SECTION 02276
PLASTIC CONCRETE CUTOFF WALL

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Construction of a deep plastic concrete cutoff wall. The cutoff shall be constructed by excavation with slurry through soil (earth dam fill) and rock. Excavation shall be performed using a rock mill.

1.2 REFERENCES

A. 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. Where a date is given for reference standards, that edition shall be used. Where no date is given for reference standards, the latest edition available on the date of Notice Inviting Bids shall be used.

1. American Petroleum Institute (API):

2. ASTM International (ASTM):
   f. C618, Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete.
UINTA BASIS REPLACEMENT PROJECT
BIG SAND WASH DAM ENLARGEMENT


B. Specifications: Section 03300, CAST-IN PLACE CONCRETE.

1.3 SUBMITTALS

A. The CONTRACTOR shall submit the following specific information:

1. Its proposed construction methodology including:
   a. Details of excavation equipment, excavation stability methods, construction sequence with multiple excavators, and construction methodology for joints between panels.
   b. Method and location for hydrating and ponding bentonite-water slurry.
   c. Methods of maintaining and measuring panel verticality and sounding the depth of the panel excavation. Method for measuring and verifying panel overlap of joints.
   d. Methods of excavation cleaning prior to placing concrete.
   e. Methods of batching and placing concrete.
   f. Method of excavating the cutoff in sloping ground.
   g. Method of joint consolidation between panels to insure water tightness of joint.
   h. Location plan of verification holes, with hole numbering system based on contract construction status.
   i. Methods to construct cutoff wall where it will intersect the existing outlet conduit including details about:
      1) Cutting of steel lines and reinforcing steel in existing outlet conduit.
      2) Sealing outlet conduit to prevent excessive slurry loss.
      3) Ensuring the safety of construction workers at all times.
   j. Methods of slurry disposal, such as drying, mixing with dry materials, spreading in thin layers or stabilization by cement and burial in trenches. Submit a plan for spreading, discing, mulching, and vegetating the slurry waste in the slurry waste disposal area if CONSTRUCTION MANAGER determines that it is not necessary to cement stabilize the slurry and to cover it in trenches.

2. A specific list of all equipment to be used, including the number of units, model, year, and type of equipment dimensions where applicable, together with the rated capacity of each. Specific information shall be provided about the cutter types to be used. The batch plant(s) shall be
identified that is capable of producing the volume of concrete required for the work.

3. Detailed contingency plan outlining steps to be followed in the event of slurry loss. The plan shall outline steps to be followed, if rapid slurry loss is encountered, to maintain stability of the panel excavation. The plan shall also describe the proposed method of treating areas of excessive slurry loss (grouting, etc.).

4. Documents certifying the properties of bentonite, cement, mixing water, aggregate, and other materials. At the CONSTRUCTION MANAGER’s request, the CONTRACTOR shall furnish samples of materials in sufficient amount for independent quality control testing.

5. The CONTRACTOR’s quality control plan.

6. Copies of all quality control test results obtained by the CONTRACTOR.

7. Reproducible drawing of the CONTRACTOR’s panel layout and numbering.

8. Shop drawing of the CONTRACTOR’s guidewall design.

9. The CONTRACTOR’s detailed procedures for correcting deficiencies in joints between panels.

10. Method of protecting the top of the cutoff from weather and equipment damage.

11. Concrete mix design report, including all test results.

12. Test section location.

1.4 DEFINITIONS

A. Whenever in this section the following terms are used, the intent and meaning shall be interpreted as stated below:

1. Concrete Cutoff: Concrete cutoff is a cutoff constructed by excavating a series of contiguous panels and backfilling them with concrete to form a seepage barrier. Alternating (primary) panels are excavated and backfilled with concrete and allowed to set before overlapping intermediate (secondary) panels are excavated and backfilled with concrete.

2. Plastic Concrete: Plastic concrete is defined for this work as the concrete used as the final cutoff material.

3. Slurry Method of Excavation: The slurry method of excavation consists of excavating a panel through rock while at the same time keeping the panel filled with bentonite-water slurry. The basic purpose of the slurry is to maintain the stability of the walls of the panel. Cutoff construction techniques utilizing methods and equipment for mixing foundation
materials with cement, or with cement and bentonite, in place in the foundation will not be allowed.

4. Excavation: Excavation is defined as a panel excavated using cutting, grinding or pounding methods.

5. Slurry: Slurry is a stable, colloidal, thixotropic suspension of powdered bentonite in water.

6. Bentonite: Bentonite is a natural clay, of which the principal mineral constituent is sodium montmorillonite meeting the requirements of API 13A.

7. Groundwater: Groundwater denotes all water below the existing ground surface, within the work area.

1.5 FIELD TESTING

A. In addition to the field quality control testing required from the CONTRACTOR, field testing may be performed by the CONSTRUCTION MANAGER to check conformance with these Specifications. Where any non-conformance is revealed, further testing will be performed by the CONSTRUCTION MANAGER. Corrective measures to the extent of complete replacement of applied material, shall be made by the CONTRACTOR until conformance is achieved. All costs for retests and rework shall be paid by the CONTRACTOR.

1.6 QUALIFICATIONS

A. The CONTRACTOR (or its proposed Subcontractor) invited to propose on this work shall submit at least three concrete cutoff projects that it has completed within the last 10 years that are of comparable size (in area), depth, and foundation conditions as those for this project. At least one project should be in a comparable dam embankment. The CONTRACTOR shall submit the following information for each project reference:

1. Name of project, date completed, location, and reference contact (position and telephone number).
2. Maximum depth, length and area of cutoff.
3. Materials excavated.
4. Equipment used, including excavation productivities.

B. The CONTRACTOR (or its proposed Subcontractor) shall provide an experienced full-time, on-site project manager and superintendent (5 years minimum experience with cutoff construction each), as well as concrete specialist(s), a quality control engineer and support personnel specifically experienced with concrete and plastic concrete. The CONTRACTOR shall be...
required to provide one full-time specialist per shift at the site during concrete placement and one specialist at the batch plant for quality control. One individual cannot assume both roles. Resumes of the proposed project manager, superintendent, and concrete specialists shall be submitted for approval by the CONSTRUCTION MANAGER.

C. The CONTRACTOR (or its proposed Subcontractor) shall identify design engineering support personnel to be assigned to provide final design and design modifications of the cutoff, and prepare CONTRACTOR submittals for review and acceptance by the CONSTRUCTION MANAGER. Resumes of design personnel highlighting relevant experience with seepage cutoffs shall be submitted.

D. The CONSTRUCTION MANAGER will review the qualifications of the proposed personnel for approval or rejection. This review may include interviews with the personnel by the CONSTRUCTION MANAGER.

PART 2 PRODUCTS

2.1 MATERIALS

A. The bentonite shall be high-swelling, Wyoming-type sodium, cation-base bentonite consisting mainly of the clay mineral montmorillonite and compatible with development of potable water supplies. The bentonite shall be high-yield, finely ground clay capable of producing at least 125 barrels of American Petroleum Institute (API) slurry per ton of dry bentonite. Any additives that have been combined with the bentonite shall require the express consent of the CONSTRUCTION MANAGER. The bentonite powder shall conform to the standards set forth in API 13A, 15th edition, June 1999, Oil Well Drilling Fluid Materials. Bio-polymer slurry fluids will not be permitted. Chemically treated, high yield bentonite, which may react unfavorably with concrete, shall not be used.

B. Water:

1. Water used in preparing the bentonite-water slurry shall be clean and free from deleterious amounts of soil, salts, and organic matter such that the resulting slurry has the necessary properties to provide stability of the excavation. The total dissolved solids shall be less than 400 ppm.

2. The source of water shall be approved by the CONSTRUCTION MANAGER prior to use, and any change in water supply shall be tested by the CONTRACTOR and approved by the CONSTRUCTION MANAGER.
MANAGER prior to use. Reservoir water will be available for construction use.

C. Additives to slurry such as dispersants, plugging agents, and/or softeners may be added to the water or slurry to obtain proper workability of the slurry and efficient use of the bentonite. Additives to the slurry shall be approved by the CONSTRUCTION MANAGER prior to use.

D. Plastic Concrete:

1. The plastic concrete design mix shall have a minimum 28-day unconfined compressive strength of 400 psi and a maximum 28-day unconfined compressive strength of 600 psi, determined in accordance with ASTM D4832.
2. The 28-day hydraulic conductivity of design mix specimens isotropically consolidated to 50 psi effective stress shall not be greater than $5 \times 10^{-7}$ cm/s when determined in accordance with ASTM D5084.
3. The design mix shall have a minimum slump of 7 inches and a maximum slump of 9 inches when determined in accordance with ASTM C143 and be workable for placement by the tremie method.
4. Bentonite slurry used in the mix shall be fully hydrated prior to mixing with the cement and aggregate.

E. Cement shall be as specified in Section 03300, CAST-IN-PLACE CONCRETE. All cement shall be procured form the same mill.

F. Fly ash, if used, shall meet the requirements of ASTM C618 for Class F pozzolan including the optional requirement for reactivity with cement alkalies. Loss on ignition shall not exceed 6.0 percent. Available alkalies shall not exceed 1.5 percent.

G. Fine and coarse aggregate shall be imported from commercial sources. Aggregates shall meet the soundness requirements and limitations on deleterious substances of ASTM C33. The maximum aggregate size shall not exceed 3/4 inch. The aggregate source shall not be changed without prior written approval of the CONSTRUCTION MANAGER. The CONTRACTOR shall submit test results for aggregate gradations.

H. Dedicated stockpiles of fine and coarse aggregate sufficient for at least 100 working days of cutoff construction shall be available prior to constructing the first panel. The CONSTRUCTION MANAGER will review and approve the dedicated stockpiles.
I. Non-shrink grouting mortar for filling drill holes in the completed cutoff shall be composed of cement, water, sand, and aluminum powder. Cement shall be Type I-II portland cement in accordance with ASTM C150, and shall meet the false-set limitations specified herein.

PART 3 EXECUTION

3.1 GENERAL REQUIREMENTS

A. The work under this section shall consist of furnishing all labor, equipment, materials and supervision for constructing the concrete cutoff as shown on the Drawings and as specified herein. The concrete cutoff shall be keyed into foundation rock.

B. The selected equipment shall be capable of excavating through foundation rock to depths ranging from 50 feet to 220 feet. The CONTRACTOR shall be responsible to provide stable cutoff excavations.

C. The cutoff shall be constructed to the lines and depths along the alignment shown on the Drawings and as specified herein, unless otherwise authorized by the CONSTRUCTION MANAGER:

1. Depth:
   a. The cutoff shall extend to a minimum depth of 50 feet into rock, as determined by the drilling of the construction borings specified in Article CONSTRUCTION BORINGS. The depth of the cutoff, as shown on the Drawings, has been estimated from design borings and variation from the estimated depth is anticipated.
   b. After evaluation of the exploratory boring results, the CONSTRUCTION MANAGER will determine the cutoff depth. After the panel excavation reaches the accepted depth, the CONTRACTOR shall measure and document the cutoff depth.

2. Where panels are used the width of each panel will be determined by the excavating equipment, but shall not be less than 24 inches wide. Panel length requirements shall be as specified in Article CONSTRUCTION LAYOUT AND SEQUENCE, paragraph Panel Length.

3. The horizontal alignment shall be as shown on the Drawings and as specified herein.

D. Excavation Spoils:

1. Under no circumstances will the CONTRACTOR be allowed to stockpile material obtained in cutoff wall excavation on the 70-foot wide work platform. At all times, when an excavating machine is
operating, suitable equipment shall be present on the work platform in a position to receive and remove the excavated material for disposal. All excavated material shall be disposed of in the disposal area downstream of the East Saddle Dam as shown on the Drawings (see 01 Series). Slurry shall be disposed of by drying, mixing with dry materials, spreading in this layers in slurry disposal area, or solidified by adding cement and buried in trenches. No slurry shall be left in ponds, and all ponds shall be pumped dry and backfilled in a controlled manner. The permanent slurry waste disposal area shall be sloped to drain, blended with the surrounding topography, covered with topsoil, and seeded.

2. The CONTRACTOR shall provide a full time attendant during periods of shutdown, weekends, and holidays to monitor the levels of bentonite slurry in the excavated panels. This individual shall have the knowledge and ability to maintain the levels integrity of slurry in each panel, as specified in Section B, Panel Stability, in Article PANEL EXCAVATION.

3. The CONTRACTOR shall provide an adequate number of sturdy, easy to handle platforms to be used to bridge any pretrench excavations and excavated panels from the commencement of excavation through completion of the concrete placement. Wooden pallets are not acceptable.

3.2 DESIGN OF PLASTIC CONCRETE MIX

A. The CONTRACTOR shall determine and submit to the CONSTRUCTION MANAGER for approval the plastic concrete mix proportions. The CONTRACTOR shall conduct a plastic concrete mix design testing program to confirm that the specified requirements of the concrete have been achieved. Variations in bentonite, cement, and fly ash (if used) content shall be checked, along with a range of desirable slump. The testing program shall be submitted to CONSTRUCTION MANAGER for acceptance prior to initiation, and shall be completed 40 days prior to excavating the first panel. Testing of the plastic concrete mix shall include unconfined compression tests with modulus measurements (ASTM D4832) and triaxial hydraulic conductivity tests (ASTM D5084). Tests on aggregate shall include gradation tests (ASTM C117 and C136).

3.3 CONSTRUCTION BORINGS FOR CUTOFF WALL DEPTH DETERMINATION

A. Exploratory borings shall be drilled along the centerline alignment of the cutoff prior to cutoff construction at the locations directed by the CONSTRUCTION MANAGER.
B. In general, exploratory borings shall be vertical and shall consist of N-size or larger core drilled at 100 foot spacing. The borings shall be drilled along the alignment to a depth 25 feet deeper than the cutoff profile elevation illustrated on the Drawings, or as determined by the CONSTRUCTION MANAGER. The CONSTRUCTION MANAGER may modify the boring spacing or depth, and add borings.

C. The CONSTRUCTION MANAGER will log the borings. Core shall be stored onsite at a location designed by the CONSTRUCTION MANAGER.

D. The CONTRACTOR shall tremie backfill the construction borings with cement-bentonite grout.

E. Drilling Equipment:
   1. All equipment necessary to perform the drilling for this Project shall be provided by the CONTRACTOR. The drilling equipment must produce cased holes through the embankment and open holes in bedrock. Casing may be extended into broken and otherwise unstable rock, at the direction of the CONSTRUCTION MANAGER. Wash rotary drilling will not be permitted in the embankment. The rock must be rotary drilled with clear water such that the rock surrounding the hole is left uncontaminated.
   2. The CONTRACTOR shall furnish all temporary casing required to advance the hole. All temporary casing shall be removed by the CONTRACTOR at the completion of the boring.
   3. CONTRACTOR shall provide wooden core boxes and place core in boxes at the direction of the CONSTRUCTION MANAGER.

F. Drilling in Embankment and Soil Layers Beneath Embankment:
   1. General:
      a. The CONTRACTOR shall drill through the embankment and the soil layers beneath the embankment and into weathered bedrock by use of a hollow-stem auger. The inside diameter of the hollow-stem auger shall be of a size to allow minimum Hw (4-inch-inside diameter) size casing to be installed through the hollow-stem auger. Water not to exceed 5 gallons per 5 feet of auger advancement may be added to the drill hole to facilitate drilling embankment materials. In no case will more than 5 gallons be added for any 5-foot interval.
      b. No samples will be required from embankment drilling.
2. Casing:
   a. Temporary casing shall be installed through the embankment and loose bedrock to prevent caving and shall be tightly seated within the upper 3 feet of bedrock to prevent loss of water or contact of water with the embankment during rock drilling. Casing shall be seated at greater than 3 feet into bedrock at the direction of the CONSTRUCTION MANAGER if a tight seal cannot be accomplished within the upper 3 feet of bedrock.
   b. The temporary casing installed in cutoff wall depth determination drill holes and instrumentation holes shall be of minimum Hw size (4 inches inside diameter).
   c. The CONTRACTOR shall furnish all temporary casing required.
   d. The CONTRACTOR should anticipate possible difficult drilling in embankment foundation materials due to saturated conditions, firm to hard conditions, and the presence of gravel and cobbles.
   e. All temporary casing shall be removed by the CONTRACTOR from the drill holes at the completion of the boring.

G. Drilling in Bedrock: The CONTRACTOR shall drill rock by wash rotary methods with clear water.

3.4 BENTONITE – WATER SLURRY

A. A bentonite-water slurry shall be prepared by mixing powdered bentonite with water in a high-speed colloidal mixer that achieves complete dispersion of the bentonite particles. The bentonite slurry shall be hydrated for a minimum of 30 minutes after mixing in the colloidal mixer and shall have a minimum viscosity of 32 Marsh seconds before being introduced into the panel excavation, or added to the plastic concrete mix.

B. The CONTRACTOR shall operate a slurry plant consisting of a powder storage facility, high speed colloidal slurry mixer, fresh slurry tank or pond, desanding plant, recirculated slurry tank or pond and slurry waste tank or pond.

C. Bentonite slurry shall have the following limiting properties:

<table>
<thead>
<tr>
<th></th>
<th>Fresh</th>
<th>In Excavation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viscosity</td>
<td>32 to 40 Marsh seconds</td>
<td>32 to 45 Marsh seconds</td>
</tr>
<tr>
<td>Density</td>
<td>1.03 to 1.04 g/cm³</td>
<td>1.04 to 1.20 g/cm³</td>
</tr>
<tr>
<td>pH</td>
<td>6.5 to 10</td>
<td>6.5 to 10</td>
</tr>
</tbody>
</table>
### Fresh vs. In Excavation

<table>
<thead>
<tr>
<th></th>
<th>Fresh</th>
<th>In Excavation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filtrate Loss</td>
<td>15 to 20 ml</td>
<td>15 to 25 ml</td>
</tr>
<tr>
<td>Cake Thickness</td>
<td>1 to 3 mm</td>
<td>&lt;5 to 3 mm</td>
</tr>
</tbody>
</table>

D. The CONTRACTOR will be allowed to recirculate and reuse bentonite slurry if the quality of the reused slurry meets the requirements of Article BENTONITE – WATER SLURRY. The CONTRACTOR will not be allowed to pump the slurry directly from one panel to another without testing the slurry properties.

E. The CONTRACTOR shall be responsible for maintaining the stability of the cutoff excavation. Weighting agents may be used to increase the density of the slurry if necessary to maintain excavation stability, provided there is no degradation of the slurry filtrate properties specified in Article BENTONITE – WATER SLURRY.

F. Slurry Loss Responses: The CONTRACTOR should recognize a relatively high risk of slurry loss in pervious geologic units or the caving of the cutoff wall excavations.

1. The CONTRACTOR shall at all times have available for immediate use twice the volume of slurry being used in the largest panel(s). The largest panel volume shall be considered 470 cubic yards, provided the primary panel is 30 feet long. Therefore, if one crane is excavating a panel, at least 940 cubic yards must be available for immediate transfer to the excavated panel at any time the panel is under excavation. Two cranes excavating would require 1,880 cubic yards available for transfer, and so forth for additional cranes. The available slurry may be composed of waste or dirty slurry and used in an emergency after all the clean slurry in reserve has been transferred to the draining panel. The waste or dirty slurry available for an emergency slurry loss shall not be more than one-third of the total available for emergencies. The available slurry shall not be from any other panel which is under excavation or which is being filled with plastic concrete. The CONTRACTOR shall provide sufficient pumping capacity to pump this entire amount of slurry to the excavation within 10 minutes. The pumping shall be capable of being started immediately. It is the responsibility of the CONTRACTOR to initiate steps to slow or stop all slurry losses and to notify the CONSTRUCTION MANAGER when a response has been initiated.

2. The CONTRACTOR shall have a minimum of 30 cubic yards of sand and gravel material adjacent to each panel excavation and the equipment to deliver these materials to any panel(s) under excavation.
of these materials into the excavation shall be used to slow or stop a slurry loss.

3. An emergency slurry loss will be defined as any slurry loss which cannot adequately be controlled or stopped by the introduction of additional slurry and/or sand and gravel material as described above. The CONTRACTOR shall provide an emergency response plan that will address this condition and should consider the following:
   a. The capability of rapidly thickening or solidifying by chemical additives, cement or other approved methods, the slurry, and if necessary completely backfilling the trench with additional sand and gravel. The method should also provide for rapidly injecting the thickening or solidifying agent to the bottom of the trench.
   b. If solidification is necessary, all the slurry in the trench must be hardened within 60 minutes from the time of initial injection. If cement is used in the trench as a thickening agent, the CONTRACTOR will be required to replace all the slurry with fresh slurry prior to continuing the excavation.
   c. The successful CONTRACTOR must be able to demonstrate by documented tests, or by an onsite test prior to excavation, that this system of delivery for thickening or solidification is viable under any expected field conditions.
   d. If all responses to an uncontrolled slurry loss fail, a meeting of all interested parties shall convene to discuss possible methods to contain the slurry loss.

G. Waste bentonite slurry shall be solidified (by cement addition) and disposed at the designated slurry waste disposal site as shown on the Drawings.

3.5 CONSTRUCTION LAYOUT AND SEQUENCE

A. Panel Length: The CONTRACTOR shall lay out panel lengths, construction sequence, and panel ID numbers for approval by the CONSTRUCTION MANAGER. The maximum cutoff panel length shall be 30 feet, unless otherwise authorized by the CONSTRUCTION MANAGER.

B. The CONTRACTOR shall lay out all panels with a sequential numbering system along the cutoff alignment.

C. The CONTRACTOR shall show evidence that a compressive strength of at least 100 pounds per square inch has been achieved in panel concrete before beginning the excavation of adjacent panels. Strength shall be verified by test cylinders cast at the time of concrete placement in accordance with ASTM D4832.
3.6 TEST SECTION

A. Before proceeding with production of the concrete cutoff, the CONTRACTOR shall construct a test section. The test section shall include three panels (two primary and one secondary panel), have a minimum length of 45 feet, and shall be a part of the cutoff. The location of the test section shall be proposed by the CONTRACTOR and approved by the CONSTRUCTION MANAGER. The test section depth shall be at least 80 feet. The test section shall be constructed using the same methodology that the CONTRACTOR intends to employ for the remaining cutoff sections.

B. The CONTRACTOR shall show that the proposed methodology is appropriate by demonstrating that the quality of the completed test section is within specified limits.

C. The CONTRACTOR shall demonstrate that specified verticality can be maintained. The test section shall demonstrate that the proposed equipment can successfully excavate to required depth, and that thorough cleaning of excavation bottom and joints is performed prior to backfilling.

D. The CONTRACTOR shall demonstrate that the proposed excavation support equipment and methodology are appropriate.

E. The CONTRACTOR shall demonstrate the plastic concrete placement technique and mix meet specified requirements. The CONTRACTOR shall demonstrate that the specified minimum width and joint overlap are attained in the test section.

F. To demonstrate the quality of the cutoff test section, the CONTRACTOR shall drill verification holes in accordance with Article FIELD QUALITY CONTROL, paragraph Drilling Verification Holes in Cutoff. The test section shall contain a minimum of five verification holes. At least two of the holes shall be drilled through cutoff joints in accordance with Article FIELD QUALITY CONTROL, paragraph Drilling Verification Holes in Transverse Joints. The holes shall be backfilled in accordance with Article FIELD QUALITY CONTROL, paragraph Backfilling Verification Holes.

G. Approval of the cutoff construction methodology will depend on successful completion of the test section.

3.7 GUIDEWALLS AND CONCRETE SLABS

A. The CONTRACTOR shall design and install concrete guidewalls along the cutoff alignment. All loose or unsuitable material shall be removed from the...
guidewall trench prior to guidewall placement. The guidewalls shall be vertical to provide guidance for excavation and maintain panel verticality. The guidewalls shall be sufficient to provide support for construction equipment, pulling of stop ends (if used), installation procedures, and shall be adequate so that they will not be displaced. The guidewalls in any reach shall be constructed prior to start of excavation.

B. Guidewalls shall be left in place after completion of the cutoff. The CONTRACTOR shall submit designs showing how the guidewalls are to be married with the clay core for approval by the CONSTRUCTION MANAGER.

3.8 PANEL EXCAVATION

A. Excavation Equipment:

1. A rock mill type excavator providing the minimum cutoff wall dimensions shall be used for all concrete cutoff construction.
2. The CONTRACTOR shall provide sufficient labor and adequate numbers and types of excavation equipment. Adequate replacement parts and equipment, including required maintenance and supervisory support, shall be provided to minimize equipment downtime. If necessary, the CONTRACTOR shall provide additional equipment or other types of equipment to maintain the specified quality of work and construction schedule.
3. The selection of excavation equipment shall be the CONTRACTOR’s responsibility. The selected equipment shall be capable of excavating site soil and rock. Excavation equipment may include, but is not limited to, cable and/or hydraulic clamshells, chisels, and rockmill type cutters. In addition, for shallow portions of the cutoff, the excavation equipment may include trenching machines or other equipment, with or without the use of slurry, if approved by the CONSTRUCTION MANAGER. If the CONTRACTOR elects to use such equipment, he shall include in his submittal a description of the limitations on depth and rock hardness of the equipment and where he proposes to use the equipment. The submittal shall also include methods of cleaning the excavation, placing concrete, and joint treatment. The submittal shall include calculations which confirm stability. Cutoff construction techniques utilizing methods and equipment for mixing foundation materials with cement, or with cement and bentonite, in place in the foundation will not be allowed. Backhoes shall not be used to excavate in situ rock (rock that has not been loosened by other excavation means) for cutoff excavation.
4. The use of explosives or similar materials/methods will not be allowed.
5. A desanding and desilting plant shall be provided to remove the cuttings from the bentonite-water slurry prior to recirculation of the slurry in order to maintain the slurry density meeting the requirements of Article BENTONITE - WATER SLURRY.

B. Panel Stability:

1. Where the cutoff is constructed of panels in soil, the CONTRACTOR shall maintain a stable suspension of bentonite slurry in the excavation sufficient to maintain the stability of the excavation walls. The CONTRACTOR shall control and supervise use of the bentonite slurry continuously (24 hours each day) to maintain the excavated trench at all times for its full depth. The level of the bentonite slurry in a panel shall not be lower than 2 feet below the top of the guidewalls. Cleanup and restoration of any trench or panel failures shall be performed by the CONTRACTOR at no cost.

2. Control of slurry loss shall be the responsibility of the CONTRACTOR. The CONTRACTOR shall be responsible for following his submitted contingency plan, which shall indicate the steps to be followed in the event of slurry loss or panel excavation collapse in accordance with the requirements of Article BENTONITE – WATER SLURRY.

3. At no time shall the combined length of all open panel excavations exceed 75 linear feet. Should more than one excavation operation be performed simultaneously, a minimum horizontal separation of 100 feet of rock shall be required between each excavation operation. No additional excavation of cutoff will be permitted until sufficient concrete placement has been completed to the point where the combined length of excavated cutoff is less than 75 feet. Individual panel lengths shall be adjusted as necessary to maintain trench stability but shall not exceed 30 feet.

C. Depth: Panel depth shall be established by the CONSTRUCTION MANAGER in accordance with the requirements of Article GENERAL REQUIREMENTS. The CONTRACTOR shall provide a sounding device and shall take soundings in a manner acceptable to the CONSTRUCTION MANAGER. The sounding device shall be capable of measuring depths through slurry to an accuracy of 0.1 foot. If the sounding device is incapable or becomes incapable of making the required depth measurements to the specified degree of accuracy, it shall be removed from the project site and replaced with a device that is capable of making the required measurements to the specified degree of accuracy.
D. Verticality: The CONTRACTOR shall maintain panel verticality within one percent over the entire depth of the panel. Verticality shall be checked throughout the excavation process using a pendulum measurement, or an alternate approved method of measuring verticality compatible with the CONTRACTOR’s equipment. The method of measuring verticality shall be accepted by the CONSTRUCTION MANAGER prior to use. Prior to concreting, the entire panel shall be checked for verticality with a Koden sonic logging device (DM-602/604) both in the upstream/downstream and left/right directions. Deviation over that specified shall be corrected by special chisel or other excavation tool, panel re-excavation or replacement at no cost.

E. Joint and Panel Continuity:

1. The transverse overlap at each panel joint shall not be less than 18 inches throughout their entire length as shown on the Drawings. This continuity shall be checked by land survey in conjunction with a Koden sonic imaging profile, prior to secondary panel concreting.

2. Cutoff panel joints between primary and secondary panels shall be formed by excavating secondary panels a minimum of 6 inches into the hardened concrete of each primary panel over the entire height. If other excavation equipment is used, a joint shall be created with an end stop detail reviewed and approved by the CONSTRUCTION MANAGER. Panel joints shall be cleaned thoroughly using the excavation equipment cutter teeth or a scratcher or other approved device prior to concreting.

3. In the event of a conflict between the verticality requirement specified in Article PANEL EXCAVATION, paragraph Depth, and the joint and panel continuity requirement specified in this Article PANEL EXCAVATION, paragraph Joint and Panel Continuity, the joint and panel continuity requirement shall govern.

4. If, in the opinion of the CONSTRUCTION MANAGER, the panel overlap is unacceptable, the CONTRACTOR shall be responsible for providing a solution satisfactory to the CONSTRUCTION MANAGER. An unacceptable panel excavation is defined as an excavation which does not provide a minimum 18-inch overlap in the transverse direction between adjacent panels over the full height of the cutoff after concrete placement.

F. Horizontal Alignment: The horizontal alignment of the centerline of the cutoff shall be as shown on the Drawings plus or minus 1 foot.

G. Panel Cleaning: When the panel excavation has reached the specified depth, and within 6 hours prior to beginning of concrete placement, the bottom of each panel shall be cleaned utilizing reverse circulation pump equipment or by
an appropriately-sized airlift system. Cleaning shall be continued until all loose soil, debris, cobbles, rock fragments and contaminated slurry pockets have been removed. If the bottom cleanup equipment is not capable or becomes incapable of removing and transporting materials as stated above, it shall immediately be removed from the project site and replaced with suitable approved equipment. Bottom conditions shall be checked by sounding as specified in Article PANEL EXCAVATION, paragraph Depth.

H. Characteristics of Bentonite Slurry Just Prior to Plastic Concrete Placement:
The bentonite slurry just prior to concrete placement shall consist of a uniform mixture of bentonite in water. As much of the slurry as is necessary is to be recycled or replaced in order to meet or better the following values of the bentonite slurry immediately prior to plastic concrete backfill operations:

1. Density: The density of the slurry just prior to plastic concrete placement shall not exceed 68 pounds per cubic foot.
2. Suspended Solids: Suspended solids in the slurry shall not exceed 5 percent by volume, as measured at the top, middle, and bottom of the trench. This test is performed as outlined in API 13A.
5. The CONSTRUCTION MANAGER shall have the option of requiring the CONTRACTOR to recycle or replace the slurry prior to a backfill placement operation.

I. The CONTRACTOR shall submit a slurry plan that details methods which will maintain the slurry properties under any foreseeable conditions. Details should include a list of equipment necessary to the slurry operation, their capacities and production rates, which equipment will be considered backup, location of the following: all machinery, slurry pond(s) or tank(s), stockpiles, test trailers and slurry lines; additional details shall discuss availability of the selected bentonite powder, the monitoring system for slurry level in each trench, reserves, mixing methods, desanding, quality assurance, and quality control. The CONTRACTOR shall immediately notify the CONSTRUCTION MANAGER in the event of a slurry loss, however minor, and be prepared to initiate measures as discussed in Article BENTONITE – WATER SLURRY.

J. If the CONTRACTOR plans to operate during cold weather, the plan should include details which address the maintenance of temperatures of the slurry and backfill and any other adverse effects cold weather may cause (e.g., exposed slurry faces, freezing water in pumps and lines, etc.).
K. The CONTRACTOR shall include in the slurry plan details specifying a continuous (24 hour) monitoring system for slurry level in the trench.

3.9 CONCRETING

A. Batch Mixing:

1. The CONTRACTOR may maintain a central concrete batch plant onsite for the production of the plastic concrete mix or may supply the plastic concrete from an off site batch plant. The batch plant and truck supply shall have sufficient capacity to conduct continuous backfill placement in each panel.

2. Bentonite shall be mixed with water and allowed to hydrate for a minimum of 120 minutes after being mixed in the high-speed colloidal mixer and shall have a minimum viscosity of 32 Marsh seconds before being added to the cement and aggregate mixture. The cement and aggregate shall be mixed together before adding the fully hydrated bentonite slurry. Water may be added at the placement site to adjust placement slump, as approved by the CONSTRUCTION MANAGER.

3. Dedicated stockpiles of fine and coarse aggregate sufficient for at least 60 working days of cutoff construction shall be available prior to constructing the first panel. The CONSTRUCTION MANAGER will review and approve the dedicated stockpiles.

B. Transportation:

1. Plastic concrete shall be placed into the approved excavation within 60 minutes after final cleaning and verification of the suitability of the panel excavation to be concreted.

2. Plastic concrete shall be transported in a truck that will continue rotary agitation until placement. Sufficient trucks shall be available to conduct a continuous placement operation. The time between batching and placing plastic concrete in the cutoff panel shall not exceed 90 minutes.

C. Tremie Placement:

1. Plastic concrete shall be placed in the slurry-filled excavation by the tremie method in such a manner that the concrete displaces the slurry from the bottom. Mixing of concrete with slurry will not be permitted. The concrete shall be placed through a metal (non-aluminum) hopper and rapid-connect, leakproof tremie pipe with 10-inch minimum diameter to permit free flow of concrete. The initial placement of concrete in the tremie pipes shall proceed as rapidly as possible without
interruption to prevent the mixing of concrete and slurry. A positive concrete head shall be maintained throughout the placement. The bottom of the tremie pipe shall remain embedded in the fresh concrete at least 5 feet as it is raised. The number of tremie pipes to be used for each panel (minimum one pipe per 15 feet of panel length or fraction thereof) shall be determined from the requirement that the horizontal concrete flow distance shall not exceed 10 feet, and the concrete level shall be kept horizontal during placement operations. All tremie pipes in a given panel shall be raised simultaneously. No horizontal movement of the tremie pipe shall be permitted. The concreting of each panel shall proceed continuously to produce monolithic panel.

2. No horizontal joints will be allowed in the cutoff. If the tremie operation is interrupted for any reason, the CONTRACTOR shall excavate (under slurry) all the plastic concrete within the panel to the original depth, length and thickness of the panel excavation at no cost. The tremie placement shall then be repeated after the excavation and slurry conditions are approved by the CONSTRUCTION MANAGER.

3. The CONTRACTOR shall overbuild the cutoff above the top of the guidewalls as required to provide cutoff concrete that meets the requirements specified in Article MATERIALS. Slurry contaminated concrete should be hauled to the waste disposal area.

4. Concrete shall be removed level with the top of the guidewalls.

5. The CONTRACTOR shall protect the top of the cutoff concrete from exposure to weather and from damage until embankment fill materials are placed.

D. Handling Displaced Slurry: Displaced slurry uncontaminated by plastic concrete shall be pumped to the slurry holding pond(s). Contaminated slurry shall be disposed of as specified in Article BENTONITE - WATER SLURRY.

E. Temperature of Plastic Concrete: The provisions for temperature of concrete in Section 03300, CAST-IN-PLACE CONCRETE, shall apply to plastic concrete except that the maximum temperature shall be 85 degrees F.

3.10 FIELD QUALITY CONTROL

A. Panel Excavation:

1. The following items shall be performed by the CONTRACTOR with concurrent verification by the CONSTRUCTION MANAGER:
   a. Monitoring and logging of materials encountered during excavation. The depth of the excavation shall be sounded prior to
each verticality control check, at the top of the slightly weathered to fresh rock zone, and at the beginning and end of each shift.
b. Monitoring and recording of slurry consumption and excessive slurry loss.
c. Monitoring and recording of excavating time.
d. Checking panel verticality and horizontal alignment at panel joints throughout the excavation sequence. The CONTRACTOR shall maintain a tabulation and plot of verticality measurement for each panel and shall provide copies of this data to the CONSTRUCTION MANAGER daily.
e. Monitoring and recording verticality data and correction of any verticality deviations.
f. Monitoring of cleanliness of bottom and joint surface prior to concreting.
g. Monitoring and recording the panel length and width.

2. Properties of the bentonite slurry during excavation and prior to concreting shall be measured by the CONTRACTOR. Samples shall be taken by the CONTRACTOR in the panel excavation, at the supply hose discharge and at the slurry plant. Quality control tests, including Marsh Funnel viscosity, mud balance density, sand content, filtrate loss, and pH, all in accordance with Article REFERENCES, shall be conducted by the CONTRACTOR upon request by the CONSTRUCTION MANAGER, but not less than two times per working shift per panel excavation. Test results shall be submitted to the CONSTRUCTION MANAGER not later than 24 hours following completion of any test.

B. Pre-construction Testing of Plastic Concrete:

1. At least 40 working days prior to the first test section production mixing of the plastic concrete, and in the presence of the CONSTRUCTION MANAGER, the CONTRACTOR shall prepare samples for pre-construction testing as indicated in Article DESIGN OF PLASTIC CONCRETE MIX. The samples shall be prepared using the actual mixer to be used for plastic concrete production.

2. The CONTRACTOR shall perform slump tests of the pre-construction mix in accordance with ASTM C143.

3. The CONTRACTOR shall prepare 12 standard 6 inch diameter by 12 inch long concrete test cylinders of the pre-construction mix. The CONTRACTOR shall prepare six standard 3 inch diameter by 6 inch long molded samples for permeability testing in accordance with ASTM D5084. The cylinders shall be cured in accordance with ASTM D4832. The CONSTRUCTION MANAGER will perform compressive strength testing on two cylinders each at ages of 7, 14 and
28 days in accordance with ASTM D4832. The CONSTRUCTION MANAGER will also perform hydraulic conductivity tests on two cylinders at an age of 14 days in accordance with ASTM D5084. Quality Assurance tests may be performed by the CONSTRUCTION MANAGER. The remaining cylinders will be reserved for testing, as determined by the CONSTRUCTION MANAGER.

C. Plastic Concrete:

1. The CONTRACTOR shall provide quality control of batch plant operations. This shall include documenting quantities of materials utilized during mixing, sequence and time of mixing, time of truck loading, review of scale certification, and batching operation monitoring. Two copies of the documented results shall be provided to the CONSTRUCTION MANAGER.

2. The CONTRACTOR shall prepare one set of four standard 6 inch by 12 inch concrete compressive strength test cylinders in accordance with ASTM D4832 for each 100 cubic yards (or portion thereof) of plastic concrete placed. The cylinders shall be made at the panel being concreted and shall be cured on site for a minimum of 10 days in accordance with ASTM D4832 before being transported to the laboratory for testing. The CONTRACTOR shall perform compression testing in accordance with ASTM D4832. One cylinder shall be tested at an age of 14 days; two cylinders, at an age of 28 days; and one cylinder, at a later date selected by the CONSTRUCTION MANAGER.

3. The CONTRACTOR shall also prepare three standard 3 inch by 6 inch cylinders of plastic concrete for hydraulic conductivity tests for every 500 cubic yards of plastic concrete placed. The CONTRACTOR shall prepare the samples for hydraulic conductivity tests in accordance with ASTM D5084. The CONTRACTOR shall perform one hydraulic conductivity test for every 500 cy of plastic concrete placed in accordance with ASTM D5084.

4. The CONTRACTOR shall perform slump tests in accordance with ASTM C143 at the panel for each 50 cubic yards of plastic concrete placed.

5. The CONTRACTOR shall record the following data regarding the placement of plastic concrete for each panel and shall provide the CONSTRUCTION MANAGER with two copies of the recorded data no more than 1 workday after placement of the panel.
   a. Panel designation.
   b. Starting date and time of concrete placement.
   c. Difficulties during concrete placing, in obtaining or maintaining the seal, and times and locations where this occurs.
d. Date and ending time of concrete placement.

e. Date and ending stations, length, thickness, depth, and bottom and top elevations of each panel of the cutoff.

f. Volume of concrete placed in each panel.

g. The theoretical volume of concrete used (i.e., the volume that would have been used if the excavation dimensions were neatline dimensions).

h. Adjusted batch count of concrete placed.

i. Slurry density, viscosity and pH immediately before all concrete placement.

j. Horizontal position of tremie pipes in panels during placement of concrete.

6. Deviations in the concrete volume curve indicative of excavation collapse shall be immediately communicated to the CONSTRUCTION MANAGER during concrete placement. Significant collapses, as determined by the CONSTRUCTION MANAGER to affect cutoff wall continuity, shall necessitate stoppage of concreting, prompt re-excavation to the bottom of the cutoff excavation, and concreting to the surface.

D. Drilling Verification Holes in Cutoff:

1. Drilling of plastic concrete cutoff in place shall be by an approved standard and accepted method of wash-rotary coring which allows continuous and complete core recovery. Equipment to be furnished by the CONTRACTOR for drilling shall include all drilling equipment as approved by the CONSTRUCTION MANAGER, complete with accessories for maintaining straight holes to the required depths with a minimum of core breakage and to maximize core recovery.

2. In addition to the verification holes for the test section (see Article TEST SECTION), the CONTRACTOR shall drill one verification boring for every five production panels (minimum) at the request and direction of the CONSTRUCTION MANAGER. Borings shall be logged by the CONTRACTOR’s Registered Geotechnical Engineer or Geologist.

3. The CONTRACTOR shall drill vertical PQ-size borings through the concrete in the completed panels. The CONTRACTOR shall wait until the concrete has reached a compressive strength of at least 300 pounds per square inch before drilling. The CONTRACTOR shall drill through the full depth of the concrete cutoff and at least 5 feet into the underlying rock, at locations selected by the CONSTRUCTION MANAGER. Core recovery in these holes shall not be less than 90 percent. If the CONTRACTOR fails to achieve this percentage, the
boring shall be backfilled with cement grout in accordance with Article FIELD QUALITY CONTROL, paragraph Backfilling Verification Holes, and a replacement core hole shall be drilled as directed by the CONSTRUCTION MANAGER.

4. The CONTRACTOR shall drill vertical PQ-size core borings through joints or where primary panels join secondary panels.

5. Survey control shall be provided by the CONTRACTOR for determining elevations to the nearest 0.1 foot and stations to the nearest 1 foot for borings drilled in the cutoff.

6. If, in the opinion of the CONSTRUCTION MANAGER, a boring reveals unacceptable plastic concrete or panel joint, the CONTRACTOR shall, as soon as practical, drill as many borings as is necessary to delineate the area(s) in question. These additional borings shall be cored in accordance with these specifications. Unacceptable concrete is defined for this purpose, as concrete containing conditions that will impede or negate the design intent of the cutoff, such as voids or honeycombed concrete or weak concrete. All costs for drilling concrete to delineate areas of suspicious concrete in accordance with the above described and defined conditions shall be borne by the CONTRACTOR.

7. All borings drilled under this section shall be required to remain within the concrete cutoff throughout the total depth of each panel drilled. If a boring should exit through the side of a concrete panel, the CONTRACTOR shall immediately fill the hole in accordance with Article FIELD QUALITY CONTROL, paragraph Backfilling Verification Holes, and the CONSTRUCTION MANAGER will require the CONTRACTOR to make additional borings, as necessary, to successfully maintain the borehole within the panel. Survey control for these borings shall be required. All costs for drilling concrete in borings that exit a concrete panel before reaching the full depth shall be borne by the CONTRACTOR.

8. The CONTRACTOR shall place a watertight temporary seal in the top of each boring made under this paragraph. The seal shall bear in permanent marking the boring number assigned to that location. No other sealing or backfilling of the borings shall be done until authorized by the CONSTRUCTION MANAGER.

9. The CONSTRUCTION MANAGER reserves the right to make tests deemed necessary to verify the effectiveness of the CONTRACTOR’s construction operations and during production cutoff construction. This work will be coordinated with the CONTRACTOR so as to minimize any impact it may have on construction operations.

10. All core removed shall remain the property of the OWNER. All core shall be boxed and delivered to the CONSTRUCTION MANAGER.
The CONTRACTOR shall furnish wood core boxes for storing all cores recovered from drilling.

11. CONTRACTOR shall record on core boxes, in clear and permanent marking, the following:
   a. Verification boring number.
   b. Location of boring (i.e., panel numbers).
   c. Date of drilling.
   d. Depth and elevations from which core contained in box was recovered.
   e. Name of logger.
   f. Location of top and bottom of core marked on core box and directly on core.

E. Drilling Verification Holes in Transverse Joints: In addition to obtaining cores in the test section concrete panels, the CONTRACTOR shall drill borings at selected transverse cutoff joints, as determined by the CONSTRUCTION MANAGER. The borings shall be made in accordance with Article FIELD QUALITY CONTROL, paragraph Drilling Verification Holes in Cutoff, except that 6-inch diameter cores shall be taken in lieu of the HQ cores for panel concrete. The CONTRACTOR shall be responsible to accurately locate the panel construction joint at the top of the cutoff. The boring shall start with the joint at the center of core with a tolerance of plus or minus 1/2 inch.

F. Backfilling Verification Holes: All core holes in the cutoff shall be backfilled with cement grout using the tremie method. The CONTRACTOR shall not backfill any holes until directed by the CONSTRUCTION MANAGER. It is contemplated that the mix proportions for the non-shrink, non-expansive grouting mortar will be 1 part cement to 1-1/2 parts sand, by weight, for a fluid mortar. The water-cement ratio of the mortar shall not exceed 0.45, by weight, and the slump of the mortar shall be the lowest practicable for the space to be filled.

END OF SECTION