

SECTION 02331

JET GROUT CUTOFF WALL

PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN PETROLEUM INSTITUTE (API) STANDARD SPECIFICATIONS

API SPEC 13A (1993; 15th Ed) Specification for Drilling-Fluid Materials

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 143 (1990a) Slump of Hydraulic Cement Concrete

ASTM C 150 (1994) Standard Specification for Portland Cement

ASTM D 698 (1991) Test Method for Laboratory Compaction Characteristics of Soils Using Standard Effort (12,400 ft-lbf/ft³ (600 kN-m/m³))

ASTM D 3740 (1996 Standard Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used In Engineering Design and Construction

ASTM D 1556 (1990) Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method

ASTM D 4832 (1995) Standard Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders

ASTM D 5084 (1990) Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter

ASTM E 329 (1990) Practice for Use in the Evaluation of Testing and Inspection Agencies as Used in Construction

1.2 SCOPE

The work covered by this section of the specifications consists of furnishing all plant, labor, equipment, materials, and of performing all operations in connection with the construction of cutoff walls utilizing

jet grouting methods, in accordance with these specifications and applicable drawings. Jet grouting shall be utilized across buried utilities to be protected in-place, low overhead clearances, and other locations as shown on the drawings.

1.3 GEOTECHNICAL SITE CONDITIONS

1.3.1 Explorations

Subsurface explorations have been obtained by the Government and are included in the contract documents. Refer to SECTION 02020 SUBSURFACE DATA. Specific discussion on difficult drilling conditions and highly pervious zones having high potential for grout takes are referenced in "Subsurface Conditions", paragraph 3.1.3 of SECTION 02020 SUBSURFACE DATA. The groundwater level indicated on the logs of explorations are at the time of drilling and will vary depending on time of year and river stage.

1.3.2 Contractor's Responsibility

It is the Contractor's responsibility to become acquainted and satisfied as to the character, quality, and quantity of surface and subsurface materials by inspecting the sites and by evaluating information derived from available exploratory work and the explorations that are required as part of this contract. Soil samples obtained during design explorations are stored at the West Sacramento Corps of Engineers Bryte Yard and can be made available to the Contractor for examination of samples. Any failure by the Contractor to become acquainted with all the available information and site conditions will not relieve him from responsibility for properly estimating the difficulty or cost of successfully performing the work. It is required that the Contractor locate existing utilities through excavation, probing or other suitable methods prior to jet grouting.

1.3.3 Modifications to the Jet Grout Cutoff Wall Depth

The Contracting Officer may at any time prior to or during construction require a change in the depth of the jet grout cutoff wall. The objective of the jet grout cutoff wall is to block potential seepage through the levee and layers of foundation sand, gravel, or cobbles. The cutoff wall may be optimized by increasing or decreasing the depth of the cutoff. The potential variation from the depth indicated in the plans is estimated to be plus or minus 1.5 meters (5 feet).

1.4 DEFINITIONS

The terms used in this section are defined as follows:

1.4.1 Jet Grout Cutoff Wall

The jet grout cutoff wall is a seepage barrier wall constructed below the existing ground or prepared working surface by using jet grouting techniques. This includes the jet grout cutoff wall cap.

1.4.2 Jet Grout Cutoff Wall Cap

The cap is a zone of compacted impervious fill material placed between the top of the jet grout cutoff wall and the final grade to be restored prior to placement of the aggregate base course or as shown on the drawings. Where cut, and cut and replacement of utilities are encountered, the cap will be as shown on the contract drawings and compensated for in the

backfill for these utilities.

1.4.3 Jet Grouting

Jet grouting, as defined in this specification, shall consist of a triple fluid system drill rod/pipe designed to inject three different fluids; air, water and grout using high pressure/velocity jets. This process excavates soil using an air/water jet(s) and grout injection using a jet located below the point where the air/water jet(s) is located. The drill rod/pipe is lifted and rotated at a slow, smooth, constant speed to achieve thorough mixing and a consistent continuous geometry and quality.

Some portions of the jet grouting will require the use of a single fluid system, which is defined as the high velocity injection of grout. Simultaneous injection of high speed grout and compressed air, the so called double fluid system, shall not be allowed for any portion of this work.

1.4.4 Bentonite

Bentonite is an ultra fine natural clay whose principal constituent is sodium cation montmorillonite.

1.4.5 Working Surface

The working surface for measurement and payment is defined as the top of the jet grout cutoff wall cap, regardless of the Contractor's selected working surface from which the wall is constructed.

1.4.6 Jet Grouting Specialist

The Contractor or sub-Contractor shall be a jet grouting specialist with at least five years experience in the last 10 years in triple fluid jet grouting on projects of similar scope and magnitude. The jet grouting specialist shall be knowledgeable in all aspects of jet grouting including but not limited to (1) control and monitoring grout placement; (2) mixing methods required to properly mix grout; (3) a thorough knowledge of construction equipment and material testing required for jet grout cutoff wall construction.

1.4.7 Grout Column

A nearly cylindrical column of grout slurry mixed with some resultant soil particles not removed by the erosive water jet.

1.4.8 Impervious Fill Material

Impervious fill material is defined in SECTION 02332 LEVEE RESTORATION AND EARTHWORK. Impervious fill material referenced in this specification shall meet the requirements in SECTION 02332 LEVEE RESTORATION AND EARTHWORK.

1.5 SUBMITTALS

Government approval is required for all submittals with a "GA" designation; submittals having an "FIO" designation are for information only. Submittals shall be sent to the Government at least three weeks prior to commencement of any mobilization of jet grouting equipment for trial field work (test section) except where noted otherwise in this specification section. The following shall be submitted in accordance with Section 01300

SUBMITTAL PROCEDURES:

SD-01 Data

Jet Grout Cutoff Wall Equipment; FIO

Data on equipment to be used in the construction of the jet grout cutoff wall and equipment to be used in the Contractor's quality control testing shall be included. If on-site testing is to be performed, include the location of the laboratory trailer/structure, name and telephone number of laboratory director. Submittals shall be stamped by a Professional Civil Engineer registered in the State of California.

Factory Calibrations on Instruments; FIO

A factory calibration shall be done on all instruments used for control of the jet grouting. Certification shall be provided to indicate that the test equipment used for this purpose is calibrated and maintained in accordance with the test equipment manufacturer's calibration requirements and that, where applicable are traceable to the National Institute of Standards and Technology. Calibration certificates for each instrument shall be maintained on-site for the duration of the project for the following instruments:

water: pressure, flow rate
 air: pressure, flow rate
 grout: pressure, flow rate, density
 depth: depth indicator and rpm's of drill rod

Factory Calibration on Borehole Surveying Instruments; FIO

Factor Calibration certificates (current) for all borehole surveying instruments.

Equipment and Procedures to Obtain Samples; FIO

Data on equipment and procedures to obtain cutting samples and cored samples. Cored samples of the cutoff wall (soil-cement) shall consist of a 102-millimeters (four-inch) diameter cored samples of hardened soil-cement obtained in 1.52-meter (5-foot) long runs. Split inner tubes will be used for core removal. Coring system shall be equivalent to Christensen Products large diameter convertible coring system (146 millimeters by 102 millimeters or 5.75 inches by 4 inches). Coring system can be used in wireline mode or in a conventional rotary drill string. Wireline coring will be permitted in the vicinity of severe overhead restrictions. Maximum overhead clearance for some areas is estimated to be about 6 meters (20 feet). Continuous cores over an estimated 21.3-meter (70-foot) length shall be required. The cored hole sample locations will be determined by the Government. Submittal shall be stamped by a Professional Civil Engineer registered in the State of California.

SD-06 Instructions

Jet Grout Cutoff Wall Construction; GA

The layout of operations for the jet grout cutoff wall construction shall include but is not limited to drawings for grout mixing equipment, injection equipment, pumps, hoses, lines, waste areas, and location of jet grouting with respect to support equipment. Methods for locating utilities

prior to jet grouting, and methods for drilling and supporting the boreholes shall be included. Submittal shall be stamped by a Professional Civil Engineer registered in the State of California.

High Pressure Operating Safety Manual; FIO

The Contractor is responsible for site safety. Contractor will establish safety protocols and provide safety training to all personnel on-site as related to operating and working within the vicinity of high pressure pumps, lines, valves, etc. As a minimum, the safety manual will contain name, telephone number and also manufacturers certificates related to safe operating pressures for all lines, valves, connections, blow-off valves and any other items which operate under high pressure (above 7 megapascals; 1000 pounds per square inch). The manual will contain pump pressure characteristics used for the project, including: pressure-flow-transmission setting curves for high pressure pump, piston size. The manual will have name, phone number, and offsite location of Contractor appointed high pressure safety officer. Each member of the crew will sign safety manual after receiving appropriate instruction. Submit safety manual at least 3 weeks prior to commencement of any mobilization of jet grouting equipment for trial field work. Any safety infractions and/or incidences no matter the severity shall be kept as a log entry in the safety manual. Copy of current manual shall be available on site for review by the Government Quality Assurance inspectors.

Contractor shall submit details of how operators at the drill rig will be kept in constant communications with the high pressure pump operator. Due to the sensitivity with injecting in a levee embankment, the Contractor will have communication system which will: not rely upon hand held devices, and has a high level of assurance that high pressure pumping can be stopped quickly (i.e. 10 seconds).

Due to the adjacent residential neighborhood and difficulty with keeping the site secured from pedestrian access, the Contractor will use appropriately sized steel pipe and fittings which are certified for high pressure pumping from the grout plant to the jet grout working area. High pressure hydraulic hoses certified by the manufacturer will only be allowed for use in the actual jet grout working area.

Jet Grout Test Section; FIO

The Contractor shall submit the layout and procedures for the test section that is used to develop jet grouting parameters, including: jetting parameters to be used (all nozzle sizes, pump pressures, flow rates, rod rotation, lift speed, inter-axis spacing, column size, grout formulations, and any other information needed to conduct the trial field).

Submit details related to soil-cement and grout testing program to assure that the technical requirements for soil-cement are met.

Submit details related to spoil handling equipment and procedures for removing spoil from levee including disposing of waste material and dump site selected.

Submit details of how water pressure testing will be accomplished, including drawings of equipment to be used including packers, flow meters, pressure gauges, and data reduction methods.

Jet grout test section shall be performed in the vicinity of Station

13+808. Sampling and testing of the test section shall be included to determine quality and properties of grout materials, minimum wall thickness uniformity and control. Submittal shall be stamped by a Professional Civil Engineer registered in the State of California.

SD-07 Schedules

Schedule and Sequence of Operation; GA

The general work sequence and schedule of operations shall include but are not limited to jet grout column installation, waste management, grout preparation and placement, grout mix design, and test section(s) shall be included. Submittal shall be stamped by a Professional Civil Engineer registered in the State of California.

SD-08 Statements

Contractor's Experience and Qualification Requirements; GA

The Contractor shall submit evidence of his qualifications as well as the qualifications of the jet grouting specialist(s). Only Government qualified jet grouting speciality contractors will be accepted for satisfying the requirements under these statements:

- 1) The jet grouting firm shall be experienced in jet grouting comparable to that described herein and have at least five years of jet grout experience within the past ten years. Jet grouting experience within the past ten years shall include at least three cutoff wall projects, constructed in North America, of similar magnitude and complexity to that required for the program specified herein.
- 2) Names, and qualifications of the firms and personnel for the jet grouting and Professional Civil Engineer, Land Surveyor, including project experience, resumes, and other documentation that demonstrates the qualifications of each field supervisor and rig operator for the jet grouting shall be submitted.
- 3) A list of Owners, responsible engineers, and project description from jet grouting projects completed within the past five years shall be submitted. The list shall include the addresses and telephone numbers for these projects representing the firm's experience.

SD-09 Reports

Quality Control Testing and Reports; FIO

Reports of inspections or tests, including analysis and interpretation of test results shall be included. Test methods used shall be identified and recorded along with test requests. Quality Control test results shall be submitted within 24 hours of completion of tests. Laboratory test results shall be stamped by a Professional Civil Engineer registered in the State of California. Daily recorded information shall include but is not limited to hard copy output and floppy disk containing digital record from each jet grouting column and any borehole surveys conducted during the shift. Digital record shall contain:

1. Summary page containing:
 - (a) basic project information, data, length, hole identification

(b) data on drilling operations including maximum depth, top of aquiclude, drilling method, any fluids, total hole deviation at the hole bottom

(c) grouting operations: top/bottom of columns, average jetting parameters, total weight of dry materials injected

(d) any observations during drilling and injecting other pertinent observations such as grout escapes, ground heave, or other unusual behavior.

2. Digital file for input into Excel spreadsheet containing the following data scanned each minute: clock time, depth, water pressure and flow rate, air pressure and flow rate, grout pressure and flow rate, air pressure and flow rate, grout pressure and flow rate, grout density, and revolutions per minute (rpm)

3. Hard copy and digital file of borehole survey from slope inclinometer survey. Digital file for input into Excel spreadsheet shall contain: general project and borehole information, surveyed ground location of injection hole, depth of survey, deviation in transverse and longitudinal directions, and total deviation.

Other records submitted shall include: test samples taken from grout cubes, wet samples of soil-cement, core samples, water pressure tests, permeability, and any other information from construction of the jet grout cutoff wall.

Results of Trial Mix Design, Testing, and Jet Grout Test Section; FIO

Prior to installation of the cutoff wall, the Contractor shall submit a laboratory test report along with the Contractor's proposed mix design(s) for the cutoff wall and test section results including column diameter, spacing, wall thickness, and procedures. Submittal shall be stamped by a Professional Civil Engineer registered in the State of California.

Cutoff Wall Depth and Width Measurements; GA

An as-built profile including width and depths of the cutoff wall including descriptions of materials encountered in the bottom of the wall shall be continuously maintained by the Contractor. Data shall be provided to demonstrate that the minimum allowable wall thickness and depth has been consistently attained. These drawings shall be furnished upon completion of a wall segment but not less than once a week.

SD-13 Certificates

Bentonite Certification; FIO

Cement Certification; FIO

Statement signed by an authorized official to certify on behalf of the manufacturer of the materials attesting that the products meet specified requirements. The statement must be dated after the award of the contract, must state the Contractor's name and address, must name the project and location, and must list the specific requirements which are being certified.

SD-14 Samples

Jet Grout Cutoff Wall Samples; FIO

Samples, including both fabricated and unfabricated physical examples of materials, products, and units of work as completed units or portions of units of work shall be included for samples collected for Government testing or as directed by the Contracting Officer.

SD-18 Records

Survey System; FIO

A system for locating stations along the cutoff wall alignment and relating them to the contract drawings shall be established by the Contractor and submitted to the Contracting Officer for approval. Submittal shall be stamped by a Registered Land Surveyor registered in the State of California.

1.6 MEASUREMENT

Measurement for jet grout cutoff wall, shall be based on the area in square meters of wall measured in a vertical plane through the centerline of the jet grout cutoff wall within the boundaries established by the working surface as defined in DEFINITIONS, the bottom of the jet grout cutoff wall and vertical lines at each end of the jet grout cutoff wall. Measurements for area shall be to the nearest 0.1 meter (0.25 feet). Measurement shall be based on surveys and measurements taken at the site as directed and approved by the Contracting Officer. Area shall be calculated to the nearest square meter. Depths measured shall be as indicated on the drawings unless a deeper or lesser depth is directed by the Contracting Officer. Measurement for the test section shall be by lump sum.

1.7 PAYMENT

Payment for jet grout cutoff wall shall be made at the contract unit price per square meter of Item, "JET GROUT CUTOFF WALL". Such price shall include all costs of levee preparation, geotechnical instrumentation, jet grout cutoff wall installation, jet grout cutoff wall installation under and around utilities N9-13 and N9-17, removal of waste material generated from jet grouting, testing, test report preparation, placing the jet grout cutoff wall caps, and all other items incidental to the construction and completion of the jet grout cutoff wall. No separate payment will be made for materials including bentonite, cement, additives, equipment and mixing, and overtime during continuous operations, cleanup, assistance in the collection and maintenance of records and quality control testing; such items being included in the price of the jet grout cutoff wall. Final acceptance of the jet grout cutoff wall will be based on meeting all the requirements of these specifications including the jet grout wall dimensions, jet grout wall properties or any Contracting Officer approved modifications to the grout mix design.

Payment for the trial field test program shall be made at the contract lump sum price for Item, "JET GROUT TEST SECTION". The jet grout test section will be constructed in the production area, between Station 13+808 to approximately Station 13+823. The actual area used for the trial field test shall be excluded from the unit price for constructing the other sections of the jet grout cutoff wall.

PART 2 PRODUCTS

2.1 MATERIALS

The Contractor shall maintain at the job site a sufficient quantity of raw materials and other supplies such that the work can proceed uninterrupted by material shortages. The grout to be used shall be suitable for the project. The Contractor shall modify the jet grout design mixes to meet the requirements for strength and hydraulic conductivity (permeability) specified in paragraph "Jet Grout Cutoff Wall Construction". The Contractor shall undertake any additional tests necessary to assist in material selection, to verify compliance with the specifications, and to demonstrate the impermeability and strength of the jet grout cutoff wall.

2.2 CEMENT

Cement shall be Portland Cement Type I or Type II (per ASTM C 150). A written certification specifying cement quality shall be provided by the cement supplier and the Contractor shall provide a record copy to the Contracting Officer.

2.3 BENTONITE

The bentonite shall be a sodium cation base montmorillonite powder (Premium Grade Wyoming-type bentonite) that conforms to the standards set forth in API SPEC 13A. The Contractor shall furnish to the Contracting Officer a certificate of compliance and a copy of the test reports from the bentonite manufacturer for each lot of bentonite shipped to the site stating that the bentonite complies with all applicable standards. No bentonite from the bentonite manufacturer shall be used prior to acceptance by the Contracting Officer. All bentonite will be subject to inspection, sampling, and verification of quality by testing under the supervision of the Government. Bentonite not meeting the specifications shall be promptly removed from the site and replaced with bentonite conforming to specification requirements at the Contractor's expense. Bentonite shall be protected from moisture during transit and storage.

2.4 ADMIXTURES

Admixtures may be used in the mix, provided they be shown necessary to satisfy strength, permeability or other technical requirements and approved by the Contracting Officer. The Contractor shall have on file a written statement as to the use of any such admixture, its effect on the grout mix, its long-term stability, and its effect on the environment.

2.5 WATER

The Contractor shall supply all water required for mixing the grout. The water shall be clean, fresh, and potable. Potable water shall be free from oil, organics, acids, alkali, or other deleterious substances. Prior to start of construction and once a month subsequent to the start of construction, the water shall be tested.

2.6 MATERIAL STORAGE FACILITIES

The Contractor shall provide all necessary materials, equipment and personnel to store bentonite, cement and other additives under conditions to prevent moisture or other contaminants from mixing with the materials prior to use in the grout mix.

2.7 IMPERVIOUS FILL

Materials placed and compacted in the jet grout cutoff wall cap shall be obtained from the borrow area and may be obtained from required project excavations. The materials obtained from the borrow area and project excavations will require selective removal and stockpiling. At the Contractor's option a commercial source may be used. The Contractor is to insure the material meets the specification requirements which will include any testing needed to classify the material at the sources.

2.8 ENVIRONMENTAL PROTECTION

The raw materials and other supplies used in the construction of the jet grout cutoff wall and any temporary jet grout waste disposed of within the project limits or at any landfill shall be non-hazardous and shall comply with SECTION 01130 ENVIRONMENTAL PROTECTION to prevent, and provide for abatement and control of, any environmental pollution arising as a part of the work.

PART 3 EXECUTION

3.1 EQUIPMENT

3.1.1 General

The Contractor shall furnish all necessary plant and equipment for jet grout cutoff wall construction including the preparation for and completion of the impervious cap on the completed cutoff wall. All equipment used for drilling boreholes; lowering, raising and rotating the jet rods/pipes; mixing grout; supplying pressurized grout and air-water to jets; and jet rods/pipes used to construct the cutoff wall shall have proven performance records for use in jet grouting work. The Contractor shall obtain and maintain at the job site spare parts and backup equipment to maintain jet grouting equipment in satisfactory operating condition to prevent loss of time due to mechanical breakdown or equipment failure.

3.1.2 Drilling Equipment

Drilling equipment shall be of the type and capacity suitable for drilling in materials at the site and of the required hole sizes and depths. Drilling equipment shall be suitable for lowering the jet rods/pipes to the depths required, raising, and rotating the jet rods/pipes to the depths and at the rates required for cutoff wall construction. Drilling technique shall create a minimum, stable, annular space in-between borehole and jet grout rod of at least 30 millimeters (1.2 inches). In no case will the borehole be smaller than 152 millimeters (6 inches) in diameter. Drilling technique shall be able to achieve a maximum drilling deviation of 1% or less. The presence of cobbles up to 305 millimeters (12 inches) as indicated in SECTION 02020 SUBSURFACE DATA will necessitate drilling equipment capable of drilling through these materials.

3.1.3 Triple Fluid Jet Rods/Pipes

The triple fluid jet rods/pipes shall have capacity for producing grout columns in the work site soil types identified in the contract documents and referenced in SECTION 02020 SUBSURFACE DATA and of the size and depth indicated in the specifications and as shown on the drawings. Triple fluid rods shall also have the capacity of being used for high pressure, single

fluid injection, or alternatively have single fluid rods on-site for this jet grout system.

3.1.4 Grout Mixing and Injection Equipment

Grout mixers, holding tanks, water tanks, air compressors, and pumps shall be of sufficient capacity and design to ensure adequate supply of homogeneous grout, air, and water delivered at the required pressure to the jet rods/pipes for a full work shift to produce grout columns of the required quality and dimensions.

The grout mixing equipment shall have a controlled weighing system for assuring that the dry and wet constituents of the grout are properly proportioned. Grout mixer/agitator will allow easy access for obtaining fresh sample of grout.

Grout plant will have mud balance, API Marsh funnel, and Fann Viscometer equipment available for manual checking of grout. Manual checks required once in the morning and once in the afternoon, or whenever setting on batch weighing is changed.

Injection equipment required for the triple fluid system shall have the following characteristics:

1. During triple fluid injection, the high pressure water pump shall have the capability of continuously pumping water at 45 megapascals (6,500 pounds per square inch) with a corresponding flow rate of about 95 liters per minute (25 gallons per minute).
2. The cement pump shall be able to continuously pump the grout selected by the Contractor at a pump pressure of at least 16 megapascals (2,300 pounds per square inch) and corresponding flow rate of 170 liters per minute (45 gallons per minute).
3. Air flow rate shall not exceed 1.2 megapascals (175 pounds per square inch), nor shall the inject air flow rate exceed 1.5 cubic meter per minute (119 cubic feet per minute).

During any single fluid injection, the high pressure pump shall have the capability to continuously pump the grout selected by the Contractor at 45 megapascals (6,500 pounds per square inch), at a corresponding rate of at least 200 liters per minute (53 gallon per minute).

The above specifications for the pump and air requirements do not necessarily correspond to the jetting parameters required for the work. Rather these specifications are the technical requirements for the equipment capabilities.

Jet grout drill shall contain a data acquisition system and appropriate instrumentation to continuously acquire the following jet grouting parameters:

1. Clock Time
2. Water Pressure and Flow Rate
3. Air Pressure and Flow Rate
4. Grout Pressure, Flow Rate, and Density
5. Depth Below Ground Surface and drill rod rpm's

During jet grouting an LCD or paper strip recorder will be available for

Government Quality Assurance inspection so that the jet parameters can be checked manually. Once the column has been completed, the Contractor will submit a hard copy of the output along with a digital record of the jetting parameters as part of the daily record.

Once the jet grout column has been completed, the Contractor will submit a hard copy of the output along with a digital record of the drilling deviations and jetting parameters as part of the daily record.

3.1.5 Equipment Weight, Speed, and Width

Weight of equipment to be used on the levee crown shall be limited to a maximum gross loaded axle weight of 8165 kilograms (18,000 pounds), and a maximum track vehicle weight of 119.7 kilopascals (2,500 pounds per square foot). The maximum operating speed of all equipment used on the levee crown roads shall be 24.1 kph (15 mph). The maximum overall width of equipment used on the levee shall be limited to 5.5 meters (18 feet), including any outriggers or extensions for drill stability.

3.2 TRAFFIC CONTROL

The Contractor shall submit to the Contracting Officer a traffic control plan pursuant to the detailed provisions for traffic control as presented in SECTION 01500 TEMPORARY (CONSTRUCTION) FACILITIES.

3.3 JET GROUTING ON LEVEE CROWN

3.3.1 Levee Preparation

The Contractor shall prepare the working surface of the levee section to a firm and essentially level condition for passage of the Contractor's machinery and equipment. A berm or other appropriate type of barrier shall be constructed to prevent movement of waste materials outside the levee crown and construction right away limits. Pavement removed due to construction of the jet grout cutoff wall shall become the property of the Contractor and shall be removed off-site.

3.3.2 Surveys and Markers

The Contractor shall provide, install, replace and maintain all layout and necessary construction staking to locate the centerline of the wall within the allowable range of cutoff wall installation shown on the contract drawings. Surveyor's caps, appropriately identified to include survey control number, grid coordinates, and elevations and mounted on a 5.1-centimeter (2-inch) diameter, 0.6 meters (2 feet) long steel pipe, driven into the ground, shall be provided at each end of the cutoff wall and at 30.5 meters (100 feet) maximum intervals between the ends. The coordinates and elevations shall have units consistent with the contract drawings. The caps shall be surveyed to establish initial elevation and final elevation to an accuracy of plus or minus 3 centimeters (0.1-foot) and these stakes shall be maintained and protected from damage or movement throughout the work. The Contractor shall submit a report to the Contracting Officer for the cutoff installation showing the final restored levee crown elevation in comparison to the pre-construction elevation. The cutoff wall stations shall have the theoretical maximum elevations of the bottom of the cutoff wall established and be furnished as part of the submittal. A survey system for locating stations along the cutoff wall alignment and relating them to the plans shall be established by the Contractor and submitted to the Contracting Officer. Upon completion of the cutoff wall installation,

permanent metal marker stakes shall be installed to indicate the location of each end of the cutoff wall. The levee station and levee kilometer/mile shall be indicated on the permanent metal markers.

3.4 JET GROUT CUTOFF WALL CONSTRUCTION

3.4.1 General

The jet grout cutoff wall shall be constructed to the elevations, lines, and grades shown on the drawings and in accordance with these specifications, unless otherwise directed by the Contracting Officer. The jet grout cutoff wall shall be constructed to the following dimensions, hydraulic conductivity (permeability), and strength:

Width: **0.91 meters (36-inches)**, (minimum)
measured perpendicular to alignment

Depth: 21.3 meters (70-feet)

Permeability (28-day): 1×10^{-6} centimeters/second (maximum)

Unconfined Compression Strength:
Soil-Cement

Strength (3-day): 1379 kilopascals (200 pounds per square inch) (average with no sample below 517 kilopascals (75 pounds per square inch))

Strength (28-day): **2758 kilopascals (400 pounds per square inch) minimum**

4137 kilopascals (600 pounds per square inch) average

5516 kilopascals (800 pounds per square inch) maximum

Final acceptance of the jet grout cutoff wall will be based on the results of the laboratory tests, field tests, and jet grout cutoff wall measurements as described in paragraphs "Jet Grout Cutoff Wall Sampling", and "Cutoff Wall Measurements". All non-complying material shall be removed and replaced by the Contractor at his expense. The Government may modify the dimensions and quantities of the work as determined necessary. The Contractor shall submit a general work sequence schedule and layout plan of operations to the Contracting Officer for approval a minimum of 2 weeks prior to the start of construction.

3.4.2 Working Surface

The working surface from which the jet grout cutoff wall is to be constructed shall be as defined in paragraph "DEFINITIONS," and shall constitute the top of the jet grout cutoff wall cap for the purpose of Measurement for jet grout cutoff wall. However, the Contractor may select to construct, at no additional expense to the Government, a working surface to a level no more than 0.9 meters (3 feet) lower than the existing levee crown for his own convenience. Lowering of the levee crown more than 0.9 meters (3 feet) will require the approval of the Contracting Officer. There

will be no payment for any additional excavation, fill, relocation, or any other work required as the result of constructing a lower working surface than the specified working surface. Upon completion of the jet grout cutoff wall installation, the levee shall be restored to final alignment and grade in accordance with Section 02332 LEVEE RESTORATION AND EARTHWORK.

Material requirements for placement and compaction shall be in accordance with Section 02332 LEVEE RESTORATION AND EARTHWORK.

3.4.3 Jet Grouting

Jet grout injection, rotation, and extraction rates shall be sufficient to produce grout columns meeting the diameter, depth, overlap, and material property requirements specified. Any jet grout hole lost or damaged as the result of mechanical failure of equipment, inadequacy of grout, air, or water supplies, or improper drilling or injection procedures shall be backfilled with cement grout and replaced by another hole, drilled and injected by the Contractor at no additional cost to the Government.

3.4.3.1 Horizontal and Vertical Alignment Tolerances

The maximum horizontal deviation of the as-installed center of any soil-cement element at ground surface shall not exceed 50 millimeters (2-inches) from the layout center coordinate, shown on the Contractor's submittal. The vertical alignment of the soil-cement elements shall not deviate in any direction more than one (1) percent from vertical. At the direction of the Contracting Officer, any soil-cement element which exceeds the allowable horizontal and vertical alignment tolerances shall be supplemented with one or more adjacent or overlapping elements, at no additional cost to the Government

Once drilling is completed to final depth, the Contractor shall measure drilling deviations for each hole prior to injection. Instrument to measure drilling deviations shall be compared against a calibrated Slope Indicator Digitilt Inclinometer as prescribed in paragraph 3.4.5, "Test Section".

3.4.3.2 Jet Grouting Stage

A critical element for the jet grouting in a levee embankment is an assurance of a continuous flush of cuttings to the surface. When jet grouting is first initiated, the cement jet and water jets will be activated to the pressure, flow rate, grout density and rod rpm's as prescribed in the Contractor's submittal. The Contractor will not lift jetting rods or start compressed air flow until steady flush of cuttings is observed at the surface. Thereafter, jet grouting will be conducted following the prescribed jetting parameters submitted by the Contractor. The Contractor shall supply triple fluid jetting monitor which will prevent clogging of the air jets while only injecting water and cement grout.

In the event that the above procedure cannot effectively produce a continuous flush of cuttings to the surface, then the Contractor will use a cased hole. Plastic casing lined holes (i.e. PVC), which are cut by the high speed jet will not be allowed.

This procedure will be followed each time the jet grouting is initiated or re-commences after rod breaks, or other stoppages.

3.4.3.3 Single Fluid Jet Grouting

Single fluid jet grout shall be conducted under several circumstances:

a) If the Contractor's selected drilling and triple fluid injection parameters causes embankment movements which consistently exceeds a total lateral displacement of 7 mm (0.25 inches) (as measured by the in-place inclinometers), then the stability of the embankment may be jeopardized. The jet grouting method must be changed, if after several modifications the jet grouting Contractor could not perform the work using the triple fluid system. Since the double fluid system is eliminated from any use on the project, the only remaining jet grouting system to be used is the single fluid system. Therefore, the jet grouting equipment brought to the site must have the capabilities of performing the single and/or the triple fluid system.

b) There is a potential for the triple fluid water/air jet to broach through the side slope of the embankment. Once the trial field test program is completed, it may become apparent that there is a need to use the single fluid system to complete the shallower portions of the cutoff wall.

c) In the event that the jet grouting is used as the method to make closure to the cutoff wall, then the single fluid jet grouting method shall be used.

3.4.4 Drilling and Grouting Sequence

The Contractor shall select equipment and drilling techniques to assure a stable 30-millimeter annular space is created between borehole and jet grouting rods. Drilling technique shall be able to **achieve a maximum drilling deviation** to 1 percent or less.

The Contractor will determine depth of aquiclude by drilling boreholes required for slope inclinometer casing. Continuous split spoon soil sampling shall be performed from 19.8-meters (65-foot) depth until aquiclude is first encountered. Additional continuous samples will be extracted to assure that the bottom of the jet grout injection rods are within the aquiclude, and the high pressure jet starts at a minimum of 0.61 meters (2 feet) below the top of the aquiclude. The jet grout cutoff wall will start 0.61 meters (2 feet) below the top of the aquiclude, the actual depth will be as determined by the Government Quality Assurance representatives.

The drilling and grouting sequence shall be such that an adequate distance is left between the freshly installed columns and any adjacent columns. A minimum of 48 hours shall elapse between injecting triple fluid jet grouting next to an installed column. Furthermore, the closest spacing shall be at least three inter-axis spacing prior to the 48 hour time elapse. The spacing shall be measured from center of installed jet grout column to center of proposed injection.

In the case of any single fluid jet grouting, columns can be injected sequentially as long as the annular space and drilling deviation restrictions are met, along with the other technical requirements for the cutoff wall.

3.4.5 Test Section

Prior to production work, a test program shall be conducted to evaluate the Contractor's proposed methods and grout mix to produce grout columns meeting the depth, diameter, overlapping and material property requirements specified in the contract documents. The general requirements are as follows:

(1) Test program shall be performed in accordance with the procedures submitted by the Contractor under paragraph "SUBMITTALS" and in accordance with the specifications.

(2) The test section shall consist of a minimum of twelve (12) grout columns installed to the same bottom elevation specified for the production work.

(3) Subsequent to the results of the test program, the Jet Grouting Specialist may require modifications in the jet grout production to achieve satisfactory results. Depending on the extent of modifications necessary, the Contractor may be required to repeat the construction of a test section.

(4) Materials, procedures, and equipment used shall be the same as that used for production grouting.

During the test program, the Government will compensate the Contractor for one test section.

The test section of the jet-grouted columns shall be in the vicinity of Station 13+808 to 13+823. As shown on the contract drawings, there are overhead electrical transmission line restrictions within this area. The bid item associated with the jet grout trial field or test section should be based upon providing all material, personnel, and equipment to conduct the following work items:

- drill three (3) inclinometer boreholes in accordance with specification SECTION 02233, GEOTECHNICAL INSTRUMENTATION
- install in two boreholes 2 sets of eight (8) EL Vertical In-Place inclinometers in accordance with specification SECTION 02233, GEOTECHNICAL INSTRUMENTATION
- provide all necessary equipment for inclinometers in accordance with specification SECTION 02233, GEOTECHNICAL INSTRUMENTATION
- provide and install eight (8) near surface deformation monitoring points (D.M.P.) in accordance with specification SECTION 02233, GEOTECHNICAL INSTRUMENTATION
- provide inclinometers for measuring drilling deviations of jet grout rods
- installation of twelve (12) triple fluid jet grout columns
- coring eight (8) holes and retrieving up to 171 lineal meters (560 lineal feet) of 102 millimeters (4-inch) diameter core
- conduct thirty-six (36) unconfined compressive strength tests on specimens formed from cuttings

- conduct thirty-six (36) unconfined compressive strength tests on cored soil-cement
- conduct insitu water pressure tests for six (6) cored holes, maximum 5 meters (16 feet) stage per test
- conduct 27 flexible wall permeability tests of cored soil-cement
- provide 2 Cole Parmer battery operated thermistor thermometers (dual probes, plus four (4) 100-foot long (each), deep water thermistor probes

Any of the above quantities not used during the trial field test program will be extended over to other sections of the production work, since the trial field is conducted within the production work zone.

The plan view of the jet grout trial field test program is schematically shown in Figure 1, located at the end of the specification 'JET GROUT CUTOFF WALL'. The twelve (12) column arrangement and sample locations are illustrative of the required locations. The trial field test program shall consist of three (3) sets of four (4) columns each, depicted as Test Columns Area 1, Test Columns Area 2, and Final Test Column Area. The actual lateral spacing between each of the three sets of columns will be part of the Contractor submittal. A key element of the test section is that at least one inclinometer hole shall be installed in-front-of each four (4) column test location, and monitored during active injection. The sequence of operations required for performing the trial field test program include the following activities:

1. Install three (3) inclinometer boreholes, and eight (8) near surface deformation monitoring points.

The first hole, IP, will have soil samples taken at 1.5 meters (5-foot) intervals (or at changes in stratigraphy) until a depth of 19.8 meters (65 feet) is reached. Thereafter, continuous soil sampling shall be done until a total depth of 25.9 meters (85 feet) is attained. For remaining two (2) boreholes, no samples will be taken from above 19.8 meters (65 feet), and thereafter continuous sampling shall be done until 3.05 meters (10 feet) of the aquiclude has been penetrated, or 85 feet maximum.

In one hole, use an inclinometer device proposed by Contractor to measure drilling deviations during trial field test program and production work. Comparisons shall be made to calibrate the Slope Indicator Digitilt Inclinometer. If the Digitilt inclinometer is to be used during drilling deviation measurements, then only calibration certificates need be submitted.

Install two (2) sets of eight (8) EL Vertical In-Place inclinometers in accordance with specification SECTION 02233, GEOTECHNICAL INSTRUMENTATION. All instrumentation becomes the property of the U.S. Government at the conclusion of the project.

2. Perform jet grouting as per the jetting parameters, inter-axis spacing, and grout requirements submitted as part of the trial field work plan, and precautions specified in paragraph 3.4.3.2, "Jet Grouting Stage". Test columns Sections 1 and 2 can be installed simultaneously. Contractor should plan to obtain 102 millimeters (4-inch) diameter core samples after three (3) days of cure from several columns in Test Sections 1 and 2. Unconfined compressive strength testing should be done the day the samples are extracted.

3. There should be sufficient water pressure testing equipment so that two (2) tests can be conducted simultaneously. The water pressure testing shall be in accordance with paragraph 3.8.3, "Jet Grout Cutoff Wall Permeability Testing".

When the jet grouting is located within 2 meters (6.5 feet) of the ground surface, the Contractor should be prepared to turn off the compressed air jet. If there are any signs of jet break-out or blow-outs on levee embankment or foundation, then the jet grouting will cease immediately. The jet grouting will be completed with only high pressure water and grout. The effectiveness of completing the shallow portion of the cutoff wall will be verified by excavating at least the top 2 meters (6.5 feet) of the wall.

4. If at anytime during the jet grouting trial field test program, a lateral displacement from the inclinometer and vertical displacement from the DMP's equals 7 millimeters (0.25 inches), then the jet grouting will immediately cease. The Contractor shall submit a plan to proceed forward with construction of the cutoff wall and prevent any additional lateral movement to the levee embankment. The Contractor shall preserve the structural integrity of the levee at all times.

5. The final four test columns will be installed after all the Test Area 1 and 2 columns are installed and sufficient preliminary test data is available to make a decision about the final test parameters which will be used for production.

6. If after the twelve (12) test columns, the Contractor cannot achieve a soil-cement cutoff wall which satisfies the contractual requirements, the Contractor will perform additional four (4) column test sections until the technical requirements for the wall are achieved. The additional work will be at no cost to the Government.

7. Any non-conforming soil-cement produced during the jet grout trial field shall be replaced as part of the lump sum payment for the trial field test program.

3.4.6 Installation of Jet Grout Columns

At least one week prior to the start of the jet grout production work, the Contractor will install additional instrumentation to monitor the potential levee movements. Borehole inclinometers will be installed every 10.6 meters (35 feet) on the water side of the cutoff wall. Continuous soil samples will be taken from the inclinometer holes from a depth of 19.8 meters (65 feet) to at least 1.5 meters (5 feet) below the top of the aquiclude or depth directed by the Contracting Officer.

The Contractor will plan production work so that the jet grout columns will be installed near the two boreholes which have the in-place inclinometers. The instrumentation shall be placed into adjacent holes. The width of the production work shall extend from the middle of the two Inclinometers up to about 10.7 meters (35 feet) to either side, for a total working length of 21.3 meters (70 feet) If the Contractor desires to use additional instrumentation to monitor the jet grouting, then the working length can be extended, or additional injection equipment used. This is to be at no additional cost to the Government, and should be included in the Contractor's initial submittals. If at any time the 7 millimeters (0.25 inches) total lateral or vertical displacement is exceeded, then the jet

grouting work will cease, and the Contractor will submit a plan to complete the cutoff wall.

Installation of the production jet grout columns shall be by the same equipment, materials, and procedures as those determined in the test program to give satisfactory results to perform the production jet grout cutoff wall. ***The minimum wall thickness of 914 millimeters (36 inches) is to be achieved.***

When the jet grouting is located within 2 meters (6.5 feet) of the ground surface, the most effective procedure developed from the trial field will be implemented to complete the near surface portion of the jet grout wall.

During the production work Contractor's Quality Control testing of the cutoff wall will be constantly on-going. However, once the production work is completed, the Contractor shall accelerate the Quality Control testing by supplying a minimum of two (2) core drills and equipment for extracting samples and performing water pressure tests of the cutoff wall. During the accelerated Quality Control phase, the Jet Grout Contractor shall have available all jet grouting equipment and the associated grout plant. The jet grouting equipment will be used to repair or replace any and all non-conforming soil-cement elements. For those days in which there is no repair work required, due to the lack of Quality Control information, then the jet grouting equipment will be on stand-by. The Contractor will make every effort to efficiently coordinate the Quality Control testing of the wall and repair of non-conforming elements. For bidding purposes the Contractor should carry 15 days of stand-by time to be charged during the final phase of the accelerated Quality Control work.

3.5 JET GROUT CUTOFF WALL CAP

The jet grout cutoff wall cap shall be constructed of impervious fill material placed to the lines and grades shown on the drawings and as specified. After the cutoff wall has been placed and the jet grout columns have set, but before drying can occur, the cutoff wall shall be capped with compacted impervious fill in accordance with the details shown on the drawings. Any settlement of compacted impervious fill over the cutoff wall shall be backfilled with compacted impervious fill. The cutoff wall cap material shall consist of impervious fill material as defined in SECTION 02332 LEVEE RESTORATION AND EARTHWORK. Subgrade preparation, placement and compaction shall be in accordance with SECTION 02332 LEVEE RESTORATION AND EARTHWORK. After the impervious fill has been properly placed and compacted at the top of the jet grout cutoff wall or levee crown shall be restored to a wearing surface as shown on the contract drawing.

3.6 CLEANUP

The Contractor shall continually clean up jet grout wastes, debris and leftover materials resulting from the jet grout cutoff wall construction process. After completion of the work, the site shall be cleared of all debris which may have accumulated in the execution of the work. The Contractor shall be responsible for disposal of these materials offsite in accordance with all Federal, State, and local regulations and codes, such as the Clean Water Act and the National Historic Preservation Act.

3.7 DISPOSAL OF WASTE MATERIALS

Waste (soil, cement, bentonite) generated by the jet grouting shall be temporarily stored at waste pit(s) or other suitable containment facilities

to allow the waste to dry for a minimum of 24 hours prior to transporting to the disposal site.

The jet grout waste shall not be saturated when delivered to the disposal site.

3.8 QUALITY CONTROL

The Contractor shall be responsible for project quality control records. Observations, measurements, and tests described in these specifications shall be performed for quality control. All quality control records, routine testing procedures, observations, and measurements shall be available for inspection by the Contracting Officer's Representative at any time. Final acceptance of the cutoff wall shall be based on the results of samples collected and tested, and wall measurements taken as described in paragraphs "Cutoff Wall Measurements", and "Jet Grout Cutoff Wall Sampling". Compressive strength and permeability quality control testing shall be performed by an established commercial testing laboratory or by the Contractor's testing facilities approved by the Contracting Officer. The laboratory facility and personnel shall meet the requirements specified in the Corps of Engineers CONSTRUCTION CONTROL MANUAL and ASTM D 3740 and ASTM E 329. The laboratory personnel performing the hydraulic conductivity tests on soil-cement materials shall have at least two years of experience testing impervious materials and have performed these tests in sufficient numbers to insure repeatability and reliability of results. No work requiring testing will be permitted until laboratory test facilities have been approved and/or inspected by the Contracting Officer. Upon completion of the Quality Control testing, any holes in the cutoff wall will be backfill with grout used for cutoff wall construction.

3.8.1 Jet Grout Cutoff Wall Soil-Cement Samples

3.8.1.1 Trial Field Samples

Cuttings:

During the trial field phase, samples of the jet grout cuttings shall be obtained for every column when the jet grouting is at three different depths such as bottom, middle, and top of column, as directed by the Government Quality Assurance inspector. Enough wet sample shall be obtained from each depth to fill six (6) plastic molds, 76-millimeter (3-inch) diameter by 152-millimeter (6-inch) long cylindrical test specimens. The wet samples shall be poured into the molds and rodded or vibrated to remove trapped air pockets and then sealed. The specimens shall be stored in a laboratory constant temperature, damp environment until tested or until otherwise directed by the Contracting Officer. Two (2) of the six cylindrical test specimens shall be delivered to the Government's Quality Assurance laboratory within 48 hours from the time the samples are taken at no additional cost to the Government.

Cored Samples:

During the trial field phase, continuous 101-millimeter (4-inch) diameter core samples shall be obtained from 8 boreholes for a total length of 171 meters (560 feet) of sample at locations directed by the Government's Quality Assurance inspector. **Drilling technique shall be able to keep drilling deviations to a value of 1 percent or less.** If the recovered core from any borehole provides less than 90 percent recovery, or less than 50 percent RQD, or fewer than two intact cores of length more than 203

millimeters (8 inches), in each of the 1.5 meters (5-foot) long core run, than the Government may direct the Contractor to drill another boring and recover additional samples. If the samples from either of these additional borings do not provide the required recovery, than this process shall be repeated until coring provides good samples of the overlap between adjacent columns. These additional borings and core samples shall be done at no additional cost to the Government. All core holes will be measured for deviations once all of the samples have been extracted from the boring.

3.8.1.2 Production Work Samples

Cuttings:

During the production work, samples of the jet grout cuttings shall be obtained for every column when the jet grouting is at three (3) different depths such as bottom, middle, and the top of column, as directed by the Government's Quality Assurance inspector. Enough wet sample shall be obtained for each depth to fill one (1) plastic mold, 76-millimeter (3-inch) diameter by 152-millimeter (6-inch) long cylindrical test specimens. The wet samples shall be poured into the molds and rodded or vibrated to remove trapped air pockets and then sealed. The specimens shall be stored in a laboratory constant temperature, damp environment until tested or until otherwise directed by the Contracting Officer.

Cored Samples:

During the production work, continuous core samples shall be obtained at every 6.1 linear meters (20 linear feet) of cutoff wall, excluding the trial field, for an estimated 762 linear meters (2,500 linear feet) of 101-millimeter (4-inch) diameter core. ***Drilling technique shall be able to keep drilling deviations to a value of 1 percent or less.*** If the recovered core from any borehole provides less than 90 percent recovery, or less than 50 percent RQD, or fewer than two intact cores of length more than 203 millimeters (8 inches), in each of the 1.5 meters (5-foot) long core run, than the Government may direct the Contractor to drill another boring and recover additional samples. If the samples from either of these additional borings do not provide the required recovery, than this process shall be repeated until coring provides good samples of the overlap between adjacent columns. These additional borings and core samples shall be done at no additional cost to the Government. All core holes will be measured for deviations once all of the samples have been extracted from the boring.

3.8.2 Jet Grout Cutoff Wall Compressive Strength Testing

3.8.2.1 Trial Field Samples

Cuttings:

Test specimens from samples of cuttings obtained from Test Column Area 1, Test Column Area 2, and the Final Acceptance Area formed in the trial field will be tested, wherein, three (3) samples (from a representative column from each test area, with one sample from top, middle, bottom of column) after curing for three (3) days, seven (7) days, fourteen (14) days, and twenty-eight (28) days, shall be subjected to an unconfined compressive strength test (ASTM D 4832). A minimum of 36 samples of the wet cuttings shall be tested for unconfined compressive strength during the trial field.

Additional testing may be required, as directed by the Contracting Officer. The need for such additional testing will be determined, based at least in part, on the results of the quality of the specimens tested.

Cored Samples:

Test specimens from samples of 102-millimeter (4-inch) diameter core from Test Column Area 1, Test Column Area 2, and the Final Test Area formed in the trial field will be tested, wherein, three (3) days, seven (7) days, fourteen (14) days and twenty-eight (28) days, shall be subjected to an unconfined compressive strength test (ASTM D 4832). A minimum of thirty-six (36) samples of core shall be tested for unconfined compressive strength during the trial field. Additional testing may be required, as directed by the Contracting Officer. The need for such additional testing will be determined, based at least in part, on the results of the quality of the specimens tested. The tests shall be performed on specimens from the same core specimens used for permeability testing and shall be selected by the Government's Quality Assurance inspector in the vicinity of the Contractor's Quality Control specimens.

3.8.2.2 Production Work Samples

Cutting Samples:

Test specimens from samples obtained from production work for cuttings will all be tested (ASTM D 4832) after three (3) days of curing.

Cored Samples:

Specimens of cored soil-cement taken from bottom, middle and top of each production column which was cored shall be tested after curing for seven (7) days, and twenty-eight (28) days shall be subjected to an unconfined compressive strength test (ASTM D 4832). Additional testing may be required, as directed by the Contracting Officer. The need for such additional testing will be determined, based at least in part, on the results of the quality of the core samples tested. The tests shall be performed on specimens from the same core samples used for permeability testing. Where both water pressure and strength tests are to be performed, the curing times shall be determined by the Government's Quality Assurance representative.

3.8.3 Jet Grout Cutoff Wall Permeability Testing

3.8.3.1 Trial Field Samples

Test specimens from samples of continuous core obtained from Test Column Area 1, Test Column Area 2, and the Final Test Area formed in the trial field will be tested for permeability, wherein, three (3) samples (from a representative column from each test area, with one sample from top, middle and bottom of column) after curing for seven (7) days, fourteen (14) days, and twenty-eight (28) days, shall be subjected to permeability testing in a triaxial type permeability cell. The permeability tests shall be specified in paragraph 3.8.3.2, "Production Work Samples".

A minimum of twenty-seven (27) samples of cored specimens shall be tested from the trial field. Additional testing may be required, as directed by the Contracting Officer. The need for such additional testing will be determined, based at least in part, on the results of the quality of the specimens tested. The tests shall be performed on specimens from the same cored sample used for unconfined compressive strength tests. A minimum of nine samples of cored specimens shall be selected by the Government's Quality Assurance representative in the vicinity of the Contractor's

Quality Control specimens.

3.8.3.2 Production Work Samples

Test specimens from samples obtained from production work for continuous core will be tested for permeability, wherein, specimens of cored soil-cement taken from bottom, middle, and top of production columns chosen by the Government's Quality Assurance representative shall be tested after curing for seven (7) days and twenty-eight (28) days shall be subjected to permeability testing.

For bidding purposes a minimum of fifty (50) triaxial permeability tests shall be performed from production work samples. Additional testing may be required, as directed by the Contracting Officer. The need for such additional testing will be determined, based at least in part, on the results of the quality of the specimens tested. The tests shall be performed on specimens from the same cored sample used for unconfined compressive strength tests.

The permeability test parameters are as follows:

- Average Effective Confining Stress: 68.9 kilopascals (10 pounds per square inch)
- Hydraulic Gradient: 4.75 meters (15 feet) divided by the minimum cutoff wall thickness in meters (feet)
- Permeate: American River water
- Backpressure: Sufficient to ensure a Skempton's pore pressure "B" parameter greater than or equal to 0.95.

The permeability tests shall be performed in accordance with ASTM D 5084 continued until inflow-outflow measurements or flow rates demonstrate that steady state seepage conditions are evident. The purpose of performing the in-place water permeability test is to aid in determining wall defects relating to seepage barrier performance.

3.8.3.3 Water Pressure Testing

Water pressure testing will be conducted as a staged down test, using a single packer for the second stages and deeper. The maximum stage will be 5 meters (16.4 feet) or less. The test stage shall be core drilled and 102-millimeter (4-inch) diameter core retrieved. The borehole will be washed out until clean water flows from the hole. Thereafter, a thermistor temperature probe shall be lowered into the borehole and temperature readings obtained. If the temperatures are acceptable for water pressure testing and operation of a borehole camera, then the Government's Quality Assurance representative will lower the camera into the hole obtaining video footage of the soil-cement in the borehole, estimated 30 minutes per stage of hole for visual inspection. Camera will be removed and water pressure test conducted as follows:

1. A low pressure for 10 minutes. This followed immediately by
2. A moderate pressure for the next 10 minutes, then
3. A peak pressure for the next 10 minutes, then the
4. Moderate pressure again for the next 10 minutes
5. The low pressure for the final 10 minutes

The peak pressures used during any stage of the tests shall depend upon the

depth of the stage and quality of the core recovered. For planning purposes, the water pressure shall not exceed a peak pressure of 138 kilopascals gage pressure (20 pounds per square inch pressure gage pressure) for shallow depths and 551 kilopascals gage pressure (80 pounds per square inch gage pressure) for the deepest stage of the test.

The Contractor will record information on date, times of testing, top and bottom of stage, gage pressure and pressure at mid-stage, total flow for 10 minute increment, and Lugeon value for each of the five test increments prior to moving to another stage. Additional time may be required for the particular stage prior to drilling the test hole deeper. The will be determined by the Government Quality Assurance representative in the field.

The second and subsequent stages shall be cored, washed, and have a single packer placed at the top of the stage to be tested. Five step water pressure test shall be conducted as started above.

During each portion of the water pressure test, pressure-flow-time data will be taken. Flow meter will have sufficient resolution for tests, and should be able to resolve flow reading to at least 0.1 liter (0.02 gallons). One hundred and thirty-eight (138) kilopascals gage pressure (20 pounds per square inch gage pressure) full scale pressure gage shall be used for shallow testing, while 689 kilopascals gage pressure (100 pounds per square inch gage pressure) full scale gage will be used for deeper water pressure tests.

Contractor will pressure test system up to 689 kilopascals gage pressure (100 pounds per square inch gage pressure) prior to use and verify that there are zero leaks in the lines, fittings, and valves used to conduct the water pressure test. The Contractor shall submit method to verify that the single packer does not have by-pass leakage during water pressure test.

Water pressure testing will be conducted on insitu of wall for about every 12.2 linear meters (40-linear feet) of wall. If the water pressure test does not meet technical specification requirements, the wall element is non-conforming and shall be repaired/replaced and additional core drilling performed and water pressure test conducted at no additional cost to the Government.

3.8.4 Grout Mixture Testing

Uniformity of the grout mixture shall be verified by unit weight (density) measurements of the mixed grout by mud balance, taken at the mixing plant. These measurements shall be taken at a minimum of one per 7,570 liters (2,000 gallons) of grout mixed and pumped. Three (3) sets of grout cubes (three cubes each) will be taken for each jet grout column formed. Three grout cubes will have unconfined compressive strength test (ASTM D 4832 performed on samples cured at three (3), seven (7), and twenty-eight (28) days. Once a correlation between grout density and strength versus time is developed, then the grout cube testing will be reduced.

3.8.5 Jet Grout Cutoff Wall Cap

Testing shall be in accordance with SECTION 02332 LEVEE RESTORATION AND EARTHWORK. Frequency and type of tests are as specified in paragraph 3.5, "Testing" of SECTION 02332, LEVEE RESTORATION AND EARTHWORK except where geomembranes are to be placed, testing shall be performed for each 91.4 lineal meters (300 lineal feet) of jet grout cutoff wall cap.

3.8.6 Cutoff Wall Measurements

The depth shall be continuously measured and recorded. The wall and overlap distance shall be continuously measured, and recorded. These information shall be submitted daily to the Contracting Officer.

3.9 RECORDS

Records shall be maintained by the Contractor for all testing, measurements, and inspections performed to ascertain that the jet grout cutoff wall construction meets the specifications. Required reports, records, and documentation shall be furnished to the Contracting Officer daily. The Contractor's required records are outlined below.

3.9.1 As-Built Profile

An as-built profile of the jet grout cutoff wall shall be continuously maintained by the Contractor. This profile shall indicate jet grout cutoff wall depth, and limits and be delivered to the Contracting Officer at the end of each shift. The Contractor shall furnish records of all observations, measurements, and tests performed, identified with the location and time of testing.

3.9.2 Results

The results of all construction quality control testing required in these specifications shall be furnished by the Contractor. The Contractor shall furnish records of all observations, measurements, and tests performed, identified with the location and time of testing. These records shall be furnished no later than 24 hours after the tests, measurements, and/or observations were made. All test results used for Quality Control shall be maintained in an electronic data base system compatible with QuatroPro or Microsoft Excel. Specification values shall be shown with the test results and shall be updated weekly and provided. Upon completion of the job, an electronic copy shall be submitted.

3.9.3 Construction Log

The Contractor shall maintain a construction log of daily activities which shall include delays encountered during construction, causes of delays, locations of affected areas, and extent of delays. The log shall also record unusual conditions or problems encountered, and the dispositions made.

3.10 QUALITY ASSURANCE

The Government may collect and perform quality assurance testing on the jet grout cutoff wall. The Government testing will in no way relieve the Contractor of the responsibility of performing tests necessary to meet the construction requirements. All routine testing procedures being conducted by the Contractor shall be available for inspection by the Contracting Officer at any time.

-- End of Section --