17.00 20 COST-LOADED NETWORK ANALYSIS SCHEDULES (NAS)]

01 45 00.00 20 QUALITY CONTROL

01 45 00.00 10 QUALITY CONTROL

01 45 00.00 40 QUALITY CONTROL

02 81 00 TRANSPORTATION AND DISPOSAL OF HAZARDOUS MATERIALS

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1.1 UNIT PRICES

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NOTE: Delete this paragraph if the work is in one lump-sum contract price. If it is retained and more detail is needed, items of consideration may include: test holes, monitoring well drilling and sampling, geophysical logging, non-hazardous sludge, pumpable liquids, analyticals for contaminated water, or PCB and asbestos, piping removal or capping and sealing, and remainder of work.

Coordinate this paragraph with the bidding schedule.

****

Payment for each specified item is 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 holes or wells abandoned due to construction practices not in accordance with this specification, or for the convenience of the Contractor. Submit catalog data for the well screen (to include the screen slot size), well 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. Include any information, written or otherwise, supplied by the manufacturers or suppliers of the above listed items.

1.1.1 Test Holes

If the total depth of the test hole is greater than that specified in the contract for "Test Holes and Samples" due to justifiable site specific conditions and other justifiable reasons, the additional depth is 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 is made for the test hole.

1.1.2 Well Drilling and Sampling

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

1.1.3 Geophysical Logging

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

1.1.4 Well Casing and Riser Pipe Selection and Installation

Payment is made for length of blank casing actually installed in the

well. Payment includes 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 in accordance with contract.

1.1.5 Monitoring Well Screen

Payment is made for monitoring well screen actually installed in the well.

1.1.6 Filter Pack Construction

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

1.1.7 Bentonite Seal

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

1.1.8 Grout Placement

The cement and/or bentonite grout,used in the annulus above the bentonite seal is paid by the cubic meter foot used. Payment includes 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.

1.1.9 Monitoring Well Development

Payment for monitoring well development is made by the hour. Payment includes compensation for pumping, surging, sample photograph, discharge water containers, analysis, and disposal.

1.1.10 Monitoring Well Completion Aboveground

Payment includes compensation for protective covers, keyed-alike padlocks, locking caps, project photographs, concrete well pads, gravel, electrical components, lighting components, fencing, sign(s) and protective steel posts.

1.1.11 Monitoring Well or Test Hole Decommissioning/Abandonment

Permanent decommissioning/abandonment of monitoring wells or test holes is 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 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 hole and for the required well or test hole abandonment records.

1.1.12 Site Cleanup

Separate payment is not made for cleanup of the site. Cleanup means restoring the site to its pre-construction condition. Cleanup is considered part of and incidental to the drilling, construction, and/or decommissioning of the monitoring 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.

State and/or local regulations/requirements may also need to be referenced.

****

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 ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 306	(2010; R 2015) Standard Specification for Drainage, Sewer, Utility, and Related Castings

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA 10084	(2017) Standard Methods for the Examination of Water and Wastewater

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A312/A312M	(2019) Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
ASTM C117	(2017) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
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 C387/C387M	(2017) Standard Specification for Packaged, Dry, Combined Materials for Concrete and High Strength Mortar
ASTM D1452/D1452M	(2016) Standard Practice for Soil Exploration and Sampling by Auger Borings
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 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 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 D4397	(2016) Standard Specification for Polyethylene Sheeting for Construction, Industrial, and Agricultural Applications
ASTM D5088	(2020) Decontamination of Field Equipment Used at Nonradioactive Waste Sites
ASTM D5092	(2016) Standard Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers
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 D6725/D6725M	(2016) Standard Practice for Direct Push Installation of Prepacked Screen Monitoring Wells in Unconsolidated Aquifers

ASTM F480	(2014) Thermoplastic Well Casing Pipe and Couplings Made in Standard Dimension Ratios (SDR), SCH 40 and SCH 80
ASTM F883	(2013) Padlocks

FORESTRY SUPPLIERS INC. (FSUP)

FSUP 77341	(2009) Munsell (R) Soil Color Book

GEOLOGICAL SOCIETY OF AMERICA (GeoSA)

GSA RCC00100R	(2009) Geological Rock Color Chart (Munsell)

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1	(2014) Safety and Health Requirements Manual

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA 530/F-93/004	(1993; Rev O; Updates I, II, IIA, IIB, and III) Test Methods for Evaluating Solid Waste (Vol IA, IB, IC, and II) (SW-846)
EPA 600-4-89-034	(1990) Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells
EPA 600/4-79/020	(1983) Methods for Chemical Analysis of Water and Wastes
EPA SW-846	(Third Edition; Update IV) Test Methods for Evaluating Solid Waste: Physical/Chemical Methods

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

29 CFR 1910	Occupational Safety and Health Standards
49 CFR 172	Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, and Training Requirements

1.3 ADMINISTRATIVE REQUIREMENTS

Ensure each system, including equipment, materials, installation, and performance, is in accordance with local, State, and Federal regulations, ASTM D5092, EPA 600-4-89-034[and DoD policies and standards] except as modified herein. Consider the advisory or recommended provisions to be mandatory. Reference to the "Project Representative" and the "Owner" is interpreted to mean the Contracting Officer. Additional requirements are included under Section 01 50 00 TEMPORARY CONSTRUCTION FACILITIES AND CONTROLS.

1.3.1 Notification

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

1.4 SUBMITTALS

****

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-01 Preconstruction Submittals

Investigation-derived Waste Management Plan; G[, [____]]

Installation Plan; G[, [____]]

Health and Safety Plan; G[, [____]]

Sampling and Analysis Plan; G[, [____]]

Well Construction Permit

Treatment Facility Permit

Qualifications; G[, [____]]

SD-02 Shop Drawings

Survey Maps and Notes; G[, [____]]

Well Construction Drawings; G[, [____]]

SD-03 Product Data

Riser Pipe; G[, [____]]

Cement; G[, [____]]

Centralizers; G[, [____]]

Surface Protective Covers; G[, [____]]

Well Vaults; G[, [____]]

Locking Caps; G[, [____]]

Oil Filters; G[, [____]]

Sampling Equipment; G[, [____]]

Chemical Specifications on Drill Lubricants and Tracers; G[, [____]]

Well Casing; G[, [____]]

Well Screen; G[, [____]]

Filter Pack; G[, [____]]

Neat Cement Grout; G[, [____]]

Bentonite; G[, [____]]

SD-06 Test Reports

Drilling Fluid Additive; G[, [____]]

Well Development Record; G[, [____]]

Filter Pack Material Test Results; G[, [____]]

Sieve Analyses of Sampled Material; G[, [____]]

Water Source Analytical Test Results; G[, [____]]

SD-07 Certificates

Permits

Installation Survey Report

Well Development Report

Borehole Analysis Report

Shipment Manifests

Delivery Certificates

Correspondence

Photographs

Treatment and Disposal Certificates

SD-11 Closeout Submittals

Installation Diagram; G[, [____]]

Well Decommissioning/Abandonment Record

Geophysical Logs

Borehole Logs; G[, [____]]

1.5 QUALITY CONTROL

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NOTE: For projects on the National Priorities List(NPL) or RCRA sites, recommend using the EPA Uniform Federal Policy for Quality Assurance Project Plans worksheets for Quality Control.
****

1.5.1 Qualifications

Submit personnel qualification documentation. Provide an onsite geologist with at least [3] [_____] years experience in hazardous waste projects, soil and rock logging, and monitoring well installation. Ensure the geologist is registered in the State of [_____], and responsible for all geophysical and borehole logging, drilling, well installation, developing and testing activities. Provide a driller licensed in the State of [_____], according to State requirements. Perform and provide geophysical log interpretation by a qualified log analyst, demonstrating competence through background, training, and experience when so called upon. Ensure the drill crew is experienced and trained in drilling, and health and safety requirements for contaminated sites.

Furnish documentation proving:

a. A minimum of [_____] years of monitor well installation experience

b. Appropriate health and safety personnel are on staff as specified in

Section 01 35 29.13 HEALTH, SAFETY, AND EMERGENCY RESPONSE PROCEDURES FOR CONTAMINATED SITES

c. That qualified personnel are available to perform the necessary chemical sampling as presented in the approved Sampling and Analysis Plan.

1.5.2 Required Drawings

Submit well construction drawings showing components and details of well casing, well screen, filter pack, annular seal, and associated items. Ensure drawings are prepared and sealed by a State certified professional geologist, hydrogeologist, or a State registered professional civil engineer, hereafter referred to as the Contractor's Professional Consultant(CPC).

1.5.3 Investigation-derived Waste Management Plan

Furnish a material handling plan 15 days prior to initiation of the work that describes the plan for handling the investigation-derived waste, including the following: a schedule to be employed in the well drilling and development stages, a sequence of operations, the method of drilling and development, material hauling, proposed equipment, handling of the investigation-derived waste, testing requirements for the investigation-derived waste.

1.5.4 Health and Safety Plan (HASP)

Describe safety precautions for each phase of the project as specifically related to handling of soil and water removed during well drilling and development operations. Identify appropriate requirements of 29 CFR 1910 and EM 385-1-1. Identify safety equipment and procedures available for use during the project. Furnish the name and qualifications based on education, training, and work experience of the proposed Health and Safety Officer (HASO) and the members of the drill crew. The CPC may perform the responsibilities of the HASO if properly qualified.

1.5.5 Sampling and Analysis Plan (SAP)

Provide a sampling and analysis plan. Describe field sampling methods and quality control procedures. Identify a certified laboratory [approved by the Contracting Officer,]with laboratory methods to be used for contamination testing. Ensure sample reports show sample identification with location, date, time, sample method, contamination level, name of individual sampler, identification of laboratory, quality control procedures, and chain of custody information.

1.5.6 Installation Plan

****

NOTE: The Monitoring Well Installation Plan may need to be included as a part of the Sampling and Analysis Plan (SAP).

****

Submit a 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. Provide the plan approved and signed by a

geologist [experienced in hazardous waste projects] as specified in the paragraph QUALIFICATIONS. Incorporate the following requirements into the Monitoring Well Installation Plan and follow in the field. Conduct sampling and testing in accordance with the guidelines as stated in: "Department of Defense Policy and Guidelines for Acquisitions Involving Environmental Sampling or Testing", November 2007. Include in the plan, but do not limit 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. Include sample of forms 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. Describe decontamination procedures for well materials and equipment.

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

1.5.7 Treatment Facility Permit

Submit verification that the proposed treatment facility is permitted to accept the contaminated materials specified, prior to the start of drilling.

1.5.8 Well Development Report

Provide a report, containing the following data[for each well]: project

name and location, well designation, date and time of well installation, date and time of well development, static water level from top of well casing before development and 24 hours after development, field measurements of pH, temperature, and specific conductivity, depth of well from top of casing to bottom of well, screen length, description of development methodology size/capacity of pump or bailer, pumping rate, and recharge rate.

1.5.9 Well Construction Permit

Submit a completed permit application and a proposed method of construction to[the appropriate state agency][Contracting Officer] prior to construction of the well. Well construction[s] [is][are] not allowed to start until the Contracting Officer has an approved Well Construction Permit.

1.5.10 Shipment Manifests

[Furnish copies of manifests and other documentation required for shipment of waste materials within 24 hours after removal of waste from the site.][Shipment manifests are signed by the Contracting Officer.]

1.5.11 Delivery Certificates

Submit verification that the wastes were actually delivered to the approved treatment facility, within 7 days of shipment.

1.5.12 Treatment and Disposal Certificates

Submit verification that the wastes were successfully treated and remediated to the levels specified herein.

1.6 DELIVERY, STORAGE, AND HANDLING

Deliver materials in an undamaged condition. Unload and store with minimal handling. Store materials in on-site enclosures or under protective coverings. Store [plastic piping and jointing materials, and] rubber gaskets under cover, out of direct sunlight. Store materials off the ground. Keep insides of pipes and fittings free of dirt and debris. Replace defective or damaged materials with new materials.

1.7 PROJECTS/SITE CONDITIONS

****
NOTE: If needed, edit and add Section 31 11 00 CLEARING AND GRUBBING.
****

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].

Submit a copy of all permits, licenses, or other requirements necessary for execution of the work to the Contracting Officer. Before beginning work,notify 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] of the type and location of wells to be constructed, the method

of construction and anticipated schedule for construction of the wells. Furnish a copy of all such well site correspondence to the Contracting Officer.

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 will agree on a suitable clearing, or relocation plan and the location of any required access road.]

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

****

NOTE: Ensure that the 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.

****

Construct each monitoring well to yield chemically representative ground water samples from 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.

2.2 COMPONENTS

2.2.1 Well Casing

****

NOTE: Selection of casing and screen material type is critical to both the life of the well and the accuracy of the sampling data. Analysis of the existing groundwater chemistry is crucial to the designer making an appropriate material selection. In the absence of water quality data, it is prudent to choose conservative materials.

Stainless steel (SS) pipe offers high strength and rigidity sufficient to withstand virtually any subsurface condition, and is highly resistant to corrosion. SS is susceptible to degradation in long-term exposure to highly corrosive environments, including saline and certain acidic environments. This degradation results in the leaching of nickel and cadmium into the sampling regime.

PVC pipe is lightweight, corrosion resistant, durable, and generally chemically resistant but is not as strong as stainless steel pipe and is not recommended for deep wells. PVC is susceptible to

degradation in long-term exposure to high concentrations of certain organic solvents. These include tetrahydrofuran (THF), methyl ethyl ketone (MEK), methyl isobutyl ketone (MIBK), and cyclohexanone.

Additional materials such as aluminum, mild steel, polypropylene, and Teflon can be used for well casings. The designer needs to be familiar with the advantages and disadvantages of each material.

****

[2.2.1.1 Stainless Steel Pipe

Use ASTM A312/A312M, Type 304, Schedule 40S pipe, with flush threaded joint end fittings. Wrap threaded joints with fluoropolymer tape, and provide with nitrile O-ring gaskets.

][2.2.1.2 PVC Pipe

Use ASTM F480, Type 1, Grade 1, PVC 12454, NSF wc or NSF pw, Schedule [40] [80] pipe, with flush threaded joint fittings. Wrap threaded joints with fluoropolymer tape, and provide with nitrile O-ring gaskets.

]2.2.2 Well Screen

****

NOTE: Well screens are located in the most reactive zone of the well environment. The material selection should be made based on similar criteria as the well casing materials. The designer should select the same material for the well screen as selected for the casing. However, in some situations, well screen material may be different from the material selected for the casing. Strength of the screen is important, as it has a large open area. Size the width of the slotted openings relative to the filter pack material, and should retain between 90 and 99 percent of that material. The open area of the screen should allow flow through the screen at approximately the same rate as the natural permeability of the aquifer.

NOTE: Continuous wrap screen is commonly used for monitoring wells; the type screen is not normally designated by schedule; however, the end fittings are selected for compatibility with the schedule of the well casing. Specify the schedule of the end fittings of the screen and the screen itself, 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.

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.

****

2.2.2.1 Stainless Steel Screens

Provide a well screen consisting of new commercially fabricated flush-joint threaded [100] [_____] mm [4] [_____] inch nominal internal diameter Type [304][316][_____] stainless steel [_____][continuous wrap] [schedule [40] [_____] slotted], non-clogging design. Use screens conforming to ASTM A312/A312M, Type [316][_____], Schedule 40S, with continuous slot construction, wire wound, with flush threaded joint ends. [Provide schedule [40] [_____] end fittings on the continuous wrap screen.] Provide a screen slot size[approved by the Government] [[0.25] [0.50] [_____] mm [0.010] [0.020] [_____]-inch], and screen length of [[_____] meters feet]. Seal the bottom section of the screen watertight by means of a flush threaded end cap of the same material as the well screen, within 150 mm 6 inches of the open portion of the screen.

2.2.2.2 PVC Screens

Provide a well screen consisting of new commercially fabricated flush-joint threaded [100] [_____] mm [4] [_____] inch nominal internal diameter [polyvinyl chloride (PVC)] [_____][continuous wrap] [schedule [40] [_____] slotted], non-clogging design. Use screens conforming to ASTM D1785, PVC 1120, NSF wc or NSF pw, Schedule [40] [80], screen, Schedule 80, machine-slotted construction, flush threaded joint ends. Ensure slots are even in width, length, and separation. [Provide schedule [40] [_____] end fittings on the continuous wrap screen.] Provide required fittings conforming to ASTM F480, flush thread male by female. Provide a screen slot size[approved by the Government] [[0.25] [0.50] [_____] mm [0.010] [0.020] [_____]-inch], and screen length of [[_____] meters feet]. Seal the bottom section of the screen watertight by means of a flush threaded end cap of the same material as the well screen, within 150 mm 6 inches of the open portion of the screen.

[2.2.2.3 Prepacked Screen Monitoring Wells

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NOTE: For direct push installation of monitoring wells in unconsolidated aquifers, prepacked screen can be used.

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Ensure materials and installation of prepacked screen monitoring wells conform to the requirements of ASTM D6725/D6725M.

]2.2.3 Primary Filter Pack

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NOTE: The primary filter pack selected should have a 30 percent finer (d-30) grain size that is 4 to 10 times greater than the d-30 grain size of the aquifer. The uniformity coefficient (60 percent passing, d-60/10 percent passing, d-10) should be less than 2.5, and ideally in the 1.0 to 1.5 range. The primary filter should extend 600 to 1500 mm 2 to 5 feet above the top of the well screen. The

secondary filter should be a minimum of 300 mm one foot thick, preferably 600 mm 2 feet thick.
****

[Provide clean, durable, well-rounded, and washed quartz or granite, with less than 5 percent non-siliceous material. Ensure the filter pack does not contain organic matter or friable materials and allow free flow of water in the well, and also prevent the infiltration of aquifer materials. Ensure the filter pack has a 30 percent finer than (d-30) grain size of [_____] mm inch, and a uniformity coefficient less than [2.5] [_____], in accordance with ASTM C117 and ASTM C136/C136M.

][Provide a filter pack consisting of clean, washed, rounded to sub-rounded siliceous material free from calcareous grains or material. Submit filter pack material test results consisting of sieve and chemical analyses. Organic matter, soft, friable, thin, or elongated particles are not permissible. Determine the gradation of the filter pack using the grain size analysis data obtained from test results. Use a uniformity coefficient for the filter pack material not exceeding 2.5. Fill an airtight liter pint size [plastic] [glass] container with a sample of filter pack material and furnish to the Contracting Officer for each well to serve as a quality control.

]2.2.3.1 Secondary Filter Pack

Ensure gradation is in accordance with ASTM D5092. Provide clean, durable, well-rounded, and washed quartz or granite. Pack cannot contain organic matter or friable materials.

2.2.4 Annular Sealants

2.2.4.1 Bentonite Seal

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NOTE: Sodium bentonite is most widely used, however, calcium bentonite may be more appropriate for high calcium environments. Bentonite seal should be placed above the secondary filter and approximately 600 to 1500 mm 2 to 5 feet above the uppermost well screen.
****

Provide powdered, granular, pelletized, or chipped [sodium] [calcium] montmorillonite in sealed containers from a commercial source, free of impurities. Ensure pellet size is less than one fifth the diameter of the borehole annular space to prevent bridging. Ensure bentonite base grout is in accordance with ASTM D5092.

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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.
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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.

2.2.4.2 Neat Cement Grout

Provide neat cement grout in accordance with ASTM D5092. Ensure cement is in accordance with ASTM C150/C150M. Quick setting admixtures are not allowed. Do not use drilling mud or cuttings as a sealing material.

2.2.4.3 Cement And Bentonite Grout

Provide cement grout with a mixture of a maximum of 26 liters of approved water per 42.6 kg 7 gallons of approved water per 94 lb bag of portland cement, conforming to ASTM C150/C150M, Type [I] [_____]. Add no more than 5 percent by weight of bentonite powder to reduce shrinkage and hold the cement in suspension prior to the grout set. Use sodium bentonite powder and/or granules for high-solids bentonite grout.

2.2.5 Bottom Plugs

Provide a flush threaded solid plug at the bottom of the well. Ensure plug material is the same as the well [casing] [screen] to which it is attached. Wrap joints with fluoropolymer tape and provide nitrile O-ring gaskets.

2.2.6 Locking Well Cap

Provide a flush threaded, weatherproof, and non-removable locking well cap on the top of the well. Ensure the well cap is the same material as the well casing to which it is attached.

2.2.7 Protective Outer Casing [and Bollards]

Install a protective outer casing[and bollards] with pipes conforming to ASTM A53/A53M, Type E or S, Grade B.

2.2.8 Polyethylene Sheeting

Ensure polyethylene sheeting conforms to ASTM D4397.

PART 3 EXECUTION

Notify the Contracting Officer at least 15 days prior to commencement of work. Well locations are as indicated. Drilling, installation, and development of the monitoring well[s] is supervised, directed, and monitored by the geologist in charge. Decontaminate equipment used for drilling, sampling, and well development before and after each use in accordance with ASTM D5088.

3.1 PREPARATION

3.1.1 Water Source

If well drilling and installation requires the use of water, prior to its use at the site, locate and obtain water from a source. Sample and test the water source for the constituents specified in the Sampling and Analysis Plan. Submit the water source analytical test results to the Contracting Officer and obtain approval to use the source water. Transport and store the water at the site.

3.1.2 Decontamination

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 monitoring well location. Perform decontamination in accordance with [ASTM D5088][ASTM D5608], at a central decontamination station located in an area that is remote from, and cross- or down-gradient from the well being drilled.

Clean the screen and well casing with high-pressure hot water and detergent cleaning solution 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.

3.1.3 Decontamination Station

a. Construct a temporary decontamination pad onsite, bermed and slightly inclined towards a sump located in one of the back corners of the pad. Line the pads and berms with plastic sheeting to contain decontamination water. Place exterior-grade plywood sheeting over the plastic sheeting to prevent damage to the plastic and allow the drill rig and heavy equipment to use the pad.

b. Make the minimum dimensions of the pad the length and width of the drill rig, plus 1.2 m 4 feet per side to allow access and steam cleaning. Use yellow ribbon to encircle the decontamination pad.

c. Pump water collected in the sump to a 200 liter 55 gallon drum labeled "Decontamination Pad Sump Water." Transfer solid waste to a separate 200 liter 55 gallon drum labeled "Decontamination Pad Sump Sludge."

3.1.4 Containerization Of Development Water, And Drill Cuttings

Furnish D.O.T. approved [polyethylene] [steel] drums or vessels with lids, lid gaskets, bolts, chain of custody forms and drum labels. Mark each drum label in accordance with 49 CFR 172 in addition to the following information:

a. Drum number,

b. Site name,

c. Well name and number,

d. Contents and date,

e. Approximate depth of material contained in each drum, and

f. The name and phone number of the [Installation Environmental Coordinator (IEC)] [Contracting Officer] [_____].

3.2 INSTALLATION

Install the well in accordance with ASTM D5092 and EPA 600-4-89-034, and as indicated on the well construction drawings submitted by the CPC and approved by the Contracting Officer.

Prevent aquifer contamination by the drilling operation and equipment, intra- and inter-aquifer contamination, and vertical [or horizontal] seepage of surface water adjacent to the well into the subsurface, especially the monitoring well intake zone. Perform work in conformance with EPA 530/F-93/004, EPA 600/4-79/020,[and] EPA SW-846[.][, and][EM 385-1-1.]

Ensure the borehole is stable and verified straight before beginning installation.

Prevent aquifer contamination by the drilling operation and equipment, intra- and inter-aquifer contamination, and vertical [or horizontal] seepage of surface water adjacent to the well into the subsurface, especially the monitoring well intake zone. Perform work in conformance with EPA 530/F-93/004, EPA 600/4-79/020,[and] EPA SW-846[.][, and][EM 385-1-1.]

3.2.1 Drilling Method

a. Use a drilling method which prevents the collapse of formation material against the well screen and casing during installation of the well. Size the inside diameter of any temporary casing used sufficient to allow accurate placement of the screen, riser, centralizer, filter pack, seal and grout.

b. 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. Ensure any drilling fluid additive used is 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. Submit manufacturer's data, if available, including analytical test results of the additive, if not a part of the manufacturer's data.

c. Provide a drill rig free from leaks of fuel, hydraulic fluid, and oil which may contaminate the borehole, ground surface or drill tools. 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. 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 weighted down so that it cannot be removed except with the aid of the drilling equipment or through the use of drill tools.

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NOTE: Type of drilling equipment is dependent upon site geology, hydrogeology, and intended use. If possible, utilize drilling methods that do not introduce water or drilling fluids into the borehole. If such methods are required, purge drilling fluid from the well during well development.

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Advance borehole using conventional [[250] [_____] mm [10] [_____] inch hollow-stem auger] [solid auger] [rotary wash] [_____] drilling methods. If it is the opinion of the geologist in charge that an alternate drilling method is required, submit justification for a boring method change to the Contracting Officer, and receive approval for the change granted prior to drilling.

3.2.2 Test Hole Requirements

Drill one test hole 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. Log test holes in accordance with paragraph BOREHOLE LOGS, and if temporary casing is used, use in accordance with paragraph DECONTAMINATION.

3.2.3 Borehole Diameter and Depth

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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.
****

Provide sufficient diameter in borings for monitoring well installation to allow at least 50 mm 2 inches of annular space between the borehole wall and all sides of the centered riser pipe and screen. Determine depths of individual borings [as specified in the approved Monitoring Well Installation Plan] [as indicated on the drawings] [_____], with actual depth adequate to allow for the collection of representative ground water samples for chemical analysis at the time of initial sampling.

3.2.4 Screen, Well Casing And Riser Pipe Placement

Locate well screens as indicated. Ensure the length of [each] [the] screen is as indicated. Distribute slotted openings uniformly around the circumference of the screen. Ensure the open areas approach the formation's natural porosity.

****
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.
****

Ensure personnel wear clean cotton or surgical gloves while handling the assembly. Ensure well casings, screens, plugs, and caps are decontaminated prior to delivery by the manufacturer and certified clean. Deliver, store, and handle materials in such a manner as to ensure that grease, oil, or other contaminants do not contact any portion of the well screen and casing assembly prior to installation.

a. Provide the monitoring well screen in length [as shown on the drawings] [[____] mm feet long] [as determined by the Contractor and approved by the Government], with specified bottom cap securely attached, set to the appropriate depth.

b. Place the bottom of the well screen no more than 1 m 3 feet above the bottom of the drilled borehole.

c. Clean the screen and well casing and riser pipe with high pressure hot water/steam just prior to installation; allowing no foreign material to 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. Place the well screen [as specified on the drawings] [at [_____]]. Ensure the well casing and riser pipe extends upwards from the screen to an elevation appropriate for the surface completion described in paragraph PROTECTIVE COVER PLACEMENT. Do not allow the well screen and riser pipe to drop or fall uncontrolled into the borehole.

d. Join the screen and well casing and riser pipe sections by flush threaded watertight joints and fastenings. Solvent glue or set screws are not permitted.

e. Use centralizers to ensure that the well screen and casing assembly is installed concentrically in the borehole. [Center and plumb the well by the use of a minimum of [_____] stainless steel centralizers, spaced at intervals not exceeding [6] [_____] m [20] [_____] feet along the length of the casing. Do not place centralizers on the screened interval or within the bentonite seal.]Verify the alignment of the well by passing a 1500 mm 5 foot long section of rigid pipe 6 mm 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 is not accepted. Thoroughly clean the pipe section with high pressure hot water prior to each test. Use temporary casing, hollow stem augers or other measures, as necessary, to prevent collapse of the boring against the well screen and well casing and riser pipe prior to placement of the filter pack and sealing materials. Install a cap on the top of the riser pipe, either vented, or a telescopic fit, constructed to preclude binding to the well casing caused by tightness of fit, unclean surfaces, or weather conditions. Make cap secure enough to preclude the introduction of foreign material into the well, yet allow pressure equalization between the well and the atmosphere.

When the assembly has been installed at the appropriate elevation, adequately secure the assembly to preclude movement during placement of the filter packs and annular seals. Cap the top of the well casing during filter pack placement.

3.2.5 Filter Pack Placement

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. Transport filter pack material to the well site in a manner which prevents contamination by other soils, oils, grease, and other chemicals.

Prior to commencement of work, receive approval from the Contracting Officer for equipment and methods required to place filters. Place primary and secondary filter packs as indicated on the approved well construction drawings to fill the entire annular space between the screen and casing assembly and the outside wall of the borehole. Place both the primary and secondary filters with a tremie pipe in accordance with EPA 600-4-89-034 and ASTM D5092. Placement of the primary and secondary filters by gravity or free fall methods is not allowed. Control speed of filter placement to prevent bridging and to allow for settlement. Take frequent measurements inside the annulus during tremie pipe retraction to

ensure that the filter pack is properly placed.

[After the screen and well casing have been concentrically placed in the hole, construct the approved filter pack around the screen by filling the entire space between the screen and the wall of the hole over the selected screened interval. Place the lowermost [300] [_____] mm [1] [_____] foot of filter pack in the boring prior to installation of the well screen, serving as a base on which to place the screen. Lower a tremie pipe having an inside nominal diameter of not less than 25 mm 1 inch, to the bottom of the annulus between the hole and well. Clean the tremie pipe with high pressure hot water/steam prior to each use. Arrange the tremie pipe 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. Raise the tremie pipe 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 is not allowed. Install the filter pack continuously and without interruption until the filter pack has been placed [to a minimum of 1 meter 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[_____] feetof the top of the ground surface]. Directly measure the depth to the top of the filter pack and record. Obtain any additional water required to be added to the filter pack material in accordance with paragraph WATER SOURCE.

3.2.6 Bentonite Seal

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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. 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. If the proposed seal location is above the anticipated static ground water level, a bentonite seal should not be used unless a fine layer of sand is placed atop the seal. In this case, use a [30 to 60 cm] [1- to 2-foot] layer of fine-grained sand (secondary filter pack) placed atop the primary filter pack or the bentonite seal. A 0.15 to 0.30 m 6 in to 1 foot layer of fine sand placed atop the bentonite seal will further enhance barrier resistance to downward grout migration. It is recommended that the bentonite seal be placed in lifts of 0.15 to 0.30 m 6 in to 1 foot with each lift allowed to hydrate for a minimum of 30 minutes prior to placing the next lift. For more guidance consult EM 1110-1-4000.

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3.2.6.1 Bentonite Pellets

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NOTE: Pellets are compressed and shaped sodium bentonite available in 6, 9, and 12.5 mm 0.25, 0.375, and 0.5 inch sizes.
****

Pouring of pellets is acceptable in shallow boreholes less than 12 meters 40 feet. In order to provide accurate measurement of bentonite pellet thickness in the well boring, tamp the pellet seal during measurement. If not placed in lifts, allow the seal a minimum hydration time of three hours, unless the manufacturer recommends a longer hydration time.

3.2.6.2 Bentonite Chips

****
NOTE: Chips are graded and sized chip material made of sodium bentonite in two sizes, 9 and 19 mm 0.375 and 0.75 inch.
****

Adequate annular space is required in the use of bentonite chips to reduce the risk of bridging. Chips are preferable to use over pellets when installing a seal in a deep water column. In order to provide accurate measurement of bentonite chip seal thickness in the well boring, tamp the seal during measurement. If not placed in lifts, allow the seal a minimum hydration time double the hydration time for pellets.

3.2.6.3 Bentonite Slurry

A bentonite slurry seal can be used when the seal location is too deep for the use of pellets or chips, or within a narrow borehole annulus. The slurry is made from granular or powder sodium bentonite. The specific gravity of cement grout placed atop a slurry seal will be greater than the bentonite slurry. Exercise care to preclude the grout from migrating downward into the slurry.

Mix water from an approved source with granular or powder bentonite to form a thick bentonite slurry, consisting of a mixture of bentonite and the manufacturer's recommended volume of water to achieve an optimal seal. A typical slurry mix contains at least 20 percent solids by weight and has a density of 4.3 kg per liter 9.4 lb per gallon of water or greater.

3.2.6.4 Bentonite Seal Thickness And Replacement

Place a minimum 1 m[3 foot][5 foot] thick hydrated bentonite seal on top of the filter pack. Control speed of bentonite placement to prevent bridging of pellets or chips, or segregation of slurry. Place Bentonite chips and pellets in lifts of 0.15 to 0.30 m 6 inches to 1 foot with each lift allowed to hydrate for a minimum of 30 minutes prior to placing the next lift. If not placed in lifts, the minimum hydration time for pellets is 3 hours, unless manufacturer recommendations for hydration are longer. The hydration time for chips can require twice the time required for pellets. Directly measure the depth to the top of the bentonite seal and record immediately after placement, without allowance for swelling. Add water to the annular space as directed by the geologist in charge to

ensure complete hydration of the bentonite. 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.

3.2.7 Grout Placement

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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 are susceptible to frost heave. If it is required that the protective casing be anchored in-place with cement grout, this should be conducted in accordance with paragraph PROTECTIVE COVER PLACEMENT. Determine the depth of maximum frost penetration 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 UFC 3-130-06 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 is not damaged 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.

****

Mechanically mix a [non-shrinking cement] [high-solids bentonite] grout, and place 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)]. Make grout injection in accordance with ASTM D5092.[If the casing interval for grouting is less than 4.5 m 15 feet, and without fluids after any drill casing is removed, place the grout either by pouring or pumping.]

Place cement grout in the annular space above the bentonite seal as indicated on the well construction drawings. Place the cement grout as a slurry through a tremie pipe, and inject from the bottom up. [Inject grout in one continuous operation until full strength grout flows out at the ground surface without evidence of drilling cuttings or fluid.][For deep wells, inject grout in lifts to ensure that the casing is not damaged.]Cure grout a minimum of 48 hours before beginning well development operations.

Add additional grout from the surface to maintain the level of the grout at the land surface as settlement occurs. Work is not permitted in the well within [48] [_____] hours after cement grouting.

Thoroughly clean the tremie pipe with high pressure hot water/steam before use in each well.

3.2.8 Concrete or Gravel Pad Placement

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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.
****

Construct a [concrete pad with a minimum radius of [600] [_____] mm [2] [_____] feet from the protective casing and 100 mm 4 inch] [coarse gravel blanket with a minimum radius of [1200] [_____] mm [4] [_____] feet from the protective casing and 150 mm 6 inch] thick, sloped away from the well around the well casing at the final ground level elevation. [Prior to placement of the gravel blanket, backfill any depression existing around the well borehole to the level of the surrounding ground surface with [near-surface drill cuttings from the well] [clay] [_____].] [Furnish pre-packaged, dry, combined concrete materials for the well pads conforming to ASTM C387/C387M normal weight, normal strength concrete. Combine the dry materials with potable water and mix in an approved mixer or container until uniform in consistency and color. Limit water to the minimum amount possible.]

3.2.9 Protective Cover Placement

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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 D5787
****

Provide all monitoring wells with a [steel] [_____] lockable protective enclosure set in the annular seal over the well casing with keyed-alike locks on the protective covers for all wells.

3.2.9.1 Aboveground Completions

Provide protective outer casing around the well casing extending above grade. The diameter of the protective outer casing is a minimum of 100 mm 4 inches larger than the well casing diameter. The top of the protective outer casing extends a minimum of 150 mm 6 inches above the top of the well casing cap. Set the protective outer casing in cement grout and extend the bottom of the protective well casing [below the depth of the frost line] [to the depth indicated]. Drill a 6 mm 1/4 inch diameter weep

hole in the protective outer casing 75 mm 3 inches above the ground surface. Fill the annular space between the protective outer casing and the well casing with pea gravel or coarse sand to just below the level of the cap on the well casing.

[Provide 150 mm 6 inch diameter steel pipe bollards, filled with concrete as indicated to protect the exposed well head.

] Provide cap on top of the protective outer casing. Ensure cap is flush threaded and of the same material as the protective outer casing. Wrap threaded joints with fluoropolymer tape and provided with nitrile O-ring gaskets.

Ensure the well cap can accommodate a padlock. Provide a long shackled padlock in accordance with ASTM F883. Provide two padlock keys to the Contracting Officer. [Ensure locks at the well site are keyed alike.]

3.2.9.2 At-Grade Completions

Provide [cast iron] [aluminum] vault box, [750 by 750 mm 30 by 30 inches] [300 mm 12 inch diameter] [_____], with watertight frame and cover. Select vault loading support for[AASHTO M 306 H-20 loading for traffic areas] [a 45,360 kg 100,000 pound loading for a less than a 60 cm 2 foot span for airfield locations]. Depth of frame is 150 mm 6 inches. Set the frame in a concrete collar with a minimum thickness of 200 mm 8 inches, and extending100 mm 4 inches beyond the edge of the frame in all directions. Ensure the frame and concrete collar is [set flush with the level of the existing pavement] [set 75 mm 3 inches above the existing grade]. Provide a locking well cap on top of the well casing, which terminates inside the vault as indicated.

[3.2.9.3 Protective Steel Casing

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

a. Install a protective steel casing around the well casing and riser pipe by placing the protective casing into the annular seal. Clean the protective casing with high-pressure hot water/steam prior to installation to ensure that it is free of any contamination. Provide a protective casing with an inside diameter of at least 100 mm 4 inches greater than the nominal diameter of the well riser. Fit the protective casing with a locking cap and install 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.

b. Position and maintain the protective casing in a plumb position. Extend the bottom of the protective casing a minimum of 750 mm 2.5 feet below the top of the ground surface; extending a minimum of [750] [_____] mm [2.5] [_____] feet below the maximum depth of frost penetration (frost line); and anchored into the cement grout annular seal; and also extending at least 750 mm 2.5 feet above the surface of the ground. Seal and immobilize the protective casing in concrete placed around the outside of the protective casing, then place dry bentonite pellets, or granules, in the annular space below ground level within the protective casing.

c. Provide the protective casing with a 6 mm 1/4 inch diameter drain hole installed just above the top of the [concrete pad] [gravel blanket]. Place coarse sand or pea gravel 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. [Install [four] [_____] protective steel posts, located 1200 mm 4 feet from the well, equally spaced around the [concrete pad] [gravel blanket]. Fill the steel posts with cement. Do not install the posts in the concrete pad, but a 150-300 mm 0.5-1.0 foot distance from the edge of the concrete pad. Set the posts in cement, and extending a minimum of 1 m 3 feet above the ground surface, with at least one third of the posts' total length below ground surface.]

[d. For wells deeper than 60 m 200 feet, verify that the well is plumb.

]][3.2.9.4 Flush-to-Ground Utility Vault

****

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

****

Install a flush-to-ground protective steel utility vault or manhole around the well casing and riser pipe which has been cut off below grade. Construct the flush mounted protective utility vault or manhole with a concrete ground surface seal. Extend the ground surface seal to, but not beyond, the total depth of the flush mounted protective utility vault. Install the ground surface seal around the flush mounted protective utility vault but do not place between the flush mounted protective utility vault and the well casing. Do not install the flush mounted protective utility vault in areas subject to ponding or flooding. Provide the wording "ground water monitoring well" on the flush mounted protective cover's lid or manhole cover on its outer surface. Install flush mounted protective utility vaults through an impervious surface such as asphalt or concrete. If an impervious surface does not exist, create one to support the weight of the traffic in the area. Provide a flush mounted protective utility vault consisting of a watertight metal casing with an inside diameter at least 100 mm 4 inches greater than the inside diameter of the monitoring well casing, made of one continuous metal piece or two metal pieces which are joined with a continuous weld; and a minimum length of [300] [_____] mm [12] [_____] inches. Allow no more than 200 mm 8 inches between the top of the monitoring well casing and the top of the flush mounted protective utility vault after installation. Provide the flush mounted protective utility vault with an exterior flange or lugs. Do not allow the flush mounted protective utility vault to extend below the top of the cement/bentonite annular space seal. To prevent damage from frost heave, extend the concrete surrounding the utility vault a minimum of 300 mm 12 inches below the frost line. Provide the flush mounted protective utility vault or the monitoring well with a locking mechanism and a watertight cap.

]3.2.10 Well Identification

****

NOTE: Local well identification requirements should be specified.

****

Affix a corrosion resistant metal tag to the exterior and interior of the protective cover. [For concrete paved areas, affix the well identification tag to the concrete with four (4) hammer set nails.]Provide the metal tag 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. Use identification numbers for the monitoring wells as indicated on the drawings.

Clearly mark and secure the well to avoid unauthorized access and tampering. Cast the words "MONITORING WELL" on the well head cover. Provide a sign reading, "WELL IS FOR MONITORING AND IS NOT SAFE FOR DRINKING." Provide stamped metal identification tag as follows:

DO NOT DISTURB
ID #: Date:
Installed By:
Total Depth:
Screened Interval:
TOC Elevation:
Other:
For Information, Call:

3.3 FIELD QUALITY CONTROL

3.3.1 Temporary Containment of Soil Removed from the Borehole

[Place soil removed from the borehole in the temporary containment area near the well site. Cover containment area with 0.25 mm 10 mil reinforced polyethylene sheeting. Place soil removed from the borehole[s] on the impervious barrier and cover with 0.15 mm 6 mil reinforced polyethylene sheeting. Provide a [straw bale berm][silt fence]around the outer limits of the containment area and cover with polyethylene sheets. Secure edges of sheets with weights to keep the polyethylene sheeting in place. Divert water runoff from the stockpiled material.

][Stockpile soil in trucks suitable for transporting contaminated soils as specified herein.

][3.3.2 Well Alignment

For wells deeper than 60 m 200 feet, verify that the well is plumb.

]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 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 the material as may be required by other Federal, state, or local laws, regulations and permits.

****

Obtain soil samples in accordance with ASTM D1452/D1452M, [ASTM D1586/D1586M][ASTM D1587/D1587M], and the Sampling and Analysis Plan. Perform standard penetration tests at the following depths: 0 to 450 mm; 450 to 900 mm; 900 to 1350 mm; and 1500 mm 0.0 to 1.5 feet; 1.5 to 3.0 feet; 3.0 to 4.5 feet; and 5 foot centers or at changes in soil formation thereafter.

Screen soil samples in the field. Conduct sample screening in accordance with the Sampling and Analysis Plan.

Record boring information in accordance with ASTM D2487 and ASTM D2488. Indicate groundwater elevation in the log.

3.3.4 Sampling for Chemical Analysis

Include sampling requirements for obtaining and preserving samples for chemical analysis in the Sampling and Analysis Plan.

3.3.5 Sampling for Geotechnical Analysis

Take samples of all materials penetrated by each drilled well/test hole. Perform soil sampling with a stainless steel split tube sampler using standard sampling techniques in accordance with ASTM D1586/D1586M. Extract samples from their in-situ environment in as near an intact, minimally disturbed condition as technically practical. Retrieve samples according to ASTM D1586/D1586M at least every [1] [_____] meter [5] [_____] feet from each test hole. Obtain samples continuously through the area expected to be screened.

Provide a sieve analyses of sampled material, conducted in accordance with ASTM C136/C136M. Clean drive sample tools with high-pressure hot water/steam between sampling events within the same boring. Place drive-sampled materials in airtight containers and label as specified in paragraph CONTAINERIZATION OF DEVELOPMENT WATER, AND DRILL CUTTINGS, and deliver to the Contracting Officer's 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. Prepare description and identification of soils in accordance with ASTM D2488, laboratory classification of soils in accordance with ASTM D2487, and perform sampling to allow completion of the documents described in paragraph BOREHOLE LOGS.

The geologist in charge reviews the log data from each borehole and compares the data with the well design requirements. The CPC verifies the adequacy of the well design, or offers a proposed modification to the design based on the geologic and hydrogeologic data obtained from the borehole. This review and analysis is conducted [for each borehole] [for one borehole considered representative of the entire project]. The geologist in charge submits the borehole boring logs, the well design analysis, and any proposed design modifications to the Contracting Officer in a Borehole Analysis Report.

[Any modifications to the well design approved by the Contracting Officer is considered a change to the contract documents and negotiated in accordance with the "CHANGES" clause.

][3.3.5.1 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 D5753.

****

Geophysically log the total depth of each test hole drilled. Document geophysical logging in accordance with Geophysical Logs. 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. Perform log analyses and interpretations by a person qualified in accordance with paragraph QUALIFICATIONS.

]3.3.6 In-Situ Permeability Determination

****

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.

****

Determine the in-situ permeability for each well following development but 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, measure and record the static water level in the well. Determine, for each well installed, the in-situ permeability of the screened formation using an appropriate method after the well has been developed. State proposed details of the methods expected to be used and references for those methods in the Well Installation Plan. Except for formation water from the well, do not introduce any other water or liquid into the well.

3.3.7 Well Development

Ensure well development is in accordance with EPA 600-4-89-034 and ASTM D5092 except as modified herein. Surging, and pumping/over pumping/backwashing are acceptable development methods. Air surging and jetting are prohibited. Method of development is chosen by the geologist in charge and approved by the Contracting Officer. Well development does not begin until the well installation is complete and accepted by the

Contracting Officer. Conduct well development operations continuously until development water flows clear and free of drilling fluids, cuttings, or other materials. At such time, test representative water samples for pH, temperature, and specific conductivity in accordance with EPA 600/4-79/020. Take samples every 3 hours. When stabilized readings of these parameters, as accepted by the Contracting Officer, have been achieved for 12 consecutive hours, cease well development operations.

****

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 varies 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, develop the well. Perform development using only mechanical surging or over pumping or a combination thereof in accordance with ASTM D5521/D5521M. Include details of the proposed development method in the Well Installation Plan. Maintain a well development record 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],

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. Stabilization has occurred for the following parameters: temperature, specific conductivity, pH, oxidation-reduction potential (ORP), dissolved oxygen (DO), and turbidity readings, measured before, twice during and after development operations. Stabilization means [variation of less than 0.2 pH units, variation of plus or minus 1

degree Celsius, 1 degree Fahrenheit, plus or minus 3 percent change in specific conductance; plus or minus 10mV for ORP; and plus or minus 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 liter 1 pint of well water in a clear glass jar. Label the jar with project name, well number and date; and digitally photograph. Suitably backlight the subject in the photograph close-up to show the clarity of the water and any suspended sediment. The photograph is a part of the well development record. [Contain water removed during development and testing operations in D.O.T. approved drums, containers or vessels and dispose of by [_____], in accordance with paragraph CONTAINERIZATION OF DEVELOPMENT WATER, AND DRILL CUTTINGS, and DRILLING WASTE DISPOSAL.] [Discharge water removed during development and testing operations to the ground surface at least [_____] meters feet from the well in a down gradient area.]

3.3.7.1 Well Development Records

Prepare and submit a monitoring well development record for each monitoring well installed under the supervision of the geologist present during well installation operations, within [_____] working days of the completion of development. Include the following information on the well development record, but do not limit 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. Source of any water added to the well.

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

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

j. Total depth of well from top of the casing and the static water level, 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.

3.3.8 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 monitoring well/test hole. Determine horizontal coordinates to the closest 300 mm 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, use an existing local grid system. Obtain a ground elevation to the closest 30 mm 0.1 foot at each well. The highest point on the top of the riser pipe serves as a measurement point; reference this elevation and survey to the nearest 3 mm 0.01 foot using the National Geodetic Vertical Datum of [1929] [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 by a registered land surveyor licensed in the State of [_____], with a scale large enough to show their location with reference to other structures. Submit this data with a well location map as the Installation Survey Report.

3.3.8.1 Survey Maps and Notes

Prepare and submit 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, consisting of the designated number of the well or monument, the X and Y coordinates, and all the required elevations within [_____] working days after completion of the survey.

3.3.9 Project Photographs

Submit digital photographs taken before, during, and after completion of the work, of each well installation site. Also take photographs of any rock that is cored at the site; 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, neatly arrange in the core box, and take color photographs. Document the following information:

Project No. Contract No.

Contractor/Photographer:

Photograph No. Date/Time:

Description:

Direction of View:

3.4 ADJUSTING AND CLEANING

3.4.1 Site Cleanup

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

3.4.2 Water From Well Development Operations

Water generated during well installation will be containerized and properly characterized in accordance with State and local regulations, the SAP, and as designated by the hazardous waste and wastewater Program Managers. Determine disposal method based on the characterization of the water and recommendations from the Program Managers.

3.4.2.1 Disposal of Containerized Water

Sample and analyze water as described in the SAP.

[a. Water exhibiting TPH less than [0.5] [_____] ppm and BTEX less than [1] [_____] ppb is considered clean. Dispose water [on-site] [on station] as directed by the Contracting Officer.

][b. If the concentration of total BTEX is greater than [1] [_____] ppb or TPH greater than [0.5] [_____] ppm, treat and dispose the water at a permitted facility.

][c. [_____].

]3.4.3 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) 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.

****

Dispose of 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 by [_____].

a. Soils exhibiting TPH less than [100] [_____] ppm, BTEX less than [10] [_____] ppm, TOX less than [100] [_____] ppm, passing TCLP tests, and testing negative for PCB's are considered clean dispose [on-site] [on station] as directed by the Contracting Officer.

b. Manage soils failing the TCLP test or exhibiting TOX greater than [100] [_____] ppm accordance with [applicable State and local regulations] [_____].

c. If the concentration of total BTEX is greater than [10] [_____] ppm or TPH greater than [100] [_____] ppm, provide disposal and treatment of the soil at at a permitted soil recycling facility.

3.4.4 Transportation Of Contaminated Soil And Water

Comply with Federal, State, and local requirements for transporting contaminated materials through the applicable jurisdictions and bear responsibility and cost for any noncompliance. In addition to those requirements, do the following:

a. Inspect and document vehicles and containers for proper operation and covering.

b. Inspect vehicles and containers for proper markings, manifest documents, and other requirements for waste shipment.

c. Perform and document decontamination procedures prior to leaving the worksite and again before leaving the disposal site.

3.4.5 Disposal of Contaminated Soil And Water

Dispose contaminated materials removed from the site [in accordance with the SAP.][to a treatment/disposal facility permitted to accept such materials.]

3.5 CLOSEOUT ACTIVITIES

3.5.1 Well Acceptance

Properly construct, install, develop, and test all wells according to the requirements of this specification so that they are suitable for the intended purpose. If installed wells are not functional or not in accordance with these specifications, the Contracting Officer will disapprove the well and direct repair or replacement, and instruct abandonment of the disapproved well in accordance with this specification.

3.5.2 Documentation Reports

****

NOTE: For projects on the National Priorities List(NPL) or RCRA sites, recommend using the EPA Uniform Federal Policy for Quality Assurance Project Plans worksheets for Quality Control.

****

Submit reports for well construction and development. Establish and maintain documentation reports for well construction and development to record the desired information and to assure compliance with contract requirements, including, but not limited to: borehole logs, well construction diagrams, geophysical logs, and well decommissioning/abandonment records.

3.5.2.1 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 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.
****

Submit original borehole logs, within [_____] working days after completion of the boring and well installation procedures. Prepare and complete a borehole log for each boring drilled, prepared by the geologist present onsite during all well drilling and installation activities. Provide the log scale at [10] [_____] mm equals [300] [_____] mm [1] [_____] inch equals [1] [_____] foot. Keep copies current and complete all well logs in the field at each well site and make available at all times for inspection by the Contracting Officer. Include, as a minimum, 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.

****
NOTE: Split spoon sampling can be used in many cases.
****

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 inchesof driven sample tubes. Include in information hammer weight and drop distance. Record information such as rod size, bit type, pump type, etc.. Also 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, and, if measured, mud viscosities and weight.

k. Depth of each change of stratum. If location of strata change is approximate, so state in the report.

l. Description of the material of which each stratum is composed, in accordance with [ASTM D2488] [_____], and/or standard rock nomenclature, as necessary. Include in soil parameters for logging, but do not limit 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.

m. Include in rock core parameters for logging , but do not limit 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.

n. 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.

o. Depth of any observed fractures, with strike and dip, weathered zones, or any abnormalities encountered.

p. 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.

q. 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. 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. Make the device onsite at all times and provide graduated measuring wire in mm 0.01 foot. Take water and NAPL level measurements to the nearest mm 0.01 foot.

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

s. Percent Rock Core Recovery. If rock is cored, show the percent core recovery for the individual drill runs.

3.5.2.2 Installation Diagrams

Submit as-built installation diagram for each monitoring well installed within [_____] working days of the completion of the installation,

prepared by the geologist present during well installation operations. The well will not be accepted by the Contracting Officer before the geologic logs and installation diagrams are received. Clearly illustrate in the diagram the as-built condition of the well and include, but do not limit 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 and 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 and 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. 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.

3.5.3 Geophysical Logs

Prepare, complete, and submit geophysical logs for each monitoring well/test hole installed, within [_____] working days of the completion of said logging. Include the following information on the logs as a minimum:

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.

x. Log vertical scale m/cm 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.

3.5.4 Well Decommissioning/Abandonment Records

Submit a well decommissioning/abandonment record, for each well, or test hole abandoned, within [_____] working days of the completion of the abandonment procedure. Include in decommissioning/abandonment records, 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.

-- End of Section --