UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2023
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DIVISION 31 - EARTHWORK

SECTION 31 62 50

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11/20, CHG 1: 05/22

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SECTION 31 62 50

DENSIFIED AGGREGATE PIERS
11/20, CHG 1: 05/22

NOTE: This guide specification covers the requirements for the design and construction of densified aggregate piers.

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).

NOTE: To download UFGS Forms, Graphics, and Tables, go to: http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-graphics-tables

NOTE: The extent and location of the work to be accomplished should be indicated on the project drawings or included in the project specification.

NOTE: Show the following information on the drawings:

1. Locations and design loads of aggregate piers.

2. Size, shape, and length of aggregate piers.

3. Locations of test piers, if required.

4. Soil data, where required.

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NOTE: Edit this document for project specific ground improvement requirements such as reinforcement or densification. Add additional information and requirements or delete requirements not required. Care should be taken to coordinate an installation surface that will accommodate the top heavy equipment that is required for installation. Coordinate the use of working pads or special subgrade requirements with the appropriate paragraphs of Section 31 00 00 EARTHWORK.

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NOTE: Provide the following information in the contract or supporting design documents as appropriate:

a. Soils data and a final Site Characterization and Geotechnical Engineering Report;

b. Dead and live loads for each footing location Bearing pressure diagrams for mat foundations, retaining wall footings, and shear wall footings, and actual load for supported slab locations. A loading diagram must be provided for any footings subject to a moment. Any net uplift loads must be highlighted so uplift anchors can be provided; and

c. Coordinated Civil Site design drawings that highlight all existing and future utilities and new fill that will be placed on site.

****

PART 1 GENERAL

1.1 DESCRIPTION

Work consists of designing, furnishing, installing, monitoring, and testing of the densified aggregate pier foundations to the lines and grades designated on the project foundation plan and as specified herein. Work will include all equipment, material, labor, and supervision to design and install aggregate pier elements, [load transfer platforms]and to perform soil and aggregate pier testing.

Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 00 and Division 01 Specification Sections, apply to this Section.

The number of piers, diameters and depth of piers are to be determined by the aggregate pier designer. Design must rely on subsurface information

presented in the project geotechnical report. The information on ground conditions must be assessed to determine its suitability for the specified ground improvement system. Prepare site [and predrill as necessary]for aggregate pier installation. The aggregate piers will be columns of compacted aggregate constructed in a columnar-type configuration to produce an intermediate foundation system for support of foundation loads to achieve the degree of improvement (allowable bearing capacity for maximum allowable settlements) as indicated in paragraph PERFORMANCE CRITERIA. The piers can be constructed with a down-hole vibratory probe, displacement mandrel system, or a down-hole tamper. It is the aggregate pier contractor's responsibility to determine and implement the systems and criteria to ensure that the specified performance is achieved.

The information on ground conditions must be assessed to determine its suitability for the specified ground improvement system. Prepare site [and predrill as necessary]for aggregate pier installation. For soils and groundwater conditions in which the predrilled hole remains open and stable, the aggregate can be placed by a loader into the open hole and compacted in lifts using a down-hole tamper. In unstable conditions, the hole stability must be maintained either with a down-hole vibratory probe, displacement mandrel system, or casing if the tamper method is used.

Removal of spoils from the site (which result from aggregate pier construction), removal of spoils off the working pad, footing excavation, and subgrade preparation following aggregate pier installation are not included. For removal of spoils from site due to aggregate pier installation, footing excavation and subgrade preparation, conform to Section 31 00 00 EARTHWORK, paragraph DISPOSITION OF SURPLUS MATERIAL.

1.1.1 Definitions

a. Aggregate piers are columns of compacted aggregate used to reinforce the ground to increase bearing capacity and reduce settlement of embankments or structures or to increase the density of soil. They can be constructed with a down-hole vibratory probe, a down-hole tamper, or a displacement mandrel system.

b. Designer is the firm employed by the Installer to design aggregate piers.

c. Installer: The firm that installs aggregate piers, who can be the general contractor or his subcontractor.

d. Load Transfer Platform: A structural layer used to transfer loads from the foundation or embankment to a group of aggregate piers.

e. Soil reinforcement refers to the aggregate piers being installed in the ground to increase the overall strength and stiffness of the soil mass, with little or no increase in the density of the soils in between the aggregate piers. A soil modulus test is typically performed to verify settlement and bearing capacity of the aggregate piers in both cohesive and cohesionless soils.

f. Soil densification refers to the aggregate piers being installed in the ground to increase the density of the soil in between the aggregate piers as well as the density of the overall soil matrix. This is only applicable to cohesionless soils and is typically verified by in situ testing of the soil between the aggregate piers, such as standard penetration, cone penetrometer, or flat dilatometer

tests.

g. Down-Hole Vibrators: Down-Hole Vibrators are specially-designed, high-energy depth vibrators. The horizontal vibrations are created by a motor and eccentric weight located near the tip of the vibrator. Extension tubes are bolted to the vibrator to allow it to be lowered to the necessary treatment depth.

h. Displacement Mandrel System: Displacement mandrel systems are constructed by advancing a specially designed mandrel augmented by dynamic vertical ramming energy to the full design depth. The hollow-shaft mandrel, filled with aggregate, is incrementally raised, permitting the aggregate to be released into the shaft, and then lowered by vertically advancing and ramming to densify the aggregate and force it laterally into the adjacent soil. The cycle of raising and lowering the mandrel is repeated to the top of pier elevation. This equipment is most often used in soil conditions with high water tables or for soils where a pre-drilled hole will not remain open.

i. Down-Hole Tampers: Down-Hole Tampers are proprietary high-energy impact apparatus. The vertical tamping energy is provided by a hammer which is connected to a round, beveled tamper. The apparatus is lowered into a pre-drilled hole to the required treatment depth. Down hole tampers may also include minimum 4990 kg 11,000 pound circular steel tampers dropped from minimum heights of 7.6 m 25 feet to create high compactive energies.

1.2 REFERENCES

****

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

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

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

****

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

AMERICAN CONCRETE INSTITUTE (ACI)

ACI 211.1	(1991; R 2009) Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete

ACI 318	(2014; Errata 1-2 2014; Errata 3-5 2015; Errata 6 2016; Errata 7-9 2017) Building Code Requirements for Structural Concrete (ACI 318-14) and Commentary (ACI 318R-14)
ACI 318M	(2014; ERTA 2015) Building Code Requirements for Structural Concrete & Commentary

ASTM INTERNATIONAL (ASTM)

ASTM C33/C33M	(2018) Standard Specification for Concrete Aggregates
ASTM C1077	(2017) Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation
ASTM D698	(2012; E 2014; E 2015) Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cu. ft. (600 kN-m/cu. m.))
ASTM D1143/D1143M	(2007; R 2013) Piles Under Static Axial Compressive Load
ASTM D1196/D1196M	(2012; R 2016) Standard Test Method for Nonrepetitive Static Plate Load Tests of Soils and Flexible Pavement Components, for Use in Evaluation and Design of Airport and Highway Pavements
ASTM D1241	(2015) Materials for Soil-Aggregate Subbase, Base, and Surface Courses
ASTM D1557	(2012; E 2015) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)
ASTM D1586/D1586M	(2018) Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils
ASTM D3689	(2007; E 2013; R 2013) Standard Test Methods for Deep Foundations Under Static Axial Tensile Load
ASTM D6913/D6913M	(2017) Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis
ASTM E329	(2021) Standard Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection
ASTM STP 399	(1966) Vane Shear and Cone Penetration

1.3 SUBSURFACE DATA

Subsurface soil data such as [Standard Penetration Tests (SPT)],[Flat Plate Dilatometer Tests (DMT)],[Seismic Piezocone Penetration Tests (SCPTu)], [Pressuremeter tests], and [laboratory test data] are [indicated] [appended to the special contract requirements] [provided on the project drawings]. [The project Geotechnical Report and samples of materials taken from subsurface investigations may be examined as indicated in specification SECTION 01 05 00 JOB CONDITIONS, paragraph 1.2.2 Explorations. These data represent the best subsurface information available; however, variations may exist in the subsurface between boring locations]

1.4 BASIS OF BID

****
NOTE: Select one of the following options:
****

****
NOTE: Use "Lump Sum" paragraph below for lump (principal) sum bidding of aggregate piers. Use this in all projects except those where exact aggregate piers lengths cannot be practically determined prior to the actual work. Clearly show number of aggregate piers, capacity, locations, and tip and cutoff elevations on the drawings.

Use "Unit Price" paragraph for unit price bidding of aggregate piers. Specify unit price bid items for aggregate piers only for projects where exact quantities cannot be practically determined prior to the actual work. Lengths of aggregate piers must be determined as accurately as possible, prior to bidding, since the unit price per meter foot of the aggregate piers varies as the length increases or decreases.
****

1.4.1 Aggregate Pier Design Acceptance Criteria

a. The ground improvement Installer is responsible for design of an Aggregate Pier ground improvement system that meets the global stability, allowable bearing capacity, densification, and settlement requirements stated on the contract plans. Industry recognized standards of design methods specific to the installer's equipment and construction methods must be used. The design must demonstrate by calculation that the spacing and layout fulfills the requirements.

b. The Aggregate Pier design stiffness modulus value must be verified by the results of the modulus test. The Contractor's Geotechnical Consultant must verify the modulus test based on the modulus test results.

c. Design Aggregate Piers in accordance with generally-accepted engineering practice and the methods described in Section 1 of these Specifications. The design must meet the following criteria.

(1) Minimum Allowable Bearing Pressure for Aggregate Pier Reinforced Soils: [170] [_____] Kpa [3,570] [_____] psf.

(2) Estimated Total Long-Term Settlement for Footings: Less than or equal to [25] [_____] mm [1.0] [_____] inches.

(3) Estimated Long-Term Differential Settlement of Adjacent Footings: Less than or equal to [13] [_____] mm [0.5] [_____] inches.

(4) Estimated Liquefaction Settlement for Footings: Less than or equal to [38] [_____] mm [1.5] [_____] inch.

(5) The modulus of the aggregate material within the aggregate piers must have a minimum modulus of [27.7x106] [_____] N/m3 [100] [_____] pci.

(6) The minimum SPT blow count in the improved zone in between aggregate piers must be [15] [_____].

d. The design submitted by the Installer must consider the bearing capacity and settlement of all footings and other structures supported by aggregate piers, and must be in accordance with acceptable engineering practice and these specifications. Total and differential settlement must be considered. The design life of the structure must be [50] [_____] years.

[1.4.2 Lump Sum Payment

****

NOTE: Use this paragraph for lump-sum contracts, consult with Contracting Officer's Technical Representative (Geotechnical Branch) on applicability of use prior to selection. Fill in Table I as required selecting columns applicable to project. Generally, aggregate piers capacity, location, and minimum tip elevation are shown on plans. Test aggregate piers and load tests are not incorporated in lump sum contracts. Delete this paragraph for unit-price contracts.

****

Base bids upon providing the number, size, capacity, and length of aggregate piers as indicated on the [drawings.] [following Table I:

Table 1

[Location]	Number	Size	[Capacity]	Length (Tip to Cut-Off)

]

Include the cost of all necessary equipment, tools, material, labor, and supervision required to meet the applicable contract requirements. Include mobilization, pre-drilling, and installation. If total number of aggregate piers or number of each length vary from that specified as the basis for bidding, an adjustment in the contract price or time for completion, or both, will be made in accordance with the contract documents. Payment for aggregate piers will be based on successfully installing piers to both the minimum tip elevation and satisfying the

acceptance criteria identified herein. No additional payment will be made for: rejected, or misplaced piers; withdrawn piers; any portion of a pier remaining above the planned top elevation; or other excesses beyond the assumed aggregate pier length indicated for which the Contractor is responsible.[Include payments for vibration monitoring, sound monitoring and precondition construction surveys].

][1.4.3 Unit Price

****
NOTE: Delete this paragraph for lump-sum contracts.
****

For unit price bid, see SF 1442, "Solicitation, Offer and Award" and "Schedule of Bid Items."

****
NOTE: For NAVFAC LANT projects, use the following paragraph for measurement and payment and subsequent sub-parts.
****

Requirements of FAR 52.211-18 Variation in Estimated Quantity do not apply to payment for aggregate piers. Each aggregate pier and test aggregate pier acceptably provided will be paid for at the bid unit price per unit length, which will include items incidental to installing the piers including mobilization and demobilization, [jetting] [predrilling] [probing], and cutting off piers at the cut-off elevation. Payment will be made for production aggregate piers [and test aggregate piers] at the bid unit price for the length of piers, from tip to final cut-off, actually provided, excluding buildups directed by the Contracting Officer to be made. If the actual cumulative aggregate pier length installed (tip to cut-off) vary more than 25 percent from the total aggregate pier length specified as a basis for bidding, at the direction of the Contracting Officer, the unit price per unit length will be adjusted in accordance with provisions of FAR 52.236-2 Differing Site Conditions.[Payments will be made per each at the respective bid unit price for pier cut-offs, pier build-ups and pier loads tests.][Include payments for vibration monitoring, sound monitoring, construction instrumentation and monitoring, and precondition construction surveys.]

][1.5 PAYMENT

1.5.1 Mobilization and Demobilization

1.5.1.1 Payment

Payment will be made for costs associated with mobilization and demobilization as a separate single lump sum item.

1.5.1.2 Measurement

Lump sum.

1.5.1.3 Unit of Measure

Lump sum.

1.5.2 Installing Aggregate Piers

1.5.2.1 Payment

Payment will be made for costs associated with installing aggregate piers, which includes costs of installing aggregate piers and removing excess waste from the work site, compiling and submitting aggregate pier records, and any other items incidental to installing aggregate piers to the required elevation.

1.5.2.2 Measurement

Aggregate piers will be measured for payment for installation on the basis of lengths, to the nearest hundredth of a linear meter tenth of a linear foot, along the axis of each pier acceptably in place below the cut-off elevation shown.

1.5.2.3 Unit of Measure

Linear meter foot.

[1.5.3 Aggregate Pier Modulus Compressive Load Tests

1.5.3.1 Payment

Payment will be made for costs associated with aggregate pier modulus compressive load tests in accordance with ASTM D1143/D1143M and ASTM D1196/D1196M, including material and labor for fabricating and furnishing load frames; calibrating load cells and hydraulic jacks; load test plates; furnishing specified test equipment; installing strain rods; placing and removing test loads and test equipment; recording, reducing, and submitting test data; and compiling and submitting load test reports. No payment will be made for rejected modulus compressive load tests.

1.5.3.2 Measurement

Aggregate pier modulus compressive load tests will be measured for payment on the basis of the applicable contract unit price per load test.

1.5.3.3 Unit of Measure

Each.

][1.5.4 Aggregate Pier Static Tensile Load Tests

1.5.4.1 Payment

Payment will be made for costs associated with aggregate pier static tensile load tests in accordance with ASTM D3689, including material and labor for fabricating and furnishing load frames; calibrating load cells and hydraulic jacks; furnishing specified test equipment; installing strain rods; placing and removing test loads and test equipment; recording, reducing, and submitting test data; and compiling and submitting load test reports. No payment will be made for rejected static tensile load tests.

1.5.4.2 Measurement

Aggregate pier tensile load tests will be measured for payment on the

basis of the applicable contract unit price per number of tensile load tests.

1.5.4.3 Unit of Measure

Each.

][1.5.5 Vibration Monitoring

1.5.5.1 Payment

Payment will be made for costs associated with vibration monitoring.

1.5.5.2 Measurement

Vibration monitoring will be measured for payment on the basis of the applicable contract unit price per vibration monitoring point.

1.5.5.3 Unit of Measure

Each.

][1.5.6 Sound Monitoring

1.5.6.1 Payment

Payment will be made for costs associated with sound monitoring.

1.5.6.2 Measurement

Sound monitoring will be measured for payment on the basis of the applicable contract unit price per vibration monitoring point.

1.5.6.3 Unit of Measure

Each.

][1.5.7 Preconstruction Condition Survey

1.5.7.1 Payment

Payment will be made for costs associated with preconstruction condition surveys.

1.5.7.2 Measurement

Preconstruction condition survey will be measured for payment on the basis of the applicable contract unit price per structure to be surveyed.

1.5.7.3 Unit of Measure

Each.

][1.5.8 Construction Instrumentation and Monitoring

1.5.8.1 Payment

Payment will be made for costs associated with construction instrumentation and monitoring.

1.5.8.2 Measurement

Construction instrumentation and monitoring will be measured as a single pay item.

1.5.8.3 Unit of Measure

One.

]]1.6 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

Designer and Installer's Qualifications; G[, [_____]]

Contractor's Geotechnical Consultant Documentation; G[, [_____]]

Testing Agency Qualifications; G[, [_____]]

SD-02 Shop Drawings

****
NOTE: Drawings, diagrams and schedules specifically prepared to illustrate some portion of the work.

Diagrams and instructions from a manufacturer or fabricator for use in producing the product and as aids to the Contractor for integrating the product or system into the project.

Drawings prepared by or for the Contractor to show how multiple systems and interdisciplinary work will be coordinated.
****

Uplift Anchor Hardware; G[, [_____]]

Aggregate Pier Installation Work Plans and Construction Drawings; G [, [_____]]

Load Test; G[, [_____]]

Aggregate Pier Progress and Final Reports; G[, [_____]]

Excavation Adjacent to Piers; G[, [_____]]

SD-03 Product Data

Uplift Anchor Hardware; G[, [_____]]

Load Tests; G[, [_____]]

Aggregate Material Data; G[, [_____]]

Aggregate Pier Installation Equipment; G[, [_____]]

SD-05 Design Data

****
NOTE: Calculations, mix designs, analyses or other data pertaining to a part of work.
****

Design Submittal; G[, [_____]]

Excavation to Adjacent Piers; G[, [_____]]

SD-06 Test Reports

****
NOTE: Test reports must include findings of tests on aggregate piers and made at the job site on portions of the work during or after installation.

Choose test methods suitable for specific project design purposes. Modulus tests on aggregate piers must be mainly for ground reinforcement applications. Standard penetration tests on soils in between aggregate piers must mainly be for soil densification applications.
****

Modulus Testing of Aggregate Piers and Test Aggregate Pier Records; G[, [_____]]

[Standard Penetration Testing (SPT) of Soils Between Aggregate Piers; G[, [_____]]

][Dynamic Cone Penetrometer Testing of Aggregate Piers; G[, [_____]]

] Aggregate Pier Progress and Final Reports;G[, [_____]]

Aggregate; G[, [_____]]

SD-07 Certificates

Aggregate; G[, [_____]]

[Cement; G[, [_____]]

] Load Test Supporting Data; G[, [_____]]

Warranty; G[, [_____]]

Daily Progress and Final Reports;G[, [_____]]

As-Driven Survey; G[, [_____]]

1.7 QUALITY CONTROL

1.7.1 Aggregate Pier Installation Equipment

Submit descriptions of proposed aggregate pier installation equipment before commencing work. Include details of the rig type and size, auger type, available torque and crowd. Include work procedures and control criteria. All proprietary tampers must be approved by the Contracting Officer prior to use.

[1.7.2 Modulus Load Test Apparatus

Submit equipment description lists or catalog cuts and a brief description of the modulus load test procedure, including maximum load and modifications in accordance with the procedure required by ASTM D1143/D1143M and ASTM D1196/D1196M before commencing tests.

][1.7.3 Contractor's Geotechnical Consultant Documentation

Hire the services of an independent, Registered Professional Geotechnical Engineer, experienced in soil mechanics, to observe test pier installation and production pier installation as specified herein. The Contractor's Geotechnical Consultant must be independent of the Contractor and must have no employee of employer relationship which could constitute a

conflict of interest. The consultant must demonstrate that they have been engaged in successful inspection of aggregate piers for at least 5 years and inspected similar projects in similar scope utilizing the methods being performed for the subject project.

]1.7.4 Design Submittal

The installer must submit three sets of detailed design calculations for aggregate piers [and load transfer platforms]for approval at least four weeks prior to the beginning of construction. A detailed explanation of the design parameters for settlement and bearing calculations must be included in the Design Submittal. Additionally, the quality control test program for aggregate piers, confirming the design requirements, must be submitted. All calculations and drawings must be prepared and sealed by a Professional Engineer in the State in which the project is constructed.

The design must consider the bearing capacity and settlement of all footings supported by aggregate piers, and be in accordance with acceptable engineering practice and these specifications. Total and differential settlement will be considered. The design life of the structure is [50] [_____] years. Detailed calculations, including anticipated loads, design assumptions and relevant subsurface information, must be provided. Drawings prepared for construction use and must include site plans showing Aggregate Pier locations and depths, and footing details showing Aggregate Pier layout beneath footings and uplift anchor connection details when applicable. Minimum Modulus at maximum design stress must be as specified in the final design documents provided by the Aggregate Pier Designer.

1.7.5 Aggregate Pier Installation Work Plans and Construction Drawings

The installer must submit three sets of construction drawings; installation work plan with aggregate pier installation details and testing details; and shop drawings with the location, spacing, numbering, diameter, and depth of the aggregate piers for approval at least 28 calendar days prior to the beginning of construction sealed by the Designer who must be a Professional Engineer in the State in which the project will be constructed.

[1.7.6 Concrete Mix Design

****
NOTE: Include this paragraph for cemented aggregate piers.
****

Certify, using a Government-approved independent commercial testing laboratory, that proportioning of mix is in accordance with ACI 211.1 or ACI 318M ACI 318 for specified strength and is based on aggregate data which has been determined by laboratory tests during last twelve months. Submit a complete list of materials including type; brand; source and amount of cement, [fly ash, pozzolan, ground slag, and admixtures;]and applicable reference specifications. Submit additional data regarding concrete aggregate if the source of aggregate changes. Submittal must clearly indicate where each mix design will be used when more than one mix design is submitted.

]1.8 QUALIFICATIONS

Installation of aggregate piers must be performed by a specialty Contractor experienced and competent in the installation of aggregate piers as specified herein. Submit evidence that the contractor has worked on similar type of projects. The projects must demonstrate proficiency of the designer as applicable to the intent of the project. The Designer must be a Professional Engineer registered in the state where the project is located.

Designers and Installers of aggregate pier foundation systems must have a minimum of 5 years of experience with the design and installation of aggregate piers in similar soil conditions and must have completed at least 20 similar projects of comparable size and type in similar soil conditions. These projects must demonstrate proficiency of the designer and the installer with either reinforcement or densification applications as applicable to the intent of the project. A list of projects, including name and description of the project, relative size, and contact person with phone number must be provided.

PART 2 PRODUCTS

2.1 MATERIALS

a. Aggregate used by the aggregate pier Installer must be pre-approved by the Contracting Officer and must demonstrate suitable performance during modulus testing. Gradation curves and physical property tests results must be submitted 28 calendar days prior to scheduled start.

   Aggregate stone consisting of [Type I Grade B in accordance with ASTM D1241,] [ASTM C33/C33M No. 57 stone,] [or other graded aggregate] approved by the Contracting Officer. For piers constructed below the water table, particles passing the No. 40 sieve must be eliminated. Where material is deemed appropriate for a dynamic penetration test (ASTM STP 399), aggregate must be compacted to a densification and strength, which provides resistance to the dynamic penetration test of a minimum average of 15 blows per 45 mm 2 inches vertical movement. Test aggregate gradation in accordance with ASTM D6913/D6913M.

   The Installer must provide the soil laboratory test data on the proposed aggregate material including the source, type, and gradation of the aggregate to be used. Submit aggregate material data at least 30 calendar days before installation. Provide letters of certification and material delivery tickets from the aggregate supplier.

b. Materials selected must remain stable during construction and working life in the anticipated soil and ground water conditions.

c. Potable water or other suitable source supply must be used to increase aggregate moisture content where required. Access to water on site must be provided to the Installer by the General Contractor.

d. General Contractor to coordinate adequate and suitable marshalling areas on the project site for the storage of aggregate and equipment.

[e. Provide concrete as specified in [_____] except as specified otherwise herein, for minimum 28-day concrete compressive strength of [_____] MPa pounds per square inch, using 19 mm 3/4 inch maximum coarse

aggregate. Concrete for base [and for uncased shaft] must have minimum 3-day compressive strength of [_____] MPa pounds per square inch.[Cased shaft must have minimum 3-day compressive strength of [_____] MPa pounds per square inch.]

][f. Provide uplift anchor hardware as specified in [the aggregate pier design][_____]. Provide drawings, diagrams, and schedules which detail hardware integration and installation. Letters of certification and material delivery tickets from the hardware suppliers must be submitted 28 calendar days prior to the scheduled start of the uplift test to verify that the materials are of the appropriate size, grade, and strength.

]PART 3 EXECUTION

3.1 CONSTRUCTION

3.1.1 Aggregate Pier Construction

Aggregate piers must be constructed in accordance with generally-accepted construction and engineering practices and the methods described in Section 1 of these Specifications. If pre-drill holes do not remain open before or during aggregate pier construction, bottom feed down-hole equipment must be used. Aggregate piers must be installed after fill is placed to raise grades if the aggregate piers are not designed to support new grading fill. The construction of the aggregate piers must not start until the project Geotechnical Engineer has determined that any ground settlement associated with placement of the new fill has ceased.

****

NOTE: Performance requirements may include criteria for structural, thermal, acoustical, or other properties. Tolerances should be stated here only as they apply to the performance of the complete system. Tolerances of fabrication and installation should be included in their respective paragraphs under Part 2.

****

a. Section 03 30 00 CAST-IN-PLACE CONCRETE.

b. Section 31 00 00 EARTHWORK.

c. Geotechnical Report and Recommendations.

3.1.2 Plan Location and Elevation of Aggregate Pier Elements

The location of each pier must be determined by the Designer to provide compliance with the design requirements of paragraph AGGREGATE PIER DESIGN ACCEPTANCE CRITERIA. The final measurement of the top of piers must be the lowest point on the aggregate in the last compacted lift. Piers not properly located and deemed not acceptable must be rebuilt at no additional expense to the Owner. The allowable construction tolerance must be within [152] [_____] mm [6] [_____] inches both for horizontal and vertical design locations.

3.1.3 Rejected Aggregate Pier Elements

Aggregate pier elements improperly located or installed beyond the

allowable tolerance must be abandoned and replaced with new piers, unless the Designer approves other remedial measures. Aggregate must be replaced with fresh aggregate if cave-ins occur during aggregate placement where the volume of caved-in soil exceeds the volume of the aggregate being compacted by more than 10 percent. All material and labor required to replace rejected piers must be provided at no additional cost to the Owner, unless the cause of the rejection is due to an obstruction that is not pre-identified or mislocated by the Contracting Officer.[Obstructions include boulders, timbers, concrete, bricks, abandoned utilities.] Aggregate piers must be monitored for heave immediately after installation and after adjacent aggregate piers are installed. If piers heave more than 13 mm 1/2 inch notify the Contracting Officer.

3.1.4 As-Driven Survey

After the installation of each aggregate pier group is complete provide the Contracting Officer with an as-built survey showing actual location and top elevation of each aggregate pier.[Do not proceed with placing concrete until the Contracting Officer has reviewed the survey and verified the safe load for the pier group installed.] Present a survey in such form that it gives deviation from plan location in two perpendicular directions and elevations of each aggregate pier to nearest 13 mm half inch. Survey must be prepared and certified by a licensed land surveyor.

3.1.5 Protection of Existing Structures

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NOTE: Include this paragraph only when protection of existing structures from aggregate pier installation is required.

The designer must indicate on the drawings all structures and facilities for which protection is required. The designer must also provide a project specific document that details design criteria, requirements for preconstruction condition surveys, post construction condition surveys, geotechnical instrumentation to measure ground movements and any other requirements.

Add any additional requirements as necessary.

****

Mitigate impact on existing facilities due to aggregate pier installation activities in accordance with the [project specific document] [_____].

3.1.6 Excavation Adjacent to Piers

Impacts to installed aggregate pier must be minimized. Submit a complete design and evaluation by the Aggregate Pier Designer in the event that utility excavations are required at horizontal distances of less than five [_____] feet from installed pier locations. Provide a drawing by the aggregate pier design which illustrates distances that must be maintained between aggregate piers and adjacent excavations.

3.2 FIELD QUALITY CONTROL

3.2.1 Quality Control Representative

The Contractor's Geotechnical Consultant must verify and report all aggregate pier installation procedures. Immediately report any unusual conditions encountered during installation to the Contracting Officer. The QC procedures must include the preparation of Aggregate Pier Progress Reports completed during each day of installation and containing the following minimum information:

a. Footing and Aggregate Pier location.

b. Aggregate Pier length and installed diameter.

c. Planned and actual Aggregate Pier elevations at the top and bottom of the element.

d. Average lift thickness for each Aggregate Pier.

e. Soil types encountered at the bottom of the Aggregate Pier and along the length of the element, if the holes were pre-drilled.

f. Depth to groundwater, if encountered.

g. Documentation of any unusual conditions encountered.

h. Type and size of densification equipment used.

i. Quality of aggregate in each individual pier

j. Any additional quality control testing performed, such as modulus tests, dynamic penetrometer tests, and standard penetration tests, as deemed appropriate by the Contracting Officer.

3.2.2 Quality Control Verification Program

****

NOTE: Edit this paragraph for project specific field verification testing and geotechnical instrumentation requirements. The minimum instrumentation requirements must be specified by the Owner and be provided in separate contract documents. The contractor should retain a testing agency (Contractor's Geotechnical Consultant) to perform quality control observations and testing. Typically a modulus test is specified if aggregate piers are installed for soil reinforcement (generally in cohesive soils), while in-situ testing such as Standard Penetration Testing is specified if aggregate piers are installed for soil densification (generally in cohesionless soils).

****

The Installer must be responsible for design of a verification program to assure the quality of the construction. The program must verify that the installed ground improvement system satisfies the performance requirements noted on the contract plans and the design requirements determined by the ground improvement system designer. The quality control program must

include testing and observations by the Contractor's Geotechnical Consultant. As a minimum, the verification program must include the following:

a. Program to monitor performance of the ground improvement system during and after construction of the proposed structure. This program may include installation of settlement plates, monitoring points, inclinometers, piezometers, or other instrumentation.

b. Proposed means and methods for verification that the installed aggregate piers meet the strength and stiffness criteria required by the design. This may include, but must not be limited to modulus or load tests on individual elements and groups, soil borings, standard penetration testing (SPT), and other methods such as monitoring by instrumentation or settlement plates as approved by the Designer. Submit load test set-up and procedures utilized to confirm that the installation procedure develops the pier modulus utilized in design. Submit load test supporting data.

c. Quality control program to verify that the ground improvement system is installed in accordance with the designer's specifications and the requirements in this specification. The quality control program must include testing and observations by Contractor's Geotechnical Consultant.

3.2.3 Bottom Stabilization Verification Test

After completion of the bottom pier bulb, or at any time during the process of construction of the pier, the energy source may be turned off, and bottom stabilization verification test may be performed. These tests must be performed when a new soil formation is encountered, or at the beginning of a project to provide quantitative information on pier stabilization. Acceptable performance is indicated if the vertical movement of the shaft is less than 150 percent of the vertical movement measured for the modulus test pier.

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NOTE: A modulus compressive load test is appropriate if aggregate piers are installed for soil reinforcement (generally in cohesive soils).

****

3.2.4 Modulus Testing of Aggregate Piers and Test Aggregate Pier Records

A modulus test must be performed by the Installer to obtain the parameter values used in design. The number of tests and locations must be determined by the Contracting Officer. The Installer must provide and install all dial indicators and other measuring devices, conduct tests, and prepare the test reports. The tests must be performed generally in accordance with ASTM D1143/D1143M and ASTM D1196/D1196M. The aggregate piers must be tested to satisfy bearing capacity at 150 percent of the design stress and to satisfy the settlement criteria in paragraph AGGREGATE PIER DESIGN ACCEPTANCE CRITERIA at 100 percent of the design stress. The Installer must submit four copies of test reports for each test no later than seven days after the test is completed. Report must include a description of the testing equipment, records, complete test data, analysis of the test data and recommended design parameter values based on the modulus test results. The report must be prepared under supervision of and sealed by a professional engineer registered in the state of project location.

[3.2.5 Standard Penetration Testing (SPT)

****

NOTE: Standard Penetration Testing on soils between aggregate pier locations is appropriate if aggregate piers are installed for densification of soils between piers.

****

a. The SPT must be performed by the Installer to verify if the ground modification criteria as measured by the SPT blow counts as specified in the Aggregate Pier Design Acceptance Criteria is met. The SPTs must be performed at midpoint locations between the aggregate piers.

b. The SPTs must be performed in accordance with ASTM D1586/D1586M.

c. The SPTs must be performed at 0.76 m 2.5 ft intervals through the entire depth of the improved soil zone.

Submit test results.

][3.2.6 Dynamic Cone Penetrometer Testing of Aggregate Piers

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NOTE: Dynamic Cone Penetrometer Test must only be performed on dense graded aggregate material and not on ASTM C33 No. 57 open graded aggregate.

****

a. The Aggregate Pier element must be tested by the Dynamic Cone Penetrometer method (ASTM STP 399) at locations within the upper one third of the pier shaft length.

b. The minimum acceptable criteria as an indicator of acceptable densification must be at least 15 blows per 50 mm 2 inches penetration.

c. Perform dynamic Cone Penetrometer in each Aggregate Pier until such time as five consecutive tests indicate that the minimum criterion is met. Thereafter, such tests need not to be performed on every pier, provided that aggregate used in the element is representative of that previously tested. If average penetration resistances measured exceed 15 blows, and less than 10 percent of tests fall below 15 blows, the testing may be reduced to spot checks. A pattern of successful tests is sufficient to reduce testing to several tests per day.

d. Observation of questionable aggregate moisture content or questionable aggregate gradation appearance may determine the need for additional dynamic penetration testing to verify that the proper densification is being achieved.

e. Use of Dynamic Cone Penetrometer is not appropriate for use on open graded aggregate such as No. 57 stone.

]3.2.7 Testing Agency Qualifications

Engage an independent testing agency qualified according to ASTM C1077 and ASTM E329 for testing indicated. Submit testing agency qualifications to the Contracting Officer for approval.

3.2.8 Responsibilities of Contractor's Geotechnical Consultant

a. Review and verify that design meets the project requirements.

b. Report any discrepancies immediately.

c. Monitor the modulus compressive load tests when performed.

d. Monitor the installation of aggregate pier elements to verify that the production installation practices are similar to those used during the installation of the modulus compressive load test elements.

[e. Perform Dynamic Cone Penetrometer tests as described herein.

]3.2.9 Aggregate Pier Records

****
NOTE: Omit reference to load test when not required in project. Where special or unusual soil conditions are expected, consultation with the Contracting Officer's Technical Representative (Geotechnical Branch) regarding special engineering supervision of installation, testing, recording and analysis of data for project may be useful.
****

Keep a complete and accurate record of each aggregate pier installed. Indicate the pier location, deviations from pier location, cross section shape and dimensions, original length, ground elevation, tip elevation, cut-off elevations, volume of aggregate used or number of lifts, densification forces during installation, and final elevations or depths of the base and top of piers. The records must also indicate the type and size of the installation equipment used, and the type of aggregate used and testing and material sampling that was performed. Provide a complete and accurate progress drawing of aggregate pier installation. Provide final drawing upon completion of installation activities.

Submit test aggregate pier records. [Submit load test data and results.]

The Installer must furnish a complete and accurate record of Aggregate Pier installation to the Government and the General Contractor. The record must indicate the pier location, length, average lift thickness and final elevations of the bases and tops of piers. The installation reports must also indicate the type and size of the densification equipment used. The installer must immediately report any unusual conditions encountered during installation to the General Contractor, to the Designer and to the Government. Submit Daily Progress and Final Reports Aggregate Pier Progress and Final Reports. Provide a Final Report documenting the results of all observations and tests conducted during the complete installation process. Report will certify that the bearing pressure has been achieved within settlement tolerances.

Provide warranty document good for [1][_____] year.

3.3 RESPONSIBILITIES OF GENERAL CONTRACTOR

3.3.1 Preparation

a. Locate the underground utilities. The Installer must protect

underground and aboveground utilities and other structures from damage during installation of the Aggregate Pier elements.

b. Provide the site to the Installer after earthwork in the area has been completed, if applicable.

c. Site subgrade must be established by the General Contractor within 150 mm 6 inches of final design subgrade, as approved by the Contracting Officer.

d. Perform layout of the aggregate piers and provide a work platform if necessary.

3.3.2 Utility Excavations and Excavation to Adjacent Piers

The General Contractor must coordinate all excavations made subsequent to aggregate pier installations so that at least 1.5 m 5 feet of horizontal distance remains between the edge of any installed Aggregate Pier and the excavation[and that the piers are outside the zone of influence of the excavation]. In the event that utility excavations are required at horizontal distances of less than 1.5 m 5 feet from installed aggregate piers or the piers are within the zone of influence of the excavation, the General Contractor must notify the Aggregate Pier Designer to develop construction solutions to minimize impacts on the installed aggregate piers.

3.3.3 Footing Bottoms

a. Excavation and surface compaction of all footings is the responsibility of the General Contractor.

b. Foundation excavations to expose the tops of Aggregate Pier elements must be made in a workman like manner, and must be protected until concrete placement, with procedures and equipment best suited to (1) prevent softening of the matrix soil between and around the Aggregate Pier elements before pouring structural concrete, (2) achieve direct and firm contact between the dense, undisturbed Aggregate Pier elements and the concrete footing. Disturbed soil and aggregate must be recompacted per paragraph FOOTING BOTTOMS, list item c.(3) (below).

c. The following criteria must apply, and a written inspection report sealed by the Contractor's Geotechnical Consultant Agency must be furnished to the installer to confirm:

(1) That water (which may soften the unconfined matrix soil between and around the Aggregate Pier elements, and may have detrimental effects on the supporting capability of the aggregate pier reinforced subgrade) has not been allowed to pond in the footing excavation at any time.

(2) That all aggregate pier elements designed for each footing have been exposed in the footing excavation.

(3) That immediately before footing construction, the tops of all aggregate pier elements exposed in each footing excavation have been inspected and recompacted as necessary with mechanical compaction equipment, and that the tops of any aggregate pier elements which may have been disturbed by footing excavation and related activity have been recompacted to a dry density equivalent

to at least 95 percent of the maximum dry density obtainable by the [Standard] [Modified] Proctor method [ASTM D698] [ASTM D1557] unless approved otherwise by the Contracting Officer.

(4) No excavations or drilled shafts must be made after installation of aggregate pier elements within a horizontal distance of five feet from the edge of any pier, without the written approval of the Contracting Officer.

[3.4 SPECIAL INSPECTION AND TESTING FOR SEISMIC-RESISTING SYSTEMS

****

NOTE: Include this paragraph only when special inspection and testing for seismic-resisting systems is required by the International Building Code (IBC).

This paragraph will be applicable to both new buildings designed and to existing building seismic rehabilitation designs done according to UFC 1-200-01, "General Building Requirements" and UFC 3-310-04, "Seismic Design for Buildings".

The designer must indicate on the drawings all locations and all features for which special inspection and testing is required in accordance with Chapter 17 of the IBC. This includes indicating the locations of all structural components and connections requiring inspection.

Add any additional requirements as necessary.

****

Perform special inspections and testing for seismic-resisting systems and components in accordance with Section 01 45 35 SPECIAL INSPECTIONS.

][3.5 VIBRATION CONTROL

****

NOTE: Include this paragraph when vibration monitoring is required. Add any additional criteria or requirements as necessary to the particular project.

****

Perform vibration monitoring at the locations [shown in the plan] [decided by the Contracting Officer] during the aggregate pier installation. Perform vibration monitoring [using] [seismographs][and geophones] within a distance of 61 meters 200 feet from the aggregate pier installation.[Engage the services of a qualified, independent vibration consultant, acceptable to the Government, to conduct the vibration monitoring. The vibration consultant must have minimum of [five] [_____] years of experience in vibration monitoring. A minimum of [28] [_____] days before the installation of vibration monitors, submit to the Government the name of the vibration consultant and a list of at least [three] [_____] previously completed projects of similar scope and purpose.]

Prior to the aggregate pier installation, obtain baseline readings of ambient vibrations. The vibration during the aggregate pier installation must be limited to [a peak particle velocity of not more than 5 cm 2 inches

per second.] [the limits mentioned in the [contract documents] [_____].][Determine appropriate vibration limits as per [US Bureau of Mines] [American Association of State Highway and Transportation Officials (AASHTO)] guidelines.] During aggregate pier installation, monitor the vibrations to ensure the limits are not exceeded. If the limits are exceeded, cease the aggregate pier installation causing the vibration until [the Vibration consultant and the Contracting Officer] [_____] are on site to observe the structures nearest to the vibration monitor which has exceeded the limits.

The Contractor must be responsible for all damages resulting from the aggregate pier installation and must take whatever measures necessary to maintain peak particle velocity within the specified limit. After completion of the project, remove the vibration monitors off the site and off Government property and restore the monitoring locations back to their original condition.

][3.6 NOISE CONTROL

****
NOTE: Include this paragraph when noise monitoring is required. Add any additional criteria, references or requirements as necessary to the particular project.
****

Perform noise monitoring at the locations [shown in the plan] [decided by the Contracting Officer] [at noise sensitive public areas] during the aggregate pier installation.[Perform noise monitoring using [noise meters][, and] [_____].][Engage the services of a qualified, independent noise consultant, acceptable to the Government, to conduct the noise monitoring. The noise consultant must have minimum of [five] [_____] years of experience in noise monitoring. A minimum of [28] [_____] days before the installation of noise monitors, submit to the Government the name of the noise consultant and a list of at least [three] [_____] previously completed projects of similar scope and purpose.]

Prior to the aggregate pier installation, obtain baseline readings of ambient noise levels.[The noise limits are mentioned in the [plan] [contract documents].][Determine appropriate noise limits as per [local agency] [Occupation Safety and Health Administration] guidelines.] During aggregate pier installation, monitor the noise to ensure the limits are not exceeded. If the limits are exceeded, cease the aggregate pier installation and install noise mitigation measures.

The Contractor must be responsible for all damages resulting from the aggregate pier installation and must take whatever measures necessary to maintain noise within the specified limit. After completion of the project, remove the noise monitors off the site and off Government property and restore the monitoring locations back to their original condition.

][3.7 PRECONSTRUCTION CONDITION SURVEY

****
NOTE: Add any additional criteria, references or requirements as necessary to the particular project.
****

Perform preconstruction condition survey of [structures] [and utilities] [within 61 meters 200 feet of the aggregate pier installation] [specified in the plans] [decided by the Contracting Officer]. Perform outreach to the owner of the structures [28] [_____] days before performing the preconstruction condition survey. The Contractor must obtain written permission from the owner of the structure prior to accessing the structure. The preconstruction condition survey must include video and photographic documentation of the exterior and interior of above ground structures and of the interior of underground structures. Video documentation must be in high definition, and show existing conditions and highlight, where possible, existing cracks, deteriorated concrete, exposed and corroded reinforcement, cracked or broken brick or mortar, and other signs of distress. For utilities, perform the survey when the greatest extent of the interior is exposed. Provide supplementary artificial lighting as needed. The video must include annotation with location and structure nomenclature which describes any areas of distress over the video and time code superimposed on the video. Photographs must be accompanied by sketches or descriptions that indicate the location and direction of each photograph. For each structure surveyed, provide a Pre-Construction Condition Survey Report following completion of the survey. The report must contain all documentation associated with the survey including DVD copies. In the report, include notes, sketches, photographs, and videos. Provide general information, such as location details and structure type, as well as particular information on materials, condition, existing damage, aperture and persistence of cracks, and disrepair observed during visual survey. Provide a graphical depiction of locations of damage or other features of concern. Submit the Preconstruction Condition Survey Reports no later than [28] [_____] days before the commencement of aggregate pier installation. Accept responsibility for damages to existing adjacent or adjoining structures created by aggregate pier installation, and repair any damages to these structures without cost to the Government.

][3.8 CONSTRUCTION INSTRUMENTATION AND MONITORING PROGRAM

****

NOTE: Include this section if instrumentation is to be installed due to concerns about vibration, settlement, lateral movement, etc. during aggregate pier installation. Instrumentation should be specified and included in the specification. This section can be deleted if there are no instrumentation requirements.

Add any additional criteria or requirements as necessary for the particular project.

****

Prepare a geotechnical instrumentation program to monitor settlement[and lateral movement] of temporary and permanent structures, utilities, [embankments] [and excavations] during aggregate pier installation. The design and distribution of instrumentation must demonstrate an understanding of the need, purpose and application of each proposed type.[Perform noise and vibration monitoring in accordance with NOISE CONTROL and VIBRATION CONTROL sections.]

Monitoring must extend before, during and for a period after completion of construction activities related to aggregate pier installation when long-term performance issues are a concern. The monitoring plan must be

designed to protect adjacent structures and utilities against damage due to the aggregate pier installation. Establish limiting values of vertical[and horizontal] movement[and angular distortion][and vibration] for each structure and utility within the zone of influence, subject to review by the Government.

Prepare a report detailing the proposed program of instrumentation and monitoring, establishing threshold values of monitored parameters, and describing the response plans that will be implemented when threshold parameters are exceeded. The report must include details about instrumentation consultant's experience, appropriate types, quantities, locations and monitoring frequencies of the instruments.

Upon acceptance of the instrumentation and monitoring program, provide, install and monitor the instrumentation and interpret the data. Submit instrumentation data reports not less than every [_____] days after the monitoring program has begun. Take corrective actions, as necessary, based on the field instrumentation data and as defined in the instrumentation and monitoring program.

] -- End of Section --