

SECTION TABLE OF CONTENTS

DIVISION 02 - SITE CONSTRUCTION

SECTION 02261A

SOIL-CEMENT-BENTONITE CUTOFF WALL

PART 1 GENERAL

- 1.1 SCOPE
- 1.2 APPLICABLE PUBLICATIONS
- 1.3 GEOTECHNICAL SITE CONDITIONS
 - 1.3.1 Exploration Borings
 - 1.3.2 Knowledge of Subsurface Data
 - 1.3.3 Modifications to the Slurry Wall Depth
- 1.4 DEFINITIONS
 - 1.4.1 Slurry Cutoff Wall
 - 1.4.2 Slurry Cutoff Wall Cap
 - 1.4.3 Bentonite slurry
 - 1.4.4 Cement Slurry
 - 1.4.5 Bentonite
 - 1.4.6 Slurry Cutoff Wall Backfill
 - 1.4.7 Working Surface
 - 1.4.8 Admixture
 - 1.4.9 Slurry Cutoff Wall Speciality Company
- 1.5 SUBMITTALS
- 1.6 QUALIFICATIONS
 - 1.6.1 Contractor
 - 1.6.2 Slurry Cutoff Wall Specialist
 - 1.6.3 Slurry Trench Excavation Equipment Operator
 - 1.6.4 Trench Logger
- 1.7 BACKFILL MIX DESIGN TEST PROCEDURES
 - 1.7.1 Mix Design Test Program
 - 1.7.2 Embankment or Import Material for Mix Design
- 1.8 UNIT PRICES
 - 1.8.1 Slurry Cutoff Wall
 - 1.8.1.1 Payment
 - 1.8.1.2 Measurement
 - 1.8.1.3 Unit of Measure
- 1.9 QUALITY ASSURANCE

PART 2 PRODUCTS

- 2.1 MATERIALS
 - 2.1.1 Cement
 - 2.1.2 Bentonite
 - 2.1.3 Admixtures
 - 2.1.4 Water
 - 2.1.5 Bentonite Slurry
 - 2.1.5.1 Initial Bentonite Slurry Mixture
 - 2.1.5.2 Trench Bentonite Slurry Mixture
 - 2.1.5.3 Additional Bentonite
 - 2.1.6 Soil
 - 2.1.7 Slurry Cutoff Wall Backfill
 - 2.1.8 Material Storage Facility

- 2.1.9 Impervious Fill (Cap) Material
- 2.1.10 Environmental Protection
- 2.1.11 Disposal Site
- 2.1.12 Trench Plates

PART 3 EXECUTION

3.1 PREPARATION

- 3.1.1 Equipment
 - 3.1.1.1 Equipment Weight, Speed and Width
 - 3.1.1.2 Trench Excavation
 - 3.1.1.3 Mixing and Delivering Slurry
 - 3.1.1.4 Cleaning of Slurry
 - 3.1.1.5 Preparation of Trench Bottom
 - 3.1.1.6 Mixing and Placing Slurry Cutoff Wall Backfill
 - 3.1.1.7 Retaining Berms
 - 3.1.1.8 Hauling Equipment

3.2 SLURRY CUTOFF WALL CONSTRUCTION

- 3.2.1 General
- 3.2.2 Potholing (Field Verification)
- 3.2.3 Working Surface
- 3.2.4 Construction Staking
 - 3.2.4.1 Initial and Final Elevation
- 3.2.5 Blasting
- 3.2.6 Excavation
 - 3.2.6.1 Impervious Stratum Excavation
- 3.2.7 Placement of Bentonite Slurry
- 3.2.8 Excavated Material
- 3.2.9 Backfilling Trench in Case of High Water
- 3.2.10 Stability
- 3.2.11 Treatment of Trench Bottom
 - 3.2.11.1 Cleaning
- 3.2.12 Backfilling
 - 3.2.12.1 Mixing Areas
 - 3.2.12.2 Mixing Backfill
 - 3.2.12.3 Placement of Backfill
 - 3.2.12.4 Mixing and Placing Backfill During Cold Weather
- 3.2.13 Protection of Top of Cutoff Wall
- 3.2.14 Impervious Fill (Cap) Material
- 3.2.15 Cleanup

3.3 QUALITY CONTROL

- 3.3.1 Bentonite
- 3.3.2 Water
- 3.3.3 Wash Water
- 3.3.4 Slurry Properties
- 3.3.5 Excavation and Backfill Soundings
 - 3.3.5.1 Elevation of Top of Impervious Stratum
 - 3.3.5.2 Elevation of Bottom of Excavation
 - 3.3.5.3 Elevation of Bottom Prior to Backfilling
 - 3.3.5.4 Profile of Backfill Slope
- 3.3.6 Backfill Properties
 - 3.3.6.1 Chain of Custody of Samples
 - 3.3.6.2 Slump Tests
 - 3.3.6.3 Compressive Strength Testing
 - 3.3.6.4 Backfill Permeability Determinations
- 3.3.7 Samples of Impervious Stratum
- 3.3.8 Records
 - 3.3.8.1 As-Built Profile
 - 3.3.8.2 Results

3.3.8.3 Bentonite Slurry Mix

3.3.8.4 Construction Log

-- End of Section Table of Contents --

SECTION 02261A

SOIL-CEMENT-BENTONITE CUTOFF WALL

PART 1 GENERAL

1.1 SCOPE

The work covered by this section of the specifications consists of furnishing all plant, labor, equipment, and materials and of performing all operations in connection with the construction of a slurry cutoff wall, in accordance with these specifications and applicable drawings.

1.2 APPLICABLE PUBLICATIONS

The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent referenced.

AMERICAN PETROLEUM INSTITUTE (API)

API RP 13B-1	(1997, 22nd Ed) Recommended Practice Standard Procedure for Field Testing Water-Based Drilling Fluids
API SPEC 13A	(1993) Specification for Drilling-Fluid Materials

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 143/C 143M	(1998) Slump of Hydraulic-Cement Concrete
ASTM C 150	(2002) Standard Specification for Portland Cement
ASTM D 2488	(1993) Description and Identification of Soils (Visual-Manual Procedure)
ASTM D 422	(1963; R 1998) Particle-Size Analysis of Soils
ASTM D 698	(1991; R 1998) Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cu ft (600 kN-m/cu m))
ASTM D 2487	(2000) Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D 4318	(2000) Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D 4832	(1995e1) Standard Test Method for

Preparation and Testing of Controlled Low
Strength Material (CLSM) Test Cylinders

ASTM D 5084

(1990; R 1997) Standard Test Method for
Measurement of Hydraulic Conductivity of
Saturated Porous Materials Using a
Flexible Wall Permeameter

1.3 GEOTECHNICAL SITE CONDITIONS

1.3.1 Exploration Borings

Subsurface exploratory borings have been obtained by the Government to determine the character of materials to be excavated. Locations of the borings are shown on the plans and the log of these explorations are included in the contract drawings for the convenience of the Contractor. The Government assumes no responsibility for interpretation or deductions made by the Contractor from the logs and borings. Local minor variations in the subsurface materials are to be expected and, if encountered, will not be considered as being materially different. Soils classifications shown on the logs are the result of field visual and laboratory classifications in accordance with the Unified Soil Classifications System.

The available borings within the limits and proposed depths of this contract are included within the contract drawings. Explorations indicate the levee embankment consist of materials ranging from sand to clay but primarily consists of very loose to firm, sand to clayey sand with gravel. Explorations indicate subsurface soils consist of foundation materials ranging from sand to clay but primarily consists of very soft clay to loose sand, silty sand and clayey sand. Materials are classified in accordance with ASTM D 2488 and ASTM D 2487. Groundwater levels indicated in the explorations were at the time of drilling and can vary depending on time of year and river stage. The potential for slurry loss is present with the presence of sandy embankment materials and rodent holes.

1.3.2 Knowledge of Subsurface Data

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 site, performing additional borings as necessary for soil classification and mix design formulation and by evaluating information derived from previously performed exploratory work and provided as part of this contract. Any failure by the Contractor to become acquainted with all the available information and any other site specific conditions such as utilities will not relieve him from responsibility for properly estimating the difficulty or cost of successfully performing the work.

1.3.3 Modifications to the Slurry Wall Depth

The Contracting Officer may at any time prior to or during construction require a change in the depth of the slurry wall. The objective of the slurry cutoff wall is to block potential seepage through the levee embankment and through layers of foundation sand or gravel interspersed within the finer material. 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 five (5) feet.

1.4 DEFINITIONS

1.4.1 Slurry Cutoff Wall

The slurry cutoff wall is a 24-inch minimum width barrier installed below the prepared working surface using the slurry trench excavation and backfill method and capped with impervious fill (cap) material as defined in subparagraph, "Slurry Cutoff Wall Cap", to form a relatively impervious cutoff wall.

1.4.2 Slurry Cutoff Wall Cap

The slurry cutoff wall cap is a gradually widening transition zone of impervious fill (cap) material as defined in SECTION 02300A: LEVEE RESTORATION AND EARTHWORK of this contract and as shown in the drawings and shall be placed between the top of the slurry cutoff wall and crown surface of the levee prior to placement of the aggregate base or asphalt pavement section.

1.4.3 Bentonite slurry

Bentonite slurry is a colloidal mixture of bentonite (fully hydrated) and water or other suitable material approved by the Contracting Officer.

1.4.4 Cement Slurry

Cement slurry is a colloidal mixture of Portland cement Type I or Type II (per ASTM C 150) and water or other suitable material approved by the Contracting Officer.

1.4.5 Bentonite

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

1.4.6 Slurry Cutoff Wall Backfill

A homogeneous mixture of material produced by mixing soil, bentonite, cement and water and/or other materials approved by the Contracting Officer which is used to construct the slurry cutoff wall below the impervious fill (cap) material.

1.4.7 Working Surface

The working surface is the top of the prepared levee surface as shown on the drawings from which the slurry cutoff wall is constructed.

1.4.8 Admixture

Any additive used to modify the properties of the bentonite slurry or the backfill material.

1.4.9 Slurry Cutoff Wall Speciality Company

A slurry cutoff wall speciality Company is a firm who has had a minimum of five (5) years of experience in slurry cutoff wall construction and has knowledge in all aspects of the slurry cutoff wall construction which includes but is not limited to: (1) the use, testing, and control of bentonite as a slurry; (2) the mixing methods required to properly mix the

slurry and backfill materials, including soil, cement and bentonite, as required; (3) trench excavation and backfill procedures, and (4) a thorough knowledge of construction equipment and material testing required for slurry trench construction.

1.5 SUBMITTALS

Government approval is required for all submittals with a GA designation; submittals having a FIO designation are for information only. the following shall be submitted in accordance with SECTION 01330: SUBMITTAL PROCEDURES.

SD-01 Preconstruction Submittals

Slurry Cutoff Wall Construction Method and Equipment; FIO

Data on equipment to be used in all sequences of the slurry cutoff construction, including excavation, backfill placement, backfill mixing and equipment to be used in the Contractor's quality control testing. Include the location of the laboratory trailer and/or structure.

Slurry Mixing, Storage and Delivery Methods and Equipment; FIO

Data on equipment such as mixers capable of producing a stable colloidal suspension of bentonite slurry, cement slurry or other mix combinations; storage facilities including tanks and methods of agitation; and delivery methods and equipment.

Contractor's Experience and Other Qualification Requirements; FIO

In accordance with requirements of paragraph "QUALIFICATIONS", the Contractor shall submit evidence of the Project Team's demonstrated experience in slurry wall construction as well as the qualification experience of the slurry cutoff wall specialist, qualification experience of the slurry trench excavation equipment operator, and trench logger. This information shall be submitted within 21 working days after the Notice to Proceed.

The Project Team demonstrated experience in slurry wall construction shall also include: a) project title and locations; b) name and address of prime/general contractor; c) complete name and address of customer/project owner and agency, commercial firm, or other organization or entity for whom work was performed; d) date of contract award, e) date the customer/owner agreed that the project was satisfactorily completed, f) owner's technical point of contact or owner's contracting or purchasing point of contact (name, title, address, telephone number and e-mail address, if known).

Other information to be provided is the following: a) name and address of the proposed team member whose corporate experience is being used to meet the experience requirements, b) identification of the components of the actual slurry wall construction performed by the in-house workforce of the proposed project team member, or corporate predecessor thereof, for the following items -

- 1) Trial Mix Design
- 2) Mixing and blending operations of the bentonite slurry and

backfill

3) Technical oversight and had overall responsibility for the mixing and blending operations of the bentonite slurry and backfill.

SD-06 Instructions

Slurry Trench Construction; FIO

The layout of operations for the construction of the slurry trench shall include but is not limited to drawings depicting the bentonite storage area, slurry preparation area, hydration pond(s) slurry storage area, backfill storage tanks, pumps, valves, lines, hoses, materials, and waste areas.

SD-07 Schedule

Schedule and Sequence of Operations; GA

The schedule and sequence of operations shall include but are not limited to preparation prior to trench excavation, use of excavated material, soil blending procedures, waste management, slurry preparation, slurry placement, trench bottom cleaning, backfill preparation and placement, and slurry cutoff wall backfill design mix, a contingency plan for controlling slurry loss within the trench, a contingency plan for controlling slurry loss on the landside and/or waterside of the levee, final grade closure, Quality Control testing, the number of excavation headings and proposed dates of operation for each heading, and the haul distances from each heading.

Sequence of Operations At Utility Line Crossings; GA

The sequence of operations shall include but are not limited to potholing, protecting or bypassing existing utility line crossings, backing near the utility line crossings, sequencing of the cutoff wall construction work and placement of the impervious cap at each utility line crossings, specifically at the PG&E high pressure gas line crossing and for allowing public access to local residence.

SD-09 Reports

Quality Control Testing and Equipment Procedures; FIO

Reports of inspections or tests, including analysis and interpretation of test results. Each report shall be properly identified. Test methods used shall be identified and test results shall be recorded. Details of laboratory test procedures for performing unconfined compression and permeability tests on soil-cement-bentonite shall be provided. Details shall include: storage requirements for samples, sample preparation, application of confining pressure, time duration required for saturation of specified permeate. Samples of testing data sheets and sample data reduction to obtain strength and permeability shall be submitted.

Quality Control Test Reports; FIO

The Contractor shall submit test results for but are not limited to tests results for all bentonite, water, bentonite slurry and backfill material quality control testing in both hardcopy and digital form. Test results shall be submitted both in summary table and laboratory data sheet format.

Results of Cutoff Wall Backfill Trial Mix Design and Testing; GA

Prior to the installation of the slurry cutoff wall, the Contractor shall submit a laboratory test report along with the Contractor's proposed initial mix design for the construction of the slurry cutoff wall backfill. The report shall summarize the test results and address the suitability of the proposed backfill mix design as it relates to the specification requirements and shall contain mix proportions and test results for all the trial batches. In addition, the proposed gradation ranges (bands) for the slurry backfill and soil part of the backfill mix shall be submitted for approval.

Cutoff Wall Depth Measurement; FIO

An as-built profile of the trench bottom, backfill slope including descriptions of materials encountered in the trench bottom shall be continuously maintained by the Contractor. These records, data and drawings shall be made available daily and furnished no later than 24 hours after the tests, measurements and/or observations were made.

Chain of Custody Form for Quality Control and Quality Assurance Samples; FIO

The Contractor shall submit a sample of the chain of custody form used to keep track of all Quality Control (QC) and Quality Assurance (QA) samples taken by the Contractor. The form shall include when (date and time) and who formed the samples, transfer of ownership, date and time of transfer, batch number and location where batch was placed (stationing and heading number) of QC/QA samples.

SD-13 Certificates

Cement Certification; FIO

As per subparagraph "Cement", the Contractor shall submit statement(s) 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, address, must name the project and location, and must list the specific requirements which are being certified.

Bentonite Certification; FIO

As per subparagraph "Bentonite", the Contractor shall submit statement(s) 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, address, must name the project and location, and must list the

specific requirements which are being certified.

SD-14 Samples

Equipment and Procedure to Obtain Slurry Backfill Bulk Samples; FIO

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

1.6 QUALIFICATIONS

1.6.1 Contractor

The Contractor's company, his subcontractor, joint venture partner, or merged company shall have experience in slurry cutoff wall construction projects after January 1, 1990. Multiple headings on any one contract shall be considered as one construction project. The project experience must have been performed by the entity who is proposing to perform the work as defined below. An individual's experience from former companies does not qualify as slurry cutoff wall construction project experience. However, that individual may be considered as a slurry wall specialist for this project. The qualifying experience in slurry cutoff wall construction projects shall consist of the following:

1) Satisfactorily completed the construction of at least one (1) soil-cement-bentonite cutoff wall, or plastic concrete diaphragm cutoff wall using the open trench method. The cutoff wall must have a minimum depth of 30 feet and a minimum length of 1500 feet. The cutoff wall properties must have a minimum unconfined compressive strength of 15 psi and a maximum permeability of 1×10^{-6} cm/sec.

For this contract the following definitions are to be used:

Performed the Work. On completed projects, must have prepared the trial mix designs and either carried out the mixing and blending operations of the bentonite slurry and backfill or provided technical oversight and had overall responsibility for the mixing and blending operations of the bentonite slurry and backfill.

Soil-Cement-Bentonite Cutoff Wall. Slurry supported trench which has been backfilled with a mixture of excavated or imported soil, bentonite, cement, water and admixtures, in which soil is the major constituent of the backfill.

Plastic Concrete Diaphragm Cutoff Wall. Slurry supported trench which has been backfilled with material composed of cement, bentonite (or native clays from the project site), water, admixtures, and concrete aggregate, in which the backfill was tremied into a panel excavation.

Soil-Bentonite Cutoff Wall. Slurry supported trench which has been backfilled with a mixture of excavated trench soil or imported soil, bentonite, water, and admixtures.

1.6.2 Slurry Cutoff Wall Specialist

The slurry trench cutoff wall specialist as defined in subparagraph "Slurry Cutoff Wall Specialist", shall provide supervision and control of composition, mixing, placing, cleaning, and maintenance of the bentonite slurry and of the backfill. The slurry cutoff specialist shall be on site at all times during trenching and backfilling operations.

1.6.3 Slurry Trench Excavation Equipment Operator

The slurry trench excavation equipment operator shall have experience using similar slurry trench equipment to at least the depth called for in this contract.

1.6.4 Trench Logger

The excavated material from the slurry cutoff wall excavation is to be described and classified as indicated within this specification. The description and classification of the excavated material shall be performed by a geologist, geotechnical engineer, or civil engineer with a minimum of five (5) years experience using ASTM D 2488. The experience information shall be submitted to the Contracting Officer for approval. The submitted experience shall include project name, phone number of customer and point of contact, date of construction, description of project feature in which classification of material was performed.

1.7 BACKFILL MIX DESIGN TEST PROCEDURES

1.7.1 Mix Design Test Program

The Contractor shall begin the trial mix designs within seven (7) calendar days from the Notice to Proceed. The Contractor shall develop a laboratory testing program to demonstrate the adequacy of the proposed backfill mix design. The Contractor shall fabricate a sufficient number of samples and mix designs to support the basis for the proposed mix design. The trial mix designs shall cover a range of percentages of bentonite, cement, and admixtures to correlate anticipated ranges of soil gradations. The minimum number of mix designs shall be ten (10). The materials used to fabricate the test specimens shall be those proposed for use in construction including (if proposed), levee embankment soil, foundation soil, imported soil, bentonite, cement, water from the proposed project's source, admixtures, and any other materials. Dry cement shall not be added to the backfill. The performance criteria shall include a hydraulic conductivity (permeability), compressive strength, and slump in accordance with the parameters and methods described herein. Upon fabrication, a duplicate sample of each trial mix shall be submitted to the Contracting Officer for quality assurance testing.

1.7.2 Embankment or Import Material for Mix Design

If levee embankment soil, foundation soil or imported soil is proposed for use in construction, trial mixes shall be made using soils which will represent the range of materials expected to be encountered or used along the entire extent of the project. If the Contractor elects to use exclusively imported material for the backfill, the Contractor shall perform subsurface explorations in sufficient number to obtain soil samples representative of the material that will be encountered during the excavation for the cutoff wall trench. The Contractor's test results, including moisture content, density, mix proportions, gradation, as well as

the 7, 14 and 28-day permeability and compressive strength results shall be submitted to the Contracting Officer for approval a minimum of 45 days from the Notice to Proceed date and a minimum of 30 days prior to the initial cutoff wall construction..

1.8 UNIT PRICES

1.8.1 Slurry Cutoff Wall

1.8.1.1 Payment

Payment for slurry cutoff wall shall be made at the contract price per square foot of bid Item, **Slurry Cutoff Wall**. Such price shall include all costs of levee preparation, cleaning the trench bottom, slurry cutoff wall installation, stockpiling or spoiling materials generated during the slurry cutoff wall installation, obtaining backfill materials from commercial sources, mixing, blending, placing the slurry cutoff wall backfill, the temporary cutoff wall cap and all other items incidental to the construction and completion of the slurry cutoff wall. No separate payment will be made for materials including bentonite, cement, additives, soil, equipment and mixing, handling and cleaning the slurry, diking around the open trench, 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 slurry cutoff wall. Final acceptance of the slurry cutoff wall will be based on meeting all the requirements for the slurry wall dimensions, bentonite slurry mix, and the 28-day permeability and strength requirements.

1.8.1.2 Measurement

Measurement for Slurry Cutoff Wall, shall be based on the area in square feet of cutoff wall measured in a vertical plane through the centerline of the slurry cutoff wall, as established by the working surface indicated on the drawings and defined in paragraph "DEFINITIONS", the bottom of the slurry cutoff wall and vertical lines at each end of the slurry cutoff wall. Measurement shall be based on surveys and sounding measurements taken at the site as directed and approved by the Contracting Officer. Payment shall be made on the basis of a slurry wall constructed to the depth indicated on the drawings unless the depth of excavation is modified by and directed by the Contracting Officer.

1.8.1.3 Unit of Measure

Unit of measure: square feet.

1.9 QUALITY ASSURANCE

The Government may collect and perform quality assurance testing on the bentonite slurry and slurry cutoff wall backfill materials using the laboratory and equipment furnished by the Contractor. The Contractor shall provide the equipment and laboratory space to Government personnel on demand and these services shall be considered a subsidiary obligation of the Slurry Cutoff Wall construction. 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 or Government representatives at any time.

PART 2 PRODUCTS

2.1 MATERIALS

The Contractor shall maintain at the jobsite a sufficient quantity of raw materials and other supplies such that the work can proceed uninterrupted by material shortages. The slurry and slurry wall backfill to be used shall be suitable for the project. The Contractor shall, if necessary, modify the cutoff wall backfill design mixes to meet the required target requirements for strength and hydraulic conductivity (permeability) as specified in paragraph, "SLURRY 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 slurry cutoff wall.

The requirements for the materials to be utilized in the slurry trench construction are as follows:

2.1.1 Cement

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

2.1.2 Bentonite

The bentonite shall be sodium cation base montmorillonite powder (Premium Grade Wyoming-type bentonite) that conforms to the standards set forth in API Spec 13A, Section 4. No chemically treated bentonite will be allowed. 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 of testing by or under the supervision of the Government. Bentonite not meeting specifications shall be promptly removed from the site of the work and replaced with bentonite conforming to specifications requirements at the Contractor's expense. Bentonite shall be protected from moisture during transit and storage.

2.1.3 Admixtures

In the event the Contractor uses any additional admixtures, it shall be subject to approval of the Contracting Officer and the Contractor shall have on file a written statement from the manufacturer as to the use of any such admixture, it's effect on the slurry, it's long-term performance and stability, and it's effect on the environment. Admixtures of the type used in the control standard properties of slurry such as apparent viscosity and filtration characteristics are subject to the approval of the Contracting Officer. Peptizing or bulking agents shall not be mixed with the slurry.

2.1.4 Water

The Contractor shall supply all water required for mixing with bentonite and cement to produce the slurries and cutoff wall backfill. Prior to and once a month subsequent to the start of construction, the water shall be tested. The water shall be free of turbidity, clean, fresh, and comply

with the standards specified below:

- a. A pH equal to 7.0 plus or minus 1.0 .
- b. Total dissolved solids not greater than 500 parts per million.
- c. Oil, organics, acids, alkali, or other deleterious substances not greater than 50 parts per million each.
- d. Hardness less than or equal to 50 ppm. (Recommendation only)

The Contractor shall furnish water quality test results for water used for mixing the bentonite slurry to assure conformance with the above limits.

The Contractor shall abide by any and all regulations and other requirements governing such use. The Contractor shall include the cost of all related fees in the bid items pertinent to the work. Water shall not be taken from the river for construction activities, except when required for testing and with the Contracting Officer's approval. Water taken from the river for testing purposes shall only be filled by hand i.e. mechanical pumps are not allowed.

2.1.5 Bentonite Slurry

The bentonite slurry for supporting the sides of the trench and that mixed with the backfill shall consist of a stable colloidal suspension of powdered, premium-grade natural bentonite in water. It is the responsibility of the Contractor that the slurry meets the necessary properties. Adjustments to the slurry mixture shall be made by the Contractor to ensure a stable excavation at all times. The properties of the slurry used in all construction sequences shall be in accordance with the testing procedures described in API RP 13B-1 and API SPEC 13A and shall conform to the following requirements:

2.1.5.1 Initial Bentonite Slurry Mixture

At the time of introducing bentonite slurry into the trench excavation, the slurry mixture shall have a minimum apparent viscosity of 40 seconds as measured by the Marsh funnel. The initial slurry density shall be a minimum of 64 pounds per cubic foot. The water loss shall not be greater than 20 cubic centimeters in 30 minutes as measured by a filter press at 100 psi. Mixture adjustment shall conform to the requirements in subparagraph, "Additional Bentonite".

2.1.5.2 Trench Bentonite Slurry Mixture

The minimum apparent viscosity of the bentonite slurry mixture in the trench at any time shall be 40 seconds as measured by the Marsh funnel. The density of the slurry mixture at the time of placement in the trench shall be between 64 and 85 pounds per cubic foot. The density of the slurry in the trench at any level shall not exceed 85 pounds per cubic foot at any time. The water loss shall not be greater than 20 cubic centimeters in 30 minutes as measured by the filter press at 100 psi. The maximum sand content for slurry in the trench shall be 15 percent by weight. Sand content shall be determined by API sand tube test. The pH level measurements shall from 6.5 to 10. Mixture adjustments shall conform to the requirement in subparagraph "Additional Bentonite".

2.1.5.3 Additional Bentonite

Additional bentonite or admixtures may be required depending on the hardness and temperature of the water and the quality of the bentonite. If directed by the Contracting Officer, the Contractor shall thicken the slurry to a more viscous condition than the limits specified above. The Contractor shall use additional bentonite, as directed.

2.1.6 Soil

Soils obtained from the slurry trench excavation, imported material, or combination thereof, for use in the slurry cutoff wall backfill, shall contain no material sizes larger than 3 inches in diameter, shall be free of roots, debris and all other deleterious material that may adversely affect the properties of the backfill. The Contractor is responsible for changes in the chemistry and gradation of soils used in the slurry wall cutoff construction and its effect on the desired properties of the backfill. Thirty (30) days prior to the utilization of any off-site borrow, representative samples of each type of material shall be submitted to the Contracting Officer for testing.

2.1.7 Slurry Cutoff Wall Backfill

The initial design mix for the slurry cutoff wall backfill shall be selected by the Contractor and approved by the Contracting Officer based upon target requirements and advanced testing as specified herein. Modifications to the initial design mix shall be made only with the approval of the Contracting Officer. Soil used in the backfill shall meet the requirements of subparagraph "Soil" and may be selectively obtained from the slurry trench excavation or off-site materials obtained by the Contractor. Cement shall be added to the backfill material, only in the form of a cement slurry. Dry cement shall not be added to the backfill material.

Materials shall be thoroughly mixed, and at the time of placement, the backfill material shall conform to the mixing and placement requirements.

2.1.8 Material Storage Facility

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

2.1.9 Impervious Fill (Cap) Material

The impervious fill (cap) material to be placed and compacted in the slurry cutoff wall cap shall be soil obtained as per SECTION 02300A: LEVEE RESTORATION AND EARTHWORK of this contract.

2.1.10 Environmental Protection

The raw materials and other supplies used in the construction of the slurry wall and any spoil disposed of within the project limits or at any landfill shall be non-hazardous and shall comply with SECTION 01355: ENVIRONMENTAL PROTECTION to prevent, and provide for abatement and control of, any environmental pollution arising as a part of the work.

2.1.11 Disposal Site

Cutoff wall trench excavated material that is not suitable for backfill material shall be disposed of off-site in the disposal site indicated in the contract specifications, SECTION 01505, GENERAL REQUIREMENTS.

2.1.12 Trench Plates

The minimum plate thickness shall be 1-1/4 inches for the specified trench width. Steel plates also known as steel plate bridging shall consist of steel designed for HS20-44 truck loading per Caltrans Bridge Design Specification Manual. The Contractor shall maintain on the steel plates a non-skid surface having a minimum coefficient of friction of 0.35 as determined by California Test Method 342 (Encroachment Permits Manual Appendix H).

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Equipment

The Contractor shall furnish all necessary plant and equipment for efficiently stripping, cutting, and/or filling to form the slurry-mixing and equipment-operating surface; excavating the trench; mixing and placement of backfill; disposal of undesirable excavated material in accordance with other provisions of this contract; preparation for and placement of the impervious fill (cap) material on the completed trench, and for testing of the materials used in such process. The Contractor shall obtain and maintain at the jobsite a supply of spare critical replacement parts or backup equipment sufficient to allow the slurry cutoff wall construction to proceed with minimum loss of time due to mechanical breakdown or equipment failure.

3.1.1.1 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 18,000 pounds and a maximum ground pressure of 2,500 pounds per square foot. The maximum weight of the excavator shall not exceed 200,000 pounds without prior approval and after evaluation by the Contractor of the effect on levee stability by use of a stability analyses. The maximum operating speed of all equipment used on the levee crown roads shall be 15 mph. The maximum overall width of equipment used on the levee shall be limited to 15 feet.

3.1.1.2 Trench Excavation

Equipment for excavating the slurry trench shall be any type of earth moving or drilling equipment capable of performing the indicated work on the drawings and/or as specified, herein. The equipment shall be that which reduces live-load surcharge to a level that will produce no significant contribution to the instability of the trench. If the trench is excavated by an extended reach backhoe, the bucket shall be designed to maintain the width of the trench and minimize raveling of the trench sides during excavation operations. The excavator bucket teeth shall be replaceable with rock excavating teeth and capable of being fitted with a ripper tooth. Regardless of the equipment type used, it shall be capable of excavating the required minimum width of trench in a single pass of the excavating equipment. The equipment shall be able to reach a minimum of 5

feet deeper than the maximum depth shown on the contract drawings. In addition to the excavating equipment, the Contractor shall have available on the job site a chopping bit, ripping block, or other suitable devices as required to accomplish the trench excavation to the full required depth. If a dragline bucket is used, it shall be a heavy duty model with no protrusions along the sides of the bucket for drag or hoist chains extending beyond the limits of the cutter teeth. All equipment and any equipment modifications shall be approved and certified by the equipment manufacturer.

3.1.1.3 Mixing and Delivering Slurry

Bentonite slurry and cement slurry mixing and placing equipment will be approved by the Contracting Officer. The slurry mixing plant shall be a colloidal batch or continuous mixing plant. The slurry mixing plant shall be equipped with a high-speed/high-shear, colloidal mixer or a high-velocity/high pressure venturi jet mixer used in conjunction with a high-speed/high-shear centrifugal pump. It shall include the necessary equipment, including a mixer capable of producing a stable, fully hydrated colloidal suspension of bentonite slurry, cement slurry, or other mix combinations approved by the Contracting Officer. The plant shall be equipped with a mechanically or hydraulically agitated sump and shall include pumps, valves, hoses, supply lines, tools, and other equipment and materials required to prepare the slurry and adequately deliver slurry in a continuous supply from the hydration pond to the slurry trench and mixing areas. The Contractor shall have sufficient ponds and pits for storage of hydrated bentonite slurry. Tanks for storage of hydrated slurry shall be mechanically or hydraulically agitated. The Contractor shall submit to the Contracting Officer for approval the equipment purposed for mixing and delivering the bentonite and cement slurries.

3.1.1.4 Cleaning of Slurry

Slurry cleaning equipment shall include but are not limited to a vibratory shaker screen, centrifugal sand separator, and/or stilling ponds.

3.1.1.5 Preparation of Trench Bottom

The bottom of the trench shall be prepared by using crane mounted clamshell, jet pipes, air lift pumps, vibrating shaker screens, probe pipes, and necessary pipes, hoses, and fittings for other suitable equipment.

3.1.1.6 Mixing and Placing Slurry Cutoff Wall Backfill

The equipment used for the mixing and placing of the backfill material, including but are not limited to the bulldozers, disks, harrows, monitor patrols, pugmills and haul trucks shall be capable of mixing backfill materials into a homogeneous mixture conforming to the contract requirements and be suitable for placement of the backfill material in the trench as specified herein. Initial placement of backfill on the trench bottom shall be by clamshell, tremie tubes or pumps or other approved methods until the surface of the backfill rises above the surface of the slurry trench at the end of the trench. Initial placement methods shall prevent free fall, segregation, and entrapment of slurry. All non-complying material shall be removed and replaced at the expense of the Contractor.

3.1.1.7 Retaining Berms

Suitable grading and earth-moving equipment shall be available for preparing the work area for slurry cutoff wall installation including equipment for the construction of slurry spill retaining/containment berms or ditches.

3.1.1.8 Hauling Equipment

Hauling equipment shall consist of pneumatic-tired vehicles having dump bodies suitable for the material being hauled and meeting the requirements of subparagraph "Equipment Weight, Speed and Width". To insure trench stability, the Contractor shall establish and maintain a minimum set back distance from the open trench side walls to the hauling equipment path.

3.2 SLURRY CUTOFF WALL CONSTRUCTION

3.2.1 General

The slurry cutoff wall, as placed, shall be homogeneous and shall be constructed to the elevations, lines, grades, and cross-sections shown on the contract drawings and in accordance with these specifications, unless otherwise directed by the Contracting Officer. The slurry cutoff wall shall be constructed to the following dimensions, hydraulic conductivity (permeability) and strength:

Width:	24-inches (minimum)
Depth:	Varies, as shown on the contract drawings measured from top of existing levee.
Hydraulic Permeability (28-day):	5×10^{-7} cm/sec (maximum)
Unconfined Compressive Strength (28-day):	30 psi (minimum) and 300 psi (maximum)

Final acceptance of the slurry cutoff wall will be based on the results of the laboratory tests of bulk samples as described in paragraph "BACKFILL PROPERTIES". 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.

3.2.2 Potholing (Field Verification)

Potholing shall occur to field locate existing utility crossings and/or the existing cutoff wall prior to construction of the new cutoff wall, to ensure that a proper tie-in is achieved.

The Contractor shall carefully excavate to expose the top of the existing slurry wall or utility crossing at each location and confirm the utility information on the contract drawings and document the condition of the utility crossing. Potholing excavation shall meet all the requirements of other excavations as described in other sections and shown on the contract drawings.

The Contracting Officer shall be informed a minimum of two (2) calendar days prior to the start of potholing so the Contracting Officer may witness such work. If the Contracting Officer chooses not to witness the

potholing, the Contractor shall report findings to the Contracting Officer within eight (8) hours of discovery.

In the area near the PG&E high pressure gas line, Mr. Carl Bish, the field representative for the Meridian PG&E shall be contacted 3 days prior to the start of any potholing work being performed near the PG&E high pressure gas line. His contact number is (530-634-6510). All excavation work shall be done by hand or with small equipment. See contract drawings for utility line details and specifications.

All excavations into the levee for potholing shall be backfilled with impervious fill material or a controlled low strength material (CLSM). Excavations within the newly placed cutoff wall shall be backfilled with a cement-bentonite slurry backfill material. Pothole backfilling shall meet all the requirements of other backfill operations as described in other sections and on the contract drawings.

3.2.3 Working Surface

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 as shown on the contract drawings. The working surfaces from which the slurry cutoff wall is to be constructed shall be defined in paragraph "DEFINITIONS", and shall constitute the top of the slurry cutoff wall for the purpose of measurement for payment. However, the Contractor may construct a working surface to a level lower than what is shown on the contract drawings, for his own convenience. Additional lowering of the working surface will require the approval of the Contracting Officer. There will be no payment for any additional excavation, fill, or reduction of slurry cutoff wall required as the result of lowering the level of working surface than the defined working surface level, for the convenience to the Contractor. A berm or other appropriate type of barrier shall be constructed to prevent off-site movement of waste materials, slurry spills, etc.

In the area near the PG&E high pressure gas line, lowering of the working surface will require specific coordination and sequencing. Mr. Carl Bish, the field representative for the Meridian PG&E shall be contacted 3 days prior to any excavation work being performed near the PG&E high pressure gas line. His contact number is (530-634-6510). During the excavation of the working surface, a minimum clearance space of 10 feet shall be maintained upstream and downstream of where the utility crosses the levee hinge points. Additional material coverage may be required by the utility owner to allow traffic over the utility crossing during construction operations. At this time, allow for an additional two (2) feet of material cover over the utility crossing with slopes of no greater than 10 horizontal on 1 vertical grades. See contract drawings for construction layout.

Upon completion of the slurry cutoff wall installation, the levee shall be restored to final alignment and grade in accordance with SECTION 02300A LEVEE RESTORATION AND EARTHWORK. Material requirements, placement and compaction shall be in accordance with SECTION 02300A LEVEE RESTORATION AND EARTHWORK.

In the event that the static ground water table is encountered at a depth of 3 feet or less below the designated working surface, the Contractor shall, at the direction of the Contracting Officer, raise the working surface to a height of 3 feet above the measured static ground water level

with approved fill material. The working surface thus constructed shall be utilized as a basis for measurement for payment.

3.2.4 Construction Staking

The Contractor shall provide, install and maintain all layout and necessary construction staking to locate the cutoff wall centerline within the allowable range of cutoff wall installation and the cutoff wall length as shown on the contract drawings. Surveyor's caps, appropriately identified and mounted on a 2-inch diameter, 2-foot-long steel pipe, driven into the ground, shall be provided at each end of the cutoff wall and at one-hundred (100)-foot maximum intervals between the ends. Coordinates and elevations shall have units consistent with the contract drawings. A tabulated list containing survey control numbers, grid coordinates, river station number, and elevations shall be submitted to the Contracting Officer within five (5) working days of completing each heading and a summary list at the completion of all survey controls. The beginning and ending of the cutoff wall and utility crossings shall be identified on this list. Survey construction control staking shall be performed by a California licensed surveyor and all survey data shall be stamped by the licensed surveyor.

3.2.4.1 Initial and Final Elevation

The caps shall be surveyed to establish initial elevation and final elevation to an accuracy of plus or minus 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 wall installation showing any settlements that occurred and also indicating 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 furnished as part of the submittal. A 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 for approval. Upon completion of the cutoff wall installation, permanent metal markers stakes shall be installed to indicate the location of each end of the cutoff wall. The levee station and levee mile shall be indicated on permanent metal markers.

3.2.5 Blasting

Explosives shall not be used in connection with this contract.

3.2.6 Excavation

The excavation shall be by the slurry trench method. Excavation shall proceed in such a manner that the up-gradient section of the slurry trench is complete before the down gradient section. This will prevent "damming" of the groundwater at the site that could cause a significant rise in the water level over the site during construction. Excavation shall be conducted in a manner which provides for a continuous 2-foot minimum width trench to the required depth, as shown on the contract drawings, at all points along the centerline of the excavation. The Contractor shall excavate the slurry trench from the working surface. The excavation shall be carried immediately to the depth shown at the point where excavation is started. The Contracting Officer may direct the Contractor to deepen the trench a maximum of 5 feet based on examination of bucket cuttings at specified locations. The toe of the slope of the trench excavations shall not precede the toe of the backfill slopes by less than 30 feet and no more

than 100 feet, or as directed by the Contracting Officer.

The slurry trench shall be constructed without undue interruption until complete. If extended delays in backfill operations occur for any reason, the Contracting Officer may require the re-excavation of the placed backfill. Delays in excess of 48 hours are considered extended delays. The re-excavation of the placed backfill shall consist of the removal of 5 feet perpendicular to the slope of the backfill for the full depth of the slurry trench. If the various sections of the slurry trench are constructed separately or in more than one straight line segment, re-excavation of a section of the previously constructed slurry trench backfill material will be required at the points of intersection. A minimum overlap length of 5 feet throughout the entire depth of backfill shall be constructed at any slurry trench corner to obtain continuous trench backfill through the entire length of the slurry trench. That section of the slurry trench backfill material that is removed and re-backfilled due to delays in backfilling or to intersect an existing wall shall be considered incidental to the Slurry Cutoff Wall pay item.

In the area near the PG&E high pressure gas line, excavation work will require specific coordination and sequencing. Mr. Carl Bish, the field representative for the Meridian PG&E shall be contacted 3 days prior to any excavation work being performed near the PG&E high pressure gas line. His contact number is (530-634-6510). During excavation of the slurry cutoff wall, a minimum clearance of 5 feet from the utility crossing shall be maintained at all times. Removal of the cover material, excavation of the working surface and excavation of the slurry cutoff wall shall be performed and approached by using two different excavation headings. Delaying or rerouting traffic and performing the work during the night may be required. See contract drawings for construction layout.

3.2.6.1 Impervious Stratum Excavation

The cutoff wall excavation into the impervious stratum shall be carried the full width of the trench to the depths shown or as otherwise directed. Any sandstone or sand lenses encountered at the minimum excavation depth shall be removed for the full width of the trench and into the underlying impervious stratum. The impervious stratum shall then be sampled in accordance with paragraph "SAMPLES OF IMPERVIOUS STRATUM". Adjustments to the termination depth and station of the excavation will be approved by the Contracting Officer.

3.2.7 Placement of Bentonite Slurry

The bentonite slurry shall be introduced into the trench at the time excavation begins. The level of the slurry in open trenches shall be at all times maintained a minimum of 2 feet above ground water level and between 6 to 18-inches below the working surface until the placement of backfill material is complete. The Contractor shall have sufficient personnel, equipment, slurry storage areas, and stored slurry materials ready to raise the slurry level at all times in the excavated trench during construction within the limitations specified in paragraph "SLURRY CUTOFF WALL CONSTRUCTION" and subparagraphs thereof.

To this end, the Contractor shall have personnel on call to raise the slurry level at any time this occurs, weekends and/or holidays included. Dilution of slurry by surface waters shall be prevented. High slurry sand content, slurry loss and high permeable conditions may occur due to the presence of permeable materials and rodent holes. The quality of the

slurry shall be maintained at all times, including periods of work stoppage, in a condition which meets the requirements set forth in subparagraph "Trench Bentonite Slurry Mixture". Cleaning and/or re-circulating the trench slurry will be required if delays in the placement of backfill material for longer than forty-eight (48) hours occurs. Conditioning and desanding of the slurry may require re-circulation through shaker screens or the addition of approved additives.

3.2.8 Excavated Material

Material excavated from the trench meeting the requirements of subparagraph "Mixing Backfill", may be used in the backfill. Any material containing cobbles shall be processed to remove the plus 3 inch material prior to being mixed into the backfill. Material not used in the backfill shall become the property of the Contractor and shall be disposed of off-site, in accordance with all State, Federal, and local regulations and codes, such as the Clean Water Act and the National Historic Preservation Act.

3.2.9 Backfilling Trench in Case of High Water

In the event the water surface elevation of the Sacramento River is forecasted by the State-Federal Flood Forecast Center to increase significantly for any reason, the Contracting Officer reserves the right to require the Contractor to stop excavation and to begin continuous operations to complete all partially completed section(s) of the slurry cutoff wall including capping layers, as specified in subparagraph "Backfilling". Continuous operations shall consist of expeditiously performing the required operations twenty-four hours per day until the operations are completed. Additionally, during such flood conditions the Contracting Officer reserves the right to require the Contractor to remove all equipment from the levee crown upon completion of the required backfilling. Compensation including time extension for actions taken for backfilling due to high water shall be through a contract modification based on work directed by the Contracting Officer. The work shall only be initiated upon receiving written notification from the Contracting Officer.

3.2.10 Stability

The Contractor shall be responsible for insuring and maintaining the stability of the excavated trench at all times for its full length and depth and shall be responsible for maintaining slurry densities and levels within specified limits. The Contractor shall control surcharges from all excavation and backfilling equipment, waste, berm construction, backfill stockpiles, and any other loading situations that may affect trench stability. It is the Contractor's sole responsibility to ensure that the mixing of backfill, any stockpiles and traffic do not affect the open trench stability. In the event of failure of the trench walls prior to completion of backfilling, the Contractor shall at his expense re-excavate the trench and remove all material displaced into the trench and take corrective action to prevent further deterioration.

3.2.11 Treatment of Trench Bottom

3.2.11.1 Cleaning

Cleaning the bottom of the trench will be required if delays in the placement of backfill material for longer than forty-eight (48) hours occurs. Trench bottom shall be cleaned by an air lift pump or other suitable equipment to insure removal of all sand, gravel, sediment, and any

other material left in the trench during excavation and/or which has settled out of the slurry. After the Contractor cleans the trench bottom by removing all loose rock and gravel, he shall then probe the trench bottom for possible potholes, cracks, and crevices. Such depressions shall be cleaned out by the above mentioned equipment. All cleaning equipment shall be operated in such a manner to prevent removal of materials from the walls of the trench. The Contracting Officer will approve the cleaning and probing operations and may require additional cleaning as he deems necessary.

3.2.12 Backfilling

3.2.12.1 Mixing Areas

Areas for the mixing of backfill, preparing compacted fill for slurry cutoff wall cap and other slurry cutoff wall operations shall be located within the designated staging areas shown on the contract drawings or within areas approved by the Contracting Officer. All mixing areas shall be cleaned up and restored upon completion of the work in accordance with subparagraph "Cleanup".

3.2.12.2 Mixing Backfill

Stockpiled material generated during the slurry cutoff wall installation and/or material from borrow or commercial sources shall be mixed and blended by approved methods.

For bulk mixing of the backfill using earth moving equipment, the Contractor shall construct a controlled volume mixing area. This area shall consist of an enclosed volume, bounded on the floor and walls by structural material such as concrete or steel. Contractor shall proportion the backfill mixing area to be consistent with the production requirements and mixing area location. Earthen berms or pits dug in the earth will not be allowed for batch proportioning of the soil-cement-bentonite mix.

The backfill material shall be thoroughly mixed into a homogeneous mass, free from large lumps or pockets of fines, sand, and/or gravel. Occasional lumps of up to three (3) inches in their largest dimension will be permitted. The backfill material shall have a consistency as approved by the Contracting Officer. The backfill material, just prior to placement in the trench, shall have a consistency to provide a slump 5 to 7 inches per ASTM C 143. Any damage to the slurry cutoff wall as a result of operating equipment near the cutoff wall or for other reasons shall be repaired or restored by the Contractor at no additional cost to the Government.

3.2.12.3 Placement of Backfill

The backfill material shall be placed in the excavated trench in such a manner that no pockets of slurry are trapped in the completed slurry trench. The Contractor shall backfill continuously from the beginning of the trench in the direction of the excavation to the end of the trench. Placing operations shall proceed in such fashion that the top of the backfill below the surface of the slurry shall follow a reasonably smooth grade and shall not have hollows which may trap pockets of slurry during subsequent backfilling. To this end, the face of the backfill below the surface of the slurry may require rodding, and the Contractor shall have such equipment available at the job site. Free dropping of backfill material through the slurry will not be permitted. Initial backfill shall be placed by lowering it to the bottom of the trench by methods approved by

the Contracting Officer until the surface of the backfill rises above the surface of the slurry trench at the end of the trench. Backfill shall then be placed in such a manner that the backfill enters the trench by sliding down the forward face of the previously placed backfill. To accomplish this, the Contractor shall backfill from the initial backfill toward the opposite end of the trench. Backfilling operations shall proceed in such a manner that the slope of the initial backfill will be maintained. The new backfill material will be allowed to slide down the slope of the previously placed backfill and shall be placed in such a manner that pockets of slurry will not be trapped during the backfilling. This remaining backfill may be accomplished by the use of other approved equipment and in such a manner that the backfill below the slurry surface will be pushed along the trench.

An acceptable substitute for the initial placing of backfill by the use of a clamshell bucket shall be to begin excavation at a point outside of the limits of work which will provide a sufficient distance for the backfill face to form into the trench before the toe of the backfill reaches the point where the slurry trench is required. Dozing or pushing material into the cutoff wall trench will not be allowed. No payments will be made for the portions of the trenches which lie outside of the limits of work.

3.2.12.4 Mixing and Placing Backfill During Cold Weather

No mixing or placing of the backfill shall be performed when the air temperature is below 32 degrees F. Frozen soil-bentonite backfill shall not be placed in the trench and backfill.

3.2.13 Protection of Top of Cutoff Wall

The slurry trench shall have backfill material placed to the lines and grades shown on the contract drawings. No construction activity on top of the cutoff wall will be permitted until the initial set of the backfill has occurred. Contractor shall take all necessary actions to protect the cutoff wall from disturbance and prevent the drying of the top of the slurry trench backfill. A temporary non-compacted soil cover shall be placed within two (2) days after backfill placement is completed over each 100-foot reach. No activity on top of the wall will be permitted for a minimum period of two days after placement of the soil cover and until the wall has reached a minimum unconfined compressive strength of 30 psi. Heavy construction equipment and machinery shall only be driven over the cutoff wall at approved equipment crossing points which are "bridged" with steel plates and additional cover material and transmit no loads to the cutoff wall.

3.2.14 Impervious Fill (Cap) Material

After the cutoff wall has reached a minimum unconfined compressive strength of 30 psi, the soil cover shall be removed and the cutoff wall shall be capped with impervious fill (cap) material in accordance with the Slurry Cutoff Wall Cap detail shown on the contract drawings. The slurry cutoff wall cap material shall consist of impervious fill (cap) material as defined in SECTION 02300a: LEVEE RESTORATION AND EARTHWORK. The subgrade preparation, placement, compaction and testing shall be in accordance with SECTION 02300a: LEVEE RESTORATION AND EARTHWORK. Any settlement of the impervious fill (cap) material over the cutoff wall shall be backfilled and compacted with additional impervious fill (cap) material. After the impervious fill (cap) material has been properly placed and compacted at the top of the cutoff wall, the levee crown shall be restored to a wearing surface as shown on the contract drawings.

3.2.15 Cleanup

The Contractor shall continually all clean up slurry wastes, debris and leftover materials resulting from the 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. During the final disposal of the bentonite slurry, the material shall be flocculated to separate the bentonite from the water. Spoils generated by the cutoff wall construction shall become the property of the Contractor and the Contractor shall be responsible for disposal of waste materials in accordance with all Federal, State, and local regulations and codes, such as the Clean Water Act and the National Historic Preservation Act.

3.3 QUALITY CONTROL

The Contractor shall be responsible for project quality control records. Observation, measurements, and tests described in these specifications shall be performed for quality control. All quality control records, routine testing procedures, summaries, observations, and measurements shall be available for inspection by the Contracting Officer's Representative at any time. Final acceptance of the slurry wall shall be based on the results of field measurements and bulk samples collected and tested as described in subparagraphs "Excavation and Backfill Soundings" and "Backfill Properties". The laboratory shall be an independent commercial laboratory and shall comply with requirements of SECTION 01451A CONTRACTOR QUALITY CONTROL.

3.3.1 Bentonite

Each truckload of bentonite delivered to the site shall be sampled in accordance with Section 4 of API Spec 13A. The samples shall be tested in accordance with the procedures of Section 3 of API Spec 13A to confirm conformance with the physical and chemical requirements listed in Table 3.1 of Section 3.

3.3.2 Water

Water for construction shall be the responsibility of the Contractor. Prior to the start of construction, the source of water to be mixed with the bentonite shall be tested for pH, hardness, and oil, organic, etc. Subsequent to the start of construction testing shall be conducted every **month**. Tests shall conform with the requirements of API RP 13B-1 and these specifications. Testing of water and the water results shall conform to the requirements listed in Part 2, subparagraph "Water".

3.3.3 Wash Water

Any wash water pumped from the slurry plant to the cutoff wall shall be monitored. The wash water shall be properly disposed of. The wash water shall not be allowed to dilute the cutoff wall slurry or backfill nor shall it be allowed to spill off the levee crown onto the levee slopes.

3.3.4 Slurry Properties

All tests specified in this paragraph shall be conducted in accordance with API RP 13B-1. The bentonite slurry shall be tested prior to placing the slurry in the trench a minimum of two (2) times each working day per 8 or 10 hour shift per heading. The following tests shall be performed: viscosity, filtration, sand content, pH and density.

At the time of placing backfill into the slurry-filled trench, the bentonite slurry within the trench shall be tested for viscosity, filtration, sand content, pH and density. The bentonite slurry in the trench shall be sampled a minimum of two (2) times each working day, or shift, 1 sample at depth intervals of 10 feet and 25 feet, both samples taken within 25 to 40 feet of the advancing backfill slope. The bentonite slurry in the trench 5 feet of the advancing backfill slope, shall also be sampled a minimum of one (1) time each working day, or shift, at a depth interval of 30 feet. The following tests shall be performed: viscosity, filtration, sand content, pH and density.

The samples shall be labeled by sample number, date, time, heading, depth and stationing. The sampling devices used to collect samples will be subject to approval by the Contracting Officer. The Contractor shall be required to obtain additional samples for the Contracting Officer at any time or location requested. Personnel shall be provided by the Contractor for conducting the tests and they must have a working knowledge of test procedures for drilling fluids in accordance with applicable API standard procedures. Equipment for bentonite slurry testing shall be furnished and maintained by the Contractor.

3.3.5 Excavation and Backfill Soundings

The Contractor shall make excavation and soil-bentonite backfill soundings at every 10-foot interval along the trench centerline using a weighted tape, cable, or other devices approved by the Contracting Officer. The soundings shall be performed and recorded a minimum of one (1) time at the beginning and one (1) time at the end of each 10 hour work day, or shift, per heading and at additional times as requested by the Construction Representative or Contracting Officer. The length of cutoff wall installed each day or lesser increment thereof shall be measured. The soundings at each interval shall record the following:

3.3.5.1 Elevation of Top of Impervious Stratum

The top of impervious stratum will be determined by the Contractor's Trench Logger and confirmed by the Contracting Officer based on an examination of bucket cuttings during trench excavation. The Contractor shall determine the elevations of the impervious stratum.

3.3.5.2 Elevation of Bottom of Excavation

Determining the depth of excavation will be made by the Contracting Officer, using the measured depth, stationing and results of the excavated impervious stratum samples, as described under paragraph "Samples of Impervious Stratum". The minimum excavation line is shown on the contract drawings. The depth of excavation may increase or decrease within 5 feet from the contract drawings due to field condition encountered. The Contractor shall determine the elevation of the bottom of the excavation.

3.3.5.3 Elevation of Bottom Prior to Backfilling

This sounding shall record the thickness of sediments accumulated at the trench bottom. Cleaning and additional material removal from the trench bottom prior to backfilling may be required by the Contracting Officer. This sounding shall not precede the toe of the soil-bentonite backfill slope more than 100 feet.

3.3.5.4 Profile of Backfill Slope

The soil-cement-bentonite backfill slope shall be measured at the beginning and at the end of each shift per heading and at additional times at the request of the Contracting Officer or Construction Representative. The slope of the soil-cement-bentonite backfill shall be sounded at horizontal intervals of 10 feet to determine the profile of the backfill slope.

3.3.6 Backfill Properties

The Contractor shall collect, prepare, and submit backfill samples to the Government. Sampling equipment shall be subject to the Contracting Officer's approval and shall be maintained on site for the duration of the job. The Government may collect and perform quality assurance testing on the bentonite slurry and slurry cutoff wall backfill materials. The Government testing will in no way relieve the Contractor of the responsibility of performing tests necessary to meet the construction requirements.

One slurry cutoff wall backfill mixture bulk sample shall be retrieved for permeability and strength testing a minimum of two (2) times per 10-hour work day, or shift, per heading and at additional times requested by the Construction Representative or Contracting Officer. The sample shall be taken prior to placement of backfill into the trench, at the location of where the backfill is being introduced into the trench. Plastic molds shall be used to cast a minimum of twelve (12) two-inch diameter by four-inch long cylindrical test specimens from the bulk sample. Additional specimens may be casted for additional testing by the Contractor. Gravel sizes greater than 1/6 (one-sixth) of the inside diameter of the mold and any clumps of bentonite, cement or excavated material not passing a 1/4-inch screen shall be manually removed and discarded. 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 constant temperature, damp environment until tested or until otherwise directed by the Contracting Officer. For each shift in which backfill is placed, six of the specimens from the bulk samples shall be transported to an independent laboratory for testing and six shall be submitted to the Contracting Officer. The samples shall be labeled by sample number, date, time, heading, and stationing.

3.3.6.1 Chain of Custody of Samples

The Contractor shall develop an approved chain of custody protocol for exchanging samples among the various parties used by the Contractor for the Quality Control program. At a minimum, the sample identification, location, heading, depth, backfill ID number, date, and person taking custody of the sample shall be entered into the chain of custody sampling form. Wherever the samples are exchanged between responsible parties, the transfer shall be noted by each party accepting and transferring the samples. The type of test, date and result of measurement shall be entered on the form once samples are used for laboratory testing. All samples stored for archive purposes shall be duly noted as to the location of the archive. The chain of custody form shall be available for inspection by the Contracting Officer at any time. Copies of the chain of custody form shall be given to the Contracting Officer on a weekly basis.

3.3.6.2 Slump Tests

The backfill material, just prior to placement in the trench, shall have a

consistency to provide a slump 5 to 7 inches in accordance with ASTM C 143/C 143M. Slump cone tests shall be performed a minimum of two (2) times per 8 or 10-hour work day, or shift, per heading and at additional times requested by the Construction Representative or Contracting Officer.

3.3.6.3 Compressive Strength Testing

Three (3) sample test specimens from each bulk sample, one after curing seven (7) days, one after curing fourteen (14) days, and one after curing twenty-eight (28) days shall be subjected to an unconfined compressive strength test in accordance with 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 bulk sample testing. It is the intent of these tests to relate unconfined compressive strength to permeability, therefore tests shall be performed on specimens from the same bulk sample.

3.3.6.4 Backfill Permeability Determinations

Three (3) sample test specimens from each bulk sample, one after curing seven (7) days, one after curing fourteen (14) days, and one after curing twenty-eight (28) days shall be subjected to permeability testing in a triaxial type permeability cell in accordance with ASTM D 5084. 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 bulk sample testing. It is the intent of these tests to relate unconfined compressive strength to permeability, therefore tests shall be performed on specimens from the same bulk sample.

The permeability test parameters are as follows:

Average Effective Confining Stress:	10 psi
Hydraulic Gradient:	15 divided by the average cutoff wall thickness in feet
Permeate:	Sacramento River water near the site.
Backpressure:	Sufficient to ensure a Skempton's pore pressure "B" parameter greater than or equal to 0.95

The permeability tests shall be continued until inflow-outflow measurements or flow rates demonstrate that steady state seepage conditions are evident.

The independent Quality Control testing laboratory selected by the Contractor shall submit a detailed testing program followed with information relating to equipment used for testing.

3.3.7 Samples of Impervious Stratum

Samples of impervious stratum shall be taken at a minimum interval of 100 feet of open excavation, per day per heading or as directed by the Contracting Officer and Construction Representative. The material encountered shall be described in accordance with ASTM D 2488 "Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)". The date, time, station, depth, heading shall be recorded and the sampling, storing, description and classification of the material performed by the Contractor's Trench Logger and confirmed by the Contracting Officer. After examining these results, the Contracting Officer will either approve the termination of excavation at the minimum excavation shown on the contract drawings or require additional or less excavation. If additional excavation is required, additional samples shall

be furnished by the Contractor as specified above. All samples shall be properly identified and labeled, placed in sealed plastic containers (baggie) and stored in a location designated by the Contracting Officer.

3.3.8 Records

Records shall be maintained by the Contractor for all testing, measurements, and inspections performed to ascertain that the cutoff wall construction meets the specifications. Required reports, records, and documentation shall be furnished to the Contracting Officer on a daily basis in hardcopy and digital (Excel and/or AutoCad) formats. All laboratory test data, test result summaries, any data acquisition from instruments, production information on amount of bentonite and cement used, volume of backfill placed, volume excavated, soundings of excavation and backfill versus stationing, depth of materials and types of materials excavated versus stationing shall be digitally written for importing in EXCEL, or in a digital format as directed by the Contracting Officer. All digital supplied data shall be presented in a useable format and have appropriate table headings, legends, quantities, location, and any other identifying elements required for Quality Assurance evaluation. The Contractor's required records are outlined below.

3.3.8.1 As-Built Profile

An as-built profile of the trench bottom, backfill slopes including descriptions of materials encountered in the trench bottom shall be continuously maintained by the Contractor. This profile shall indicate extent of excavation and the soil-cement-bentonite backfill profile at the beginning and end of each work day or shift, as determined from the soundings. The daily profile drawing shall be in AutoCAD Version 14 or a newer updated version of AutoCAD as well as in electronic format written for import into EXCEL or in a digital format as directed by the Contracting Officer. Material encountered in the trench and bottom of the trench shall be described by the approved Trench Logger, in accordance with ASTM D 2488 at a maximum trench length of 20 feet. The Contractor shall furnish profile drawings, individual and summary of records of all observations, measurements, and test 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.

3.3.8.2 Results

The results of all construction control testing required in these specifications, including water tests, slurry tests, backfill tests, and depth soundings 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. Test summaries comparing test results with contract requirements shall be maintained in an electronic data base and updated daily with both digital and hard copies submitted at least weekly and with the progress payment requests.

3.3.8.3 Bentonite Slurry Mix

Bentonite slurry mix quantities, proportions of all additives utilized, and placement locations into the trench shall be recorded by the Contractor. Any adjustments in the bentonite slurry mix shall be approved by the Contracting Officer and shall also be recorded and documented by the

Contractor.

3.3.8.4 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 excavation problems, slurry losses and unusual conditions or problems encountered, and the dispositions made. The Contracting Officer shall be immediately notified of unusual conditions or problems and followed by a written description.

-- End of Section --