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Mojave Solar New Ponds Project- Segment 003

Additional submitted attachment is included below.

D. Additional testing may be performed to verify that the defect has been corrected before the Earthwork Contractor performs any additional work in the area of the deficiency.

E. The Owner or Owner's Representative will determine in-place density and moisture content by any one or combination of the following methods: ASTM D1556, D2216, D6938, or other methods selected by the Owner or Owner's Representative. The Earthwork Contractor shall cooperate with this testing work by leveling small test areas designated by the Owner or Owner's Representative. Backfilling of test areas shall be at Earthwork Contractor's sole expense. The frequency and location of testing shall be determined solely by the Owner or Owner's Representative. The Owner or Owner's Representative may test any lift of fill at any time, location, or elevation.

3.5 PROTECTION OF WORK

A. The Earthwork Contractor shall use all means necessary to protect all prior work, including all materials and work completed pursuant to other sections of the Specifications.

B. In the event of damage, the Earthwork Contractor shall immediately make all repairs and replacements necessary to the approval of the Owner or Owner's Representative at no additional cost to the Owner.

C. At the end of each day, the Earthwork Contractor shall verify that entire work area was left in a state that promotes surface drainage off and away from the area and from finished work. If threatening weather conditions are forecast, compacted surfaces shall be seal-rolled with a smooth drum roller to protect finished work.

****END OF SECTION 02200****

SECTION 02082
MANHOLES

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: The work specified in this Section consists of constructing precast concrete, cylindrical, manhole components and accessories.

B. Related Sections:
1. Cast-in-Place Concrete: Section 03400

1.2 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO):
1. AASHTO M-198, Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants.
2. AASHTO Standards as referenced throughout these Specifications.

B. American Society for Testing and Materials.
1. ASTM a 48, Specification for Gray Iron Castings.
2. ASTM A240, Specification for Heat Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels.
3. ASTM A276, Specification for Stainless and Heat-Resisting Steel Bars and Shapes.
4. ASTM A307, Specification for Carbon Steel Externally Threaded Standard Fasteners.
5. ASTM A615, Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
6. ASTM C144, Specification for Aggregate for Masonry Mortar.
7. ASTM C150, Specification for Portland cement.
8. ASTM C207, Specification for Hydrated Lime for Masonry Purposes.
9. ASTM C270, Specification for Mortar for Unit Masonry.
10. ASTM C36 l, Specification for Reinforced Concrete Low-Head Pressure Pipe.
11. ASTM C443, Specification for Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets.
12. ASTM C478, Specification for Precast Reinforced Concrete Manhole Sections.
13. ASTM C497, Standard Methods of Testing Concrete Pipe, Manhole Sections, or Tile.
14. ASTM C923, Specification for Resilient Connectors between Reinforced Concrete Manhole Structures and Pipes.

15. ASTM C990, Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants.
16. ASTM 0412; Standard Test Methods for Rubber Properties in Tension.
17. ASTM D5 l 8; Standard Test Method for Rubber Deterioration - Surface Cracking.
18. ASTM D573; Standard Test Method for Rubber - Deterioration in an Air Oven.
19. ASTM D624; Standard Test Method for Rubber Property - Tear Resistance.
20. ASTM D695, Test Method for Compressive Properties of Rigid Plastics.
21. ASTM D2000, Standard Classification System for Rubber Products in Automotive Applications.
22. ASTM D2 I 37; Standard Test Method for Rubber Property - Brittleness Point of Flexible Polymers and Coated Fabrics.
23. ASTM D2240, Test Method for Rubber Property-Durometer Hardness.
24. ASTM D3676; Standard Specification for Rubber Cellular Cushion Used for Carpet or Rug Underlay.
25. ASTM D4 l O I, Specification for Propylene Plastic Injection and Extrusion Materials.
26. ASTM F593, Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
27. ASTM F594, Specification for Stainless Steel Nuts.

1.3 Submittal's

A. Shop Drawings and Product Data: Submit manufacturer's published detail drawings, modified to suit design conditions if required, catalog cuts and Contractor prepared drawings as applicable.

B. Certificates: Submit certified records or reports of results of shop tests with such records or reports containing a sworn statement that shop tests have been made as specified.

I. Submit manufacturer's sworn certification that components and products will be manufactured in accordance with specified reference standards for components and products.

1.4 QUALITY ASSURANCE

A. Quality Control: Maintain uniform quality of products and component compatibility by using the products of one manufacturer for precast reinforced concrete manholes.

B. Certifications:

1. Obtain certificate of materials and construction compliance with ASTM C478 from the precast reinforced concrete manhole manufacturer. Submit this certificate as part of required submittals.

2. Obtain certificate of material and construction compliance with ASTM A48, Class 30 tensile strength from the manhole frame and cover manufacturer. Furnish certification that tensile test bars were from same pour as castings. Submit the certificate as part of required submittals.

1.5 DELIVERY, STORAGE AND HANDLING

A. Delivery and Handling: Transport and handle precast reinforced concrete manhole components, and other products specified herein, in a manner recommended by their respective manufacturers to prevent damage and defects.

1. Through-wall lifting holes are not permitted in manhole component construction.

B. Storage: Store precast reinforced concrete manhole components in accordance with their manufacturer's recommendations to prevent joint damage and contamination. Exercise such care in storage of other specified products as recommended by their respective manufacturers.

1.6 PROJECT/SITE CONDITIONS

1. Environmental Requirements:
2. Do not set or construct manhole bases on subgrade containing frost.
3. To improve workability of Preformed Plastic Sealing Compound during cold weather, store at temperature above 70 degrees F or artificially warm compound in a manner as recommended by manufacturer.
4. During warm weather, stiffen Preformed Plastic Sealing Compound as recommended by the manufacturer.

PART 2 PRODUCTS

2.1 BASIC MATERIALS

A. Cast-In-Place Concrete Products: As specified in Section 03400.

1. Use Class A (4000 psi) quality concrete, unless indicated otherwise on the Drawings.

B. Non-Shrink Non-Metallic Grout .

C. Waterproofed Mortar: Conforming to requirements of ASTM C270 for Type M, 2500 psi. Parts by volume include: One part cement, 1/4 part lime, and sand at not less than 2-1/4 nor more than three times the sum of the volumes of cement and lime used and of the following materials:

1. Waterproofing Agent: Medusa Waterproofing Powder by Medusa Portland Cement Co.; Hydratase by Grace Construction Materials; or Hydro lox by Chem-Master Corp. Add the Medusa product in the ratio of two pounds per bag of cement; add the other products per manufacturer's recommendations.

1. Portland cement: Conforming to ASTM C150, Type I.
2. Hydrated Lime: Conforming to ASTM C207, Type S.
3. Sand: Conforming to ASTM Cl 44.
4. Water: Clean and free from deleterious amounts of acids, alkalis, and organic materials.

D. Epoxy Bonding Compound: Provide a high-modulus, low viscosity, moisture insensitive epoxy adhesive having the following characteristics.

1. Mix Ratio: I 00 percent solids, two-component; mixed one part by volume component B to two parts by volume component A.
2. Ultimate Compressive Strength: 13,000 psi after cure at 73 degrees F. and 50 percent relative humidity determined in accordance with ASTM 0695.
3. Acceptable Manufacturers:
    a. Sika Corporation: Sikadur Hi-Mod.
    b. Euclid Chemical Company; No. 452 Epoxy System.
    c. A. C. Horn, Inc.; Epoxtite Binder. ·
    d. Or Approved Equal.

E. Manhole Steps: The Contractor is permitted the option to provide one type of manhole step in the Project as selected from the step types and designs below:

1. Aluminum Step: Aluminum Alloy AA Designation 606l-T6. Coat that portion of aluminum step being embedded in concrete with heavy bodied bituminous paint.

2. Reinforced Plastic Step: Composed of a 1/2 inch Grade 60, ASTM A6 I 5 deformed steel reinforcing bar completely encapsulated in Grade 49108, ASTM D4101 polypropylene copolymer compound, Type II.
   a. Acceptable Manufacturers:
      1) M. A. Industries, Inc., Type PS2-B.
      2) Or Approved Equal.

F. Ladder Up Safety Post: Telescoping aluminum tubular section with stainless steel spring balance mechanism.

1. Provide safety post at all ladder locations.
2. Acceptable Manufacturer:
   a. Bilco Company; Model LU-4.
   b. Or Approved Equal.

G. Manhole Frame and Cover:

1. Gray iron castings conforming to ASTM A48, Class No. 35B, designed for AASHTO Highway Loading Class H-20. Provide castings of uniform quality, free from blowholes, porosity, hard spots, shrinkage distortion or other defects. Frame and cover design and dimensions are as indicated on Drawings.
   a. Finish: Bearing surfaces machined to prevent rocking and rattling under traffic. Casting finished to meet AASHTO Specification M 306, 4.3.3. Painting, Welding, Plugging not allowed.
   b. Identification: Cast the applicable word SEWER, WATER, STORM, WASTEWATER, ELECTRIC, TELEPHONE, DRAIN, or other as indicated on Drawings or required by Engineer, integrally on cover in two-inch size raised letters.
   c. Frame Hold-down Bolts: Conforming to ASTM A307.
   d. Aluminum Inner Cover: Fabricate from aluminum alloy 606l-T6 sheet or plate to dimensions indicated on Drawings. Provide cover with vents and lift handle.
   e. 0-ring Cover Gasket: One piece 0-ring gasket factory installed in a machined rectangular or dovetail groove in the bearing surface of the cover.
      1) Gasket material of neoprene composition having good abrasion · resistance, low compression set, Type D 40 durometer hardness determined in accordance with ASTM D2240 and suited for use in sanitary sewer manholes.
      2) Gluing of gasket is not permitted.

2. Access Hatch: Access hatch shall be a WlR (single leaf) access frame and cover as manufactured by Halliday Products, Inc. of Orlando, Florida, or equal, and shall have a 1/4.-in. thick one-piece, mill finish, extruded aluminum channel frame, incorporating a continuous concrete anchor. A 1-1/2-in. drainage coupling shall be located in the front left corner of the channel frame. Door panel(s) shall be 1/4-in. aluminum diamond plate, reinforced to withstand a live load of 300 lbs. psf. Door(s) shall open to 90 degrees and automatically lock with T-316 stainless steel hold-open arm(s) with aluminum release handle(s). Door(s) shall close flush with the frame. Hinges and all fastening hardware shall be T-316 stainless steel. Unit shall lock with a noncorrosive locking bar and have a non-corrosive handle. Unit shall carry a Lifetime guarantee against defects in material and/or workmanship.

H. Watertight Manhole Frame and Cover: Gray iron castings conforming to specified requirements for Manhole Frame and Cover with the addition of cover hold-down bolts.

1. Cover Hold-down Bolts: AISI Type 316 stainless steel conforming to ASTM A276 for bolts and washers, or manufacturer's standard bronze bolts and washers.

I. Manhole Component (Section-to-Section) Seals: The Contractor is permitted the option to provide one type of manhole component seal in the Project as selected from seal types specified below, except where required otherwise on the Drawings:

1. Preformed Plastic Sealing Compound: Flexible rope gasket of butyl rubber material meeting or exceeding all requirements of ASTM C990 and AASHTO M198, extruded in rectangular or square shapes and provided in rolls on coated release paper.

a. Dimensions: Size the cross-section of rope form to provide squeeze-out of material around entire interior and exterior circumference of each manhole section joint when joint is completed.

b. Acceptable Manufacturers:

1) Concrete Sealants, Inc., ConSeal CS-I 028.

2) Press-Seal Gasket Corporation, EZ-STIK.

3) Hamilton Kent Manufacturing Company; KENT-SEAL NO. 2.

4) Continental Concrete Products, Inc., PRO-STIK.

5) Henry Company; RUB'R-NEK.

2. Rubber Compression Gasket: Of material composition conforming to ASTM C361 or ASTM C443.

J. PVC Waterstop: Provide PVC waterstop for use on pipe entering manhole base where the manhole base is of cast-in-place construction.

1. Material Composition: Gasket type waterstop composed of virgin polyvinyl chloride (PVC) material.
2. Acceptable Manufacturers:
    a. FERNCO Inc., CMA Concrete Manhole Adapter.
    b. Or Approved Equal.

K. Sleeve Type Pipe Seal: Use sleeve type pipe seal in making a core-drilled connection of piping to existing manholes or structures. Pipe seal construction as follows:

1. In general, the pipe seal shall conform to the requirements of ASTM C923 and shall incorporate a positive compression fit of the gasket to both the manhole and the pipe.
2. Acceptable Manufacturers:
    a. Press-Seal Gasket Corp.; PSX Seal.
    b. NPC Inc.; Kor-N-Seal.
    c. A-LOK Products, Inc.
    d. Or Approved Equal.

L. Modular, Mechanical Type Pipe Seal: Use modular, mechanical type pipe seal in making a core-drilled connection of piping to existing manholes or structures. Pipe seal construction as follows:

1. The seal shall consist of inter-locking synthetic rubber links shaped to continuously fill the annular space between the pipe and the wall opening.
2. The elastomeric element of the seal shall be sized and selected in accordance with the seal manufacturer's recommendations. Elastomeric element shall conform to ASTM 02000 requirements for EPDM material.
3. The hardware provided in the seal shall be as recommended by the seal manufacturer for buried service such as will exist at the project site.
4. Acceptable Manufacturers:
    a. Thunderline Corporation; Link-Seal
    b. Or equal.

M. Manhole Exterior (Infiltration Prevention) Seals: New manholes shall be sealed on the exterior using the following seals:

1. Manhole Section to Section Seals: The seals shall be a multi-layered reinforced collar type mechanical seal of material composition as specified herein:

a. Band: The band shall have an outer layer of polyethylene with an under layer of rubberized mastic that is reinforced with a woven polypropylene fabric. There shall be a peelable protective paper against the mastic which wrapper is removed when the collar is applied to the joint.

b. Straps: Within the collar two 5/8-inch wide steel straps are embedded 3/4- inch from each edge of the band. The straps are encased in sheathing to isolate them from the mastic and allow them to slip freely when tightened around the manhole joint.

c. Acceptable Manufacturer:

1) Cretex Specialty Products; MacWrap.

2) Aqua Dynamic Systems, Inc.; Infi-Shield Seal Wrap.

3) Or equal.

2. Manhole Chimney Seals: The Contractor shall have the option to use either of the following types of chimney Seals. The chimney area of the manhole is that portion between the cone (tapered) section and the cast iron manhole frame and cover, which portion is usually composed of precast concrete grade rings and mortar.

a. Banded Gland Type Seals: The seals shall be composed of flexible, pleated, high quality rubber gland with stainless steel expansion bands, and shall be designed to conform to the exterior shape of the chimney area of manholes.

1) Design: The manhole frame seals shall be contained in-place on the exterior of the manhole frame chimney area through the use of stainless steel compression bands designed to clamp the gland to form a compression seal between the rubber gland and the manhole chimney area surface.

2) Rubber Gland: A molded rubber gland of a material compound conforming to the applicable requirements of ASTM C923, with a minimum tensile strength of 1,500 psi, a maximum compression set of 18 percent, and a durometer hardness of 48 (plus/minus 5).

3) Bands: The bands shall be fabricated of 16 gauge AISI Type 304 stainless steel conforming to ASTM A240, and shall be equipped with a positive locking, worm-screw type mechanism. Screw hardware shall be AISI Type 304 stainless steel conforming to ASTM F593 and ASTM F594.

4) Acceptable Manufacturer: Cretex Specialty Products; Manhole Chimney Seal.

b. Elastomeric Band Type Seal: Composed of a .045-inch thick highly flexible EPDM (Ethylene Propylene Diene Terpolymer) compounded elastomer sheet type material, and factory fabricated into a continuous

band. The band shall be of slightly smaller dimensions than the chimney section diameter so as to fit in tension on installation.

1) Upper and lower contact seal areas on the band shall have a factory applied adhesive which is protected by a peelable wrapper. On installation the wrapper is removed and the seal areas are adhered to the manhole using the band manufacturer's companion liquid primer/adhesive.

2) Acceptable Manufacturer: AquaDynamic Systems, Inc.; Infi-Shield External Sealing Kit. ·

2.2 PRECAST REINFORCED CONCRETE MANHOLE COMPONENTS

1. Materials and Fabrication: Conforming to requirements specified in ASTM C478 except as follows:
    1. Concrete: Composition and compressive strength conforming to ASTM C478 except use Type II or Type III cement in manhole components and increase compressive strength to 4500 psi (at 28 days) in precast bases.
    2. Casting and Curing: Wet cast and steam curing process in accordance with Section 3.6.11 and 3.7.2 of AWWA C302:
    3. Manhole Steps: Factory installed in manhole components, prealigned vertically, spaced on equal centers, and located the minimum distance from ends of risers and top sections as indicated on Drawings.
    4. Manhole Component Seals: As specified previously. Manhole component joints factory formed for self-centering concrete to concrete bearing employing either a rubber compression gasket or preformed plastic sealing compound.
    5. Manhole Component Design: Designs shall conform to ASTM C478. Base, tapered and straight riser section, and top section dimensions and diameters, not consistent with ASTM C478, are as indicated on Drawings.
    6. Lifting Holes and Lugs: Through-wall lifting holes not permitted in manhole component construction. Factory-install lifting keys or lugs integrally in manhole components.

2. Precast Base and Riser Sections: Design, materials and construction as specified previously under Materials and Fabrication.
    1. Pipe Openings: Provide precast base sections with custom preformed pipe openings with integral pipe seals. Preform the pipe opening to accommodate the type of pipe and pipe opening seal required.

2. Prefabricated Pipe Opening Seals: Provide precast base sections with resilient gaskets of the types and designs which conform to the requirements specified in ASTM C923.

3. Precast Top Sections: Designs as required by the Drawings, and of materials and construction as specified herein, except additional and differing requirements as follows:
   1. Hold down Bolt Inserts: Factory cast the inserts in the top section with no fewer than two 3/4-inch threaded inserts or slotted inserts to accommodate manhole frame hold down bolts. Provide threaded inserts of three inches depth and designed for an ultimate load in tension of 12,500 pounds. Inserts factory plugged for shipping. Coordinate insert locations in the top sections to match the bolt hole locations in the manhole cover frames.
   2. Flat Slab Tops: Thickness versus diameter is as indicated on the Drawings. Tops factory formed to properly accept and support required manhole cover frame and properly formed underside to join the top section to the riser section in a matching joint.
   3. Eccentric Cone Tops: Provide precast tops of the same minimum wall thickness and with same area of circumferential steel reinforcement as riser sections.

4. Precast Grade Rings: Provide one-piece design (two-piece design not acceptable) precast concrete leveling and adjusting units of three inches or four inches thickness, and of materials and construction as specified previously under Materials and Fabrication.
   1. Provide precast grade rings with hold down bolt holes matching location of bolt holes in the cast iron manhole cover frame.
   2. The grade ring design shall provide for full bearing of the cast iron manhole cover frame.

5. Dampproofing Coating: Provide asphalt compound coating of either the solvent type or the emulsion type. However, mixtures of the two types in the Project is not permitted.
   1. Solvent Type: Brush or spray-on asphalt compound, cold-applied.
   2. Emulsion-Type: Brush or spray-on asphalt-base, clay emulsion with fibers, cold- applied.
   3. Acceptable Manufacturers:
      a. W.R. Meadows, Inc.; SEALMASTIC.
      b. Coopers Creek; Coopers Black.

c. Tnemec; 46-465.

d. Or Approved Equal.

4. Application: The coating may be either shop or field applied. Apply coating to the exterior of manhole components.

   a. Apply coating in two coats at the rate of 75 to 100 square feet per gallon per coat. Allow 24 hours drying between coats.

6. Protective Coatings: Prior to application of coatings, prepare manhole surfaces for coating in accordance with the written instructions of the coating manufacturer, including mechanical cleaning, blast cleaning or acid etching as required.

   1. Coat precast components at the factory.

   2. Exterior Surface Coating; Use one of the following:

      a. Tnemec Company, Inc., 46H-413, 20 dry mils minimum thickness.

      b. Roskote Mastic A-51 as manufactured by Royston Laboratories, Inc., Pittsburgh, Pennsylvania. Apply two coats, each coat to have a dry film thickness of 12 mils.

   3. Interior Surface Coating; Use one of the following:

      a. Tnemec Company, Inc.; 104 H. S. Epoxy, 12 to 16 mils minimum thickness.

      b. Roypex as manufactured by Royston Laboratories, Inc., Pittsburgh, Pennsylvania. Apply two coats, each coat to have a dry film thickness of 7 to 9 mils.

7. Manhole Liner: Provide corrosion resistant liner in only those manholes where so noted on the Drawings as having the liner. Liner shall meet the following requirements:

   1. Materials: Semi-rigid thermosetting polyvinyl chloride (PVC) sheet having a service life equal to PVC sewer pipe. The liner shall assure such service life under severe sewer conditions, being resistant to H2S, acids, alkalis, and salts which attach sewer systems.

   2. Design: The PVC liner sheet shall be formed to fit the manhole interior contour. The sheets shall have ribs formed in the back side with the ribs of a design to be integrally locked into the precast concrete structure.

      a. The liner shall extend sufficiently into the manhole section joint to completely cover the concrete when the sections are joined and sealed with preformed plastic sealing compounds.

      b. The liner shall have a white or light color for light reflectance.

3. Acceptable Manufacturers:
   a. A-Lock Products Inc., Dura Plate 100.
   b. Ameron, T-Lock Amerplate.
   c. Or equal.

2.3 ELECTRICAL WORK MANHOLES

A. Cast-In-Place Concrete Products: As specified in Section 03400.

B. Watertight Manhole Frame and Cover: Gray iron castings conforming to ASTM A48, Class 30, designed for AASHTO Highway Loading Class HS-20. Provide castings of uniform quality, free from blowholes, porosity, hard spots, shrinkage distortion or other defects. Frame and cover design and dimensions are as indicated on Drawings.
   1. Finish: Bearing surfaces machined to prevent rocking. Castings shot-blast cleaned and coated with asphalt paint, non-tacky drying.
   2. Identification: Cast the word [ELECTRIC] integrally on cover in 2-inch size, raised letters.
   3. Frame Hold-down Bolts: conforming to ASTM A307.
   4. Anchor Bolts: J or L shape with standard coarse thread ends, conforming to ASTM A307.
   5. Cover Hold-down Bolts: Type 316 stainless steel conforming to ASTM A276 for bolts and washers, or manufacturer's standard bronze bolts and washers.
   6. Inner Sealing Lid: Gray iron casting with steel locking bar and bronze locking screw. Provide rubber gasket of commercial grade red rubber, 75 durometer hardness, by Melrath Gasket Company.

C. Cable Racks: Fabricated of 1-1/2 x 9/16 x 3/16-inch channel steel with notched holes to receive and lock cable supporting hooks in place. Hook holes spaced 1-1/2-inches apart. Provide 5/8 x 3/4-inch mounting slots. Offset cable rack bottom for overlapping so two racks may be combined as one unit. Racks finished by hot-dipped galvanizing.

D. Pulling-In Irons: Hot-dipped galvanized steel 7/8-inch thick and designed to extend six inches from wall. Use product similar to Joslyn Catalog No. 8120, or similar by Blackburn, or equal.

E. Backwater Valve and Drain: Gray iron casting manufactured according to the Plumbing and Drainage Institute standards and having 25,000 psi minimum tensile strength in the casting.

1. Finish: Manufacturer's standard asphalt paint, non-tacky drying.
2. Acceptable Manufacturer: Catalog numbers as indicated on Drawings, Zurn Industries, Josam, or equal.

2.4 SOURCE QUALITY CONTROL

A. Tests, Inspection: As a condition of the Contract, certain materials require periodic testing according to methods referenced, or as required by the Engineer.

1. Shop Tests:
   a. Manhole component manufacturers must be equipped to, and will perform the number of tests Engineer deems necessary to establish quality of proposed manhole components.
   b. Have manufacturers furnish to the Engineer ce1tified test records or reports with sworn statement of tests made as specified.
2. Precast Reinforced Concrete Manholes: Conduct tests as specified in ASTM C478.
3. Manhole Frames and Covers: Test for AASHTO H-20 highway loading. Test one manhole cover of each design submitted for approval.
4. Engineer reserves the right to accept certified test records or reports of previously conducted tests.

PART 3 EXECUTION

3.1 EXAMINATION

A. Field Inspection: Inspect precast reinforced concrete manhole components in accordance with requirements of ASTM C478 regarding repairable defects and defects subject to rejection by the Engineer.

3.2 PREPARATION

A. Earthwork: Perform earthwork for manhole installation as specified in Section 02324 and according to the following:

1. Protection: During the earthwork operations, keep pipe and manhole interiors cleared of debris as construction progresses.

B. Waterproof Coating Touch-Up: Touch-up chipped, cracked, or abraded surfaces and finished joints with two coats of the factory applied waterproof coating material.

1. Bring coating materials for touch up and field coating to the job site in the original sealed and labeled containers of the manufacturer.

C. Protective Coating Touch-Up: Touch-up chipped, cracked, or abraded surfaces and finished joints with two coats of the factory applied protective coating material.

1. Bring coating materials for touch up and field coating to the job site in the original sealed and labeled containers of the manufacturer. The Contractor shall submit to the Engineer, immediately upon completion of the field applied coating, certification from the manufacturer indicating that the quantity of each coating purchased was sufficient to properly coat all surfaces.

3.3 MANHOLE CONSTRUCTION METHODS

A. Construction Options: The Contractor has the option to construct either cast-in-place concrete manhole bases or to provide precast concrete manhole bases, except where indicated otherwise on the Drawings.

B. Cast-In-Place Concrete Manhole Base Construction: Construct in accordance with design and dimensions indicated on Drawings. When necessary to construct wider or deeper manhole bases than indicated or specified, build such bases as required by the Engineer.

1. Form and pour concrete in accordance with requirements of Section 03400. Additional requirements as follows:

a. Vibrate poured concrete using mechanical vibrator of a type and design approved by Engineer. Use vibrators of type capable of

transmitting vibration to concrete in frequencies of not less than five thousand impulses per minute.

b. Form and pour joint monolithically in manhole base top to match joint of adjoining precast riser section. Use template as obtained from precast concrete manhole component manufacturer of manhole components used in the Project.

2. Install piping in cast-in-place manhole bases prior to pouring the concrete.

a. Apply Epoxy Bonding Compound in accordance with manufacturer's instructions to pipe at base connection prior to pouring the concrete.

b. Install PVC Waterstop on pipes entering and leaving manhole base prior to pouring concrete. Install PVC Waterstop in accordance with manufacturer's written instructions.

3. Use Class A (4000 psi) concrete as specified in Section 03300, unless indicated otherwise on Drawings.

4. Doghouse Style Base Installation: Set base as indicated on Drawings and fill pipe openings with bedding material.

5. Coat bases in accordance with the requirements for precast manhole components.

C. Precast Concrete Manhole Base Installation: Install precast base on a 6-inch deep compacted layer of Class 2 aggregate.

1. Set pipe in the Prefabricated Pipe Opening Seals so that an equal annular space is created on the interior and exterior of the wall of the manhole base section.

2. Following pipe installation through the seal, grout the annular space at the pipe connection, on both sides of the wall, to the spring line of the pipe. Finish the grout smooth and flush with face of manhole.

D. Length of Pipe Connections into Manholes: Use pipes no longer than five feet in length when connecting into manholes through Prefabricated Pipe Opening Seals.

1. For other types of pipe connections into manholes, use pipes of such length that a pipe joint is provided at the outside edge of manhole base or wall as applicable. Also use pipes no longer than 6 feet in length for first pipe joined thereto.

E. Concrete Channel Fill: Field pour and form concrete channel fill for each manhole base except in the case where precast bases are used, factory preformed channels may be provided.

1. Form inverts directly in concrete channel fill.
2. Accurately shape invert to a semi-circular bottom conforming to inside of connecting pipes, and steel trowel finish to a smooth dense surface.
3. Make changes in size and grade gradually.
4. Make changes in direction of entering piping and branches to a true curve of as large a radius as manhole size will permit.
5. In terminal manholes, install concrete channel fill with formed channel extending from downstream pipe opening directly across the base to future pipe opening on upstream side of the base.
6. Make slopes gradual outside the invert channels.
7. Use Class B (3000 psi) concrete as specified in Section 03400, unless indicated otherwise on Drawings.
8. When precast bases with preformed channels are used, fill the annular space at the pipe connections, on both sides of the wall, to assure flow through the channel and bring grout up to the spring line of the pipe.

    a. Use Non-Shrink Non-Metallic grout .

F. Manhole Wall Installation: Provide precast reinforced concrete straight riser, tapered riser and top sections necessary to construct complete manholes. Fit the different manhole components together to permit watertight jointing and true vertical alignment of manhole steps.

1. If rubber compression gaskets are used between sections, install gaskets and join sections in accordance with written instructions of manhole component manufacturer.
2. If Preformed Plastic Sealing Compound is used between sections, install sealing compound in accordance with manufacturer's recommendations, and join sections in accordance with written instructions of manhole component manufacturer.

    a. Prime joint surfaces if required by sealing compound manufacturer.

    b. If sealing compound is installed in advance of section joining, leave exposed half of two piece protective wrapper in place until just prior to section joining.

c. Use sealing compound as the sole element utilized in sealing section joints from internal and external hydrostatic pressure.

d. Arrange and pay for the sealing compound manufacturer's representative to be present for first installation of manhole sections to instruct workmen on proper installation methods of sealing compound and to be present while manhole sections are being installed.

e. Following manhole section installation, trowel sealing compound surface smooth and flush with interior face of manhole.

f. Make pipe connections into manhole walls as specified for pipes connecting into manhole bases.

G. Lifting Recess Sealing: Seal with properly designed tapered rubber plugs. Drive plugs into recesses in such manner to render them completely water and air tight. Sealing of lifting recesses with grout not permitted. ·

H. Manhole Frame and Cover Installation: Where required, make final adjustment of frame to elevation using Grade Rings. Set manhole frame and cover to conform to roadway grade and crown. Set top of manhole frame and cover 1/8-inch below finished paving elevation.

1. Precast Concrete Grade Ring: Wet, but do not saturate the grade rings immediately before laying. Pre-set grade rings to proper plane and elevation using wedges or blocks of cementitious material not exceeding the joint thickness. No more than four wedges or blocks per grade ring permitted. Incorporate wedges or blocks in fresh mortar in a manner to completely encase each. Mortar thickness not to exceed 3/4-inch maximum and 3/8-inch minimum. Crown fresh mortar to produce squeeze-out between grade rings. Tool exposed joints with appropriately shaped tool and compact mortar edge into joints. Clean off excess mortar prior to initial mortar set.

2. Cast Iron Manhole Frame and Cover Anchorage: Anchor manhole frames in place on manhole top section, or on leveling units, after installing 1/2-inch thick preformed plastic sealing compound on bearing surface of manhole frame. Remove excess sealing compound squeeze-out after manhole frame is bolted in place

a. Anchor Bolt Length: Size bolts according to the following:

1) Sufficient length to properly pass through leveling units, if any.

2) Sufficient length to engage full depth of manhole top section inserts.

3) Sufficient length to allow enough threaded end to pass through manhole frame to properly tighten nut and washer.

b. Tighten manhole frame bolts after mortar has cured.

c. Install manhole covers using the proper bolts as provided with the covers for the waterproof installations.

I. Plugging Pipe Openings: Plug pipe openings in manholes where such openings are required for future pipe connections.

1. Use masonry units and waterproofed mortar laid up to prevent deterioration.
2. Install such materials to meet exfiltration limits and to allow future removal without damage to manhole.

J. Installation of Manhole Exterior (Infiltration Prevention) Seals: In general, install Manhole Section to Section Seals and Manhole Chimney Seals in accordance with the manufacturer's installation instructions and the following:

1. Field Verification: Field verify the external measurements of the manhole sections and the manhole frame and chimney areas prior to ordering the applicable seals.
2. Preparation: Clean the manhole frame (casting) and the concrete surfaces to the extent as required by the seal manufacturer. Additionally prepare the surfaces to be free from protruding defects.
3. Specialty Installation Tools: Provide as required the specialty tools from the seals manufacturers for the installation of the two types of manhole seals."

K. Drop Manholes: Construct in accordance with Type indicated in Details on the Drawings, or bound in Project Manual. Use the same type pipe and fittings in drop connection as used in the sewer line from which drop connection is made.

L. Installing Electrical Manhole Accessories: Set cable racks and pulling-in irons in manhole construction forms prior to pouring concrete. Drilled-in and grouted anchorage for these is not acceptable.

1. Set backwater valve and drain in manhole base prior to concrete pour.
2. Provide grounding in the manhole by driving a ground rod and leaving sufficient rod length within manhole for ground wire connection. Set ground rod prior to pouring manhole base.
3. Electrical Conduit connections to manhole are as specified in Division 16 - Electrical.

3.4 INTERFACING EXISTING SEWER

A. Bypass Provisions: As work of this Section, maintain flow in the existing sewer both during construction operations and until concrete is cured, both in the case of cast-in- place work and newly formed invert channels.

1. Provide a fail-safe (and properly sized) temporary means and methods of continued wastewater system service. The means and methods are at the Contractor's discretion.
2. Do not permit ground or surface water to enter the existing wastewater sewer facilities during the construction or the bypass work.
3. Do not flush or drain water, or deposit debris from the new manhole construction, into the existing wastewater sewer facilities.

B. Constructing Manholes on Existing Sewer: Where new manholes are constructed on existing sewers, the Contractor shall have the option to construct the specified cast-in- place manhole bases or precast manhole bases. In either case, make the appropriate connection of the new and existing sewer pipe to the new manhole.

1. Where the invert difference between the new and existing sewer is two feet or more, construct a drop manhole base. No separate or additional payment will be made for the vertical feet of drop connection required.
2. Where the existing piping is damaged beyond the new manhole base as a result of work of constructing the new manhole, replace such damaged pipe with new to the first joint or to such point as agreed to by the Engineer.
3. Where precast manhole bases are used, replace the existing sewer pipe with new to the first joint outside the manhole base.
4. Where cast-in-place manhole bases are constructed, saw-cut the existing piping to be removed. Chipping or breaking pipe as a cutting method is not acceptable.
5. Following the manhole base construction, install a watertight pipe plug until debris and accumulated water have been removed from the new manhole base and the new sewer facilities have passed the specified acceptance tests.

3.5 FIELD QUALITY CONTROL

A. General Requirements: Test each manhole constructed in the Project and conduct tests in presence of, and to complete satisfaction of the Engineer. Should a manhole not satisfactorily pass testing, discontinue manhole construction in the Project until that manhole does test satisfactorily.

1. Provide tools, materials, equipment and instruments necessary to conduct the manhole testing specified herein.

a. Vacuum Testing Equipment: Use vacuum apparatus equipped with necessary piping, control valves and gauges to control air removal rate from the manhole and to monitor vacuum.

1) ·Provide an extra vacuum gauge of known accuracy to frequently check test equipment and apparatus.

2) Vacuum testing equipment and associated testing apparatus are subject to Engineer’s approval.

3) Provide seal plate with vacuum piping connections for inserting in manhole frame.

2. Prior to testing, clean manholes thoroughly and seal openings, both to the complete satisfaction of the Engineer. Seal openings using properly sized plugs.

3. Perform testing with the cast iron frames and covers installed. Include the joint between the precast manhole component and the cast iron manhole frame in the test.

4. The Contractor may elect to make a test for his own purposes prior to backfilling. However, conduct tests of the manholes for acceptance, only after the backfilling has been completed.

5. If a manhole is constructed on an existing active sanitary sewer, where sewage flow must be maintained, the test will be waived.

B. Vacuum Test Procedure: Perform vacuum testing in accordance with the testing equipment manufacturer's written instructions and the following:

1. Draw a vacuum of ten inches of mercury and close the valves.

2. Consider manhole acceptable when vacuum does not drop below nine inches of mercury for the following manhole sizes and times:

a. Four foot diameter - 60 seconds.

b. Five foot diameter - 75 seconds.

c. Six foot diameter - 90 seconds.

d. Seven foot diameter - I 05 seconds.

C. Repair and Retest: Determine source or sources of leaks in manholes failing acceptable limits.

1. Repair or replace defective materials and workmanship, as is the case, and conduct such additional Manhole Acceptance Tests and such subsequent repairs and retesting as required until manholes meet test requirements.
2. Materials and methods used to make manhole repairs shall meet with Engineer's approval prior to use.
3. Make repairs, replacements and retests at no increase in Contract Price.

****END OF SECTION 02082****

SECTION 02324
WASTEWATER FORCE MAINS

PART I GENERAL

1.1 SUMMARY

A. Section Includes: The work specified in this Section consists of constructing the piped wastewater force mains and appurtenances:

B. Related Sections:

a. Manholes: Section 02082.

1.2 REFERENCES

A. American National Standards Institute:

1. ANSI BI. I, Unified Inch Screw Threads.
2. ANSI B16.1, Cast-Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250, and 800.
3. ANSI Bl6.2I, Nonmetallic Gaskets for Pipe Flanges.
4. ANSI B18.2.1, Square and Hex Bolts and Screws, Including Askew head Bolts, Hex Cap Screws, and Lag Screws.
5. ANSI Bl 8.2.2, Square and Hex Nuts.

B. American Society for Testing and Materials.

1. ASTM A 47, Specification for Malleable Iron Castings.
2. ASTM A 48, Specification for Gray Iron Castings.
3. ASTM A 167, Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet and Strip.
4. ASTM A 183, Specification for Carbon Steel Track Bolts and Nuts.
5. ASTM A 240, Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet and Strip for Fusion-Welded Unfired Pressure Vessels.
6. ASTM A 283, Specification for Low and Intermediate Tensile Strength Carbon Steel Plates of Structural Quality.
7. ASTM A 320, Specification for Alloy Steel Bolting Materials for Low-Temperature Service.
8. ASTM A 536, Specification for Ductile Iron Castings.

9. ASTM B 62, Specification for Composition Bronze or Ounce Metal Castings.
10. ASTM B 85, Specification for Aluminum-Alloy Die Castings.
11. ASTM B 371, Specification for Copper-Zinc-Silicon Alloy Rod.
12. ASTM B 438, Specification for Copper-Base Sintered Bearings (Oil-Impregnated).
13. ASTM B 584, Specification for Copper Alloy Sand Castings for General Applications.
14. ASTM C 76, Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
15. ASTM C 923, Specification for Resilient Connectors between Reinforced Concrete Manhole Structures, Pipes and Laterals.
16. ASTM D 1248, Specification for Polyethylene Plastics Molding and Extrusion Materials.
17. ASTM D 1598, Standard Test Method for Time-to-Failure of Plastic Pipe under Constant Internal Pressure.
18. ASTM D 1599, Standard Test Method for Short-Time Hydraulic Failure Pressure of Plastic Pipe, Tubing, and Fittings.
19. ASTM D 1784, Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
20. ASTM D 2000, Standard Classification System for Rubber Products.
21. ASTM D 2241, Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe (SDR- PR).
22. ASTM D 2774, Standard Recommended Practice for Underground Installation of Thermoplastic Pressure Pipe.
23. ASTM D 2837, Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials.
24. ASTM D 3139, Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals.
25. ASTM D 3261, Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.
26. ASTM D 3350, Polyethylene Plastic Pipe and Fittings Materials, Spec. for.
27. ASTM F 714, Specification for Polyethylene (PE) Plastic Pipe (SOR-PR) Based on Outside Diameter. ·
28. ASTM F 477, Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

C. American Water Works Association:

1. ANSI/AWWA Cl 10/A21.10, American National Standard for Ductile-Iron and Gray-Iron Fittings, 3 in. Through 48 in., for Water and Other Liquids.
2. ANSI/AWWA C111/A21. L I, American National Standard for Rubber Gasket Joints for Ductile Iron Pressure Pipe and Fittings.
3. ANSI/AWWA C115/A2 l. l 5, American National Standard for Flanged Ductile- Iron Pipe With Threaded Fittings.
4. ANSI/AWWA Cl 50/A21.50, American National Standard for the Thickness Design of Ductile-Iron Pipe.
5. ANSI/AWWA Cl 51/A21.51, American National Standard for Ductile-Iron Pipe, Centrifugally Cast in Metal Molds or Sand-Lined Molds, for Water or Other Liquids.
6. ANSI/AWWA C153/A21.53, American National Standard for Ductile-Iron Compact Fittings for Water Service.
7. ANSI/AWWA C207, Standard for Steel Pipe Flanges for Waterworks Service- sizes 4 in. Through 144 in.
8. ANSI/AWWA C500, Gate Valves - 3 In. through 48 In. for Water and Other Liquids.
9. ANSI/AWWA C509, Resilient-Seated Gate Valves, 3 through 12 NPS, for Water and Sewage Systems.
10. 10. ANSI/AWWA C550, Protective Interior Coatings for Valves and Hydrants.
11. ANSI/AWWA C600, Installation of Gray and Ductile Cast-Iron Water Mains and Appurtenances.
12. ANSI/AWWA C900, Polyvinyl chloride (PVC) Pressure Pipe, 4-inch through 12-inch, for Water.

D. U.S. Commercial Standard Specification CS 226-59.

1.3 SUBMITTALS

A. Shop Drawings and Product Data: Submit completely dimensioned shop drawings, catalog cuts and such other data as required to provide complete descriptive information for the following:

1. Force Main Pipe and Fittings
2. Piping Specialties
3. Sewage Valve
4. Gate Valves
5. Air Release and Cleanout Chambers

B. Certificates: Submit certified records or reports of results of shop tests, with such records or reports containing a sworn statement that shop tests have been made as specified.
    1. Sworn certifications shall bear the seal of a Registered Professional Engineer.
    2. Provide manufacturer's sworn certification stating that the pipe will be manufactured in accordance with specified reference standards for each pipe type.

1.4 QUALITY ASSURANCE

A. Design Criteria:
    1. Use only one type and class of pipe in any continuous force main between structures, unless otherwise indicated on the Drawings.
    2. Use pipe and fittings designed to withstand imposed trench loadings and prevailing site conditions at the various locations.

B. Source Quality Control:
    1. Shop Tests: As a condition of the Contract, factory test pipe materials listed in the following table, shall have been performed. Each pipe manufacturer shall have facilities to perform listed tests. The Engineer reserves the right to require the manufacturer to perform such additional number of tests as the Engineer may deem necessary to establish the quality of the material offered for use.

MATERIAL	TEST METHOD	NUMBER OF TESTS
Ductile Iron Pipe	ANSI/AWWA C15I/A2l.51	As specified in ANSI/A WWA C151/A21.51
Polyvinyl Chloride Pipe	ASTM D2241	As specified in ASTM D2241
Polyvinyl Chloride Pipe	AWWAC900	As specified in AWWA C900
Polyethylene Pipe	ASTM D1598	As specified in ASTM D1598
Reinforced Concrete Pipe	ASTM C76 or AWWA C301	As specified in ASTM C76 or AWWA C301

2. Laboratory Tests: The Engineer reserves the right to require that laboratory tests also be conducted on materials that are shop tested. Furnish without compensation, labor, materials, and equipment necessary for collecting, packaging, and identifying representative samples of materials to be tested and the shipping of such samples to the Testing Laboratory. These laboratory tests will be paid for as provided in the Bid Form from the fund stipulated for the purpose.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Transport, handle and store pipe materials and precast reinforced concrete manhole components and the associated materials specified herein, in a manner recommended by the respective manufacturers to prevent damage and defects.

1.6 SITE CONDITIONS

A. Environmental Requirements:

1. Keep trenches dewatered until pipe joints have been made and concrete cradle and encasement, if any, have cured.
2. Under no circumstances lay pipe in water or on bedding containing frost.
3. Do not lay pipe when weather conditions are unsuitable for pipe laying work, as determined by the Engineer.

PART 2 PRODUCTS

2.1 PIPE AND FITTINGS

A. Elastomeric Gaskets: For pipe joint gasket material, provide elastomeric gaskets that have been tested as suitable for continuous contact with domestic sewage.

B. Ductile Iron Pipe (DIP): Conforming to ANSI/AWWA Cl 50/A21.50 and ANSI/AWWA Cl 5 J/A21.51 requirements for 350 psi working pressure (to 20 inch diameter).

1. Wall Thickness Class, Buried Pipe: As indicated on Drawings.
2. Wall Thickness Class, Exposed Pipe: Class 53 except as noted otherwise on Drawings.
3. Fittings: Gray iron or ductile iron conforming to ANSI/AWWA C11O/A2 l.10 requirements, rated for 250 psi working pressure.
4. Rubber-Gasket Joints, Buried Pipe: Conforming to ANSI/AWWA Cl l l/A2 l. l l requirements.
    a. For buried pipe installation, provide either push-on or mechanical joints except where other types of joints are indicated on the Drawings or required by the Specifications.
    b. For buried pipe installation, provide mechanical joints except where other types of joints are indicated on the Drawings or required by the Specifications.
    c. For buried pipe installation, provide push-on joints except where other types of joints are indicated on the Drawings or required by the Specifications.
5. Restrained Joints: Conforming to requirements of ANSI/AWWA Cl l l/A2 l. l l and designed for a working pressure equal to connected pipe rating. Provide joints for pipe and fittings similar to the following:
    a. American Cast Iron Pipe Company; Lok-Fast or Lok-Set.
    b. Clow Corporation; Super-Lock.
    c. United States Pipe and Foundry Company; TRFLEX.
    d. EBAA Iron; Meg-a-lug.
    e. Or equal.
6. Flanged Joints, Exposed Pipe: Conforming to ANSI/A WWA Cl l 5/A21. I 5 requirements. Unless indicated otherwise on the Drawings, use flanged joints for pipe and fittings installed inside of structures.

a. Gaskets: 1/16 in. thick cloth insertion rubber full face type conforming to ANS] B16.21 requirements.

b. Bolts: Conforming to ANSI B18.2.l requirements.

c. Nuts: Conforming to ANS] B18.2.2 requirements.

7. Retainer Glands: Designed for pipe joint retaining through the use of a follower gland and set screw anchoring devices which impart multiple wedging action against the pipe. The mechanical joint restraint device shall have a working pressure of at least 250 psi with a minimum safety factor of two to one. Material components as follows:

   a. Gland: Manufactured of ductile iron conforming to ASTM A536 requirements. Gland dimensions shall match ANSI/AWWA Cl l l/A21.l l and ANSI/AWWA Cl53/A21.53.

   b. Restraining Devices: Manufactured of ductile iron heat treated to a minimum hardness of 370 BHN. Restraining devices shall incorporate a set screw/twist off nut bolt to insure the proper actuating of the restraining device. The twist off nut shall be designed to come off at the torque limit desired to anchor the restraining device in place on the pipe.

   c. Joint Deflection: Retainer Gland joint deflection shall be limited to a two degree maximum. Joint deflection shall be applied before the set screws are torqued.

   d. Acceptable Manufacturers:

      1) EBAA Iron, Inc.; Megalug 1100 Series.

      2) Or equal.

8. Pipe and Fitting Lining: Manufacturer's standard cement-mortar lining in accordance with ANSI/AWWA CI 04/A21.4, single thickness. Lining shall include an asphaltic seal coat to prevent moisture loss in cement-mortar curing sequence.

9. Pipe and Fitting Coating: Manufacturer's standard asphaltic coating, approximately one mil thick in accordance with ANSI/AWWA Cl 51/A21.51, applied to the outside of pipe and fittings.

10. Pipe and Fittings Coating (Special Coating): Factory coated inside and out with 46H-4 l 3 Hi-Build Tneme-Tar by Tnemec Company, Inc., or equal. Prepare pipe surfaces according to coating manufacturer's instructions and apply coating 18 to 20 mils minimum dry mil thickness.

C. Flanged Adapters: Fabricated from high strength steel (Style 128), or cast iron (Style 127), and designed for joining DIP plain-end pipe to flanged fittings, valves, and flanged end equipment.

1. The compression-end of the adapter shall have the Dresser-Coupling type pack utilizing a Grade 2_7 wedge gasket for positive, watertight sealing. The flanged- end shall match the flange of the proposed fitting, valve or equipment connection.
2. Acceptable Manufacturers:
    a. Dresser Manufacturing Division of Dresser Industries, Inc.; Dresser Style 128 and 127.
    b. Rockwell-International.
    c. R.H. Baker & Co., Inc.
    d. Or equal.

D. Polyvinyl Chloride (PVC), 4 Through 8 Inch Diameter Pipe: Provide pipe which is permanently marked with manufacturer's trademark, size and AWWA conformance designation. Pipe design and material requirements shall conform to AWWA C900 requirements for DR 18, 150 psi pressure class.
    1. PVC Pipe Joints: Push-on or compression type, rubber gasket, conforming to ASTM 03139 and ASTM F477 requirements.
    2. Fittings: Gray iron or ductile iron conforming to ANSI/AWWA C110/ A21.I 0 requirements, rated for 250 psi working pressure.
        a. Fitting Joints: Rubber-gasket push-on or mechanical type conforming to ANSI/AWWA C1 11/A21. L 1 requirements.
        b. Fitting Coating: Manufacturer's standard asphaltic coating, approximately one mil thick in accordance with ANSI/AWWA Cl 5 l/A21.5).
    3. Retainers for PVC Pipe: Manufactured from 60-42-10 ductile iron conforming to ASTM A536 requirements, including the glands and tie bolts. The retainers shall have a sufficient number of tie bolts to restrain the working and test pressures established by the retainer manufacturer.
        a. The glands shall have serrations on the inside diameter sufficient to hold against both the working and test pressures.
        b. Acceptable Manufacturer: EBAA Iron Sales, Inc. or equal.
    4. Restraints for PVC fittings: Manufactured from 60-42-10 ductile iron conforming to ASTM A536 requirements, including the bell ring, restraint ring and tie bolts.
        a. A split ring shall be utilized behind the bell of the fitting outlets. A serrated ring shall be used to grip the pipe and a sufficient number of bolts shall connect the bell ring and the serrated gripping ring. The combination shall restrain continuously against a working pressure rating of 150 psi. .

b. Acceptable Manufacturer:

1) EBAA Iron Sales, Inc.

2) Or equal.

E. Polyvinyl Chloride (PVC) 1 1/2, Through 3 Inch Diameter Pipe: Provide pipe which is permanently marked with manufacturer's trademark, size and ASTM conformance designation. Pipe design and material requirements shall conform to ASTM 02241, SDR-21 for200 psi pressure. PVC material shall conform to ASTM 01784 requirements for Cell Classification 12454B.

1. Pipe Joints: Push-on or compression type, rubber gasket, conforming to ASTM 03139 and ASTM F477 requirements; rubber gasket that have been tested as suitable for continuous contact with domestic sewage.
2. Pipe Fittings: Manufactured in one piece of injection molded PVC compound meeting ASTM D1784 requirements.

a. Fittings shall be Class 200 and conform to requirements of DR 21.

b. Fittings shall withstand a minimum of 630 psi quick burst pressure at 73 degrees F. when tested in accordance with ASTM D1599 requirements.

c. Bells shall be gasketed joint conforming to ASTM 03139 with gaskets conforming to ASTM F477 requirements.

d. Acceptable Manufacturer: The Harrington Corporation or equal.

3. Retainers for PVC Pipe: Manufactured from 60-42-10 ductile iron conforming to ASTM A536 requirements, including the glands and tie bolts. The retainers shall have a sufficient number of tie bolts to restrain the working and test pressures established by the retainer manufacturer.

a. The glands shall have serrations on the inside diameter sufficient to hold against both the working and test pressures.

b. Acceptable Manufacturer:

1) EBAA Iron Sales, Inc.

2) Or equal.

4. Restraints for PVC fittings: Manufactured from 60-42-10 ductile iron conforming to ASTM A536 requirements, including the bell ring, restraint ring and tie bolts.

a. A split ring shall be utilized behind the bell of the fitting outlets. A serrated ring shall be used to grip the pipe and a sufficient number of bolts shall connect the bell ring and the serrated gripping ring. The combination shall restrain continuously against a working pressure rating of 150 psi.

b. Acceptable Manufacturer:

1) EBAA Iron Sales, Inc.

2) Or equal.

F. Polyethylene (PE) Pipe and Fittings: Provide pipe which is permanently marked with manufacturer's trademark, size and ASTM conformance designation.

1. Pipe Design: Conforming to ASTM F714 for DR 11 performance requirements.

2. Pipe Construction: The polyethylene material shall have a PE 3408 designation and shall conform to ASTM D1248 requirements for a Type Ill, Class C Category 5, and Grade P34 material. Pipe material shall also have a cell classification of 345434C as defined in ASTM 03350, and have a hydrostatic design value basis of1600 psi when tested in accordance with ASTM 02837.

3. Fittings: Molded from polyethylene compound equal to the compound used in the PE pipe construction. Fabricated fittings shall conform to ASTM 03261, SOR 17 requirements and shall be pressure rated to match the system piping in which they are installed.

4. Joining: Both pipe and fittings joined to one another by thermal butt fusion, saddle fusion, or socket fusion in accordance with procedures developed by the pipe manufacturer.

5. Flanged Joints: PE pipe and fittings joined to other materials by means of flanged connections composed of PE flange (fusion joined to pipe) and type 316 stainless steel back-up rings rated for the same pressure service as the pipe.

2.2 PIPING SPECIALTIES

A. PVC Waterstop: Use PVC waterstop in making a grouted connection of piping to existing manholes or structures. Waterstop construction as follows:

1. Gasket type waterstop composed of virgin polyvinyl chloride (PVC) material which meets the performance requirements of U.S. Commercial Standard Specification CS 226-59.

2. Acceptable Manufacturers:

a. FERNCO Inc., CMA Concrete Manhole Adapter, Distributed by the General Engineering Company.

b. Or equal.

B. Sleeve Type Pipe Seal: Use sleeve type pipe seal in making a core-drilled connection of piping to existing manholes or structures. Pipe seal construction as follows:

1. In general, the pipe seal shall conform to the requirements of ASTM C923 and shall incorporate a positive compression fit of the gasket to both the manhole and the pipe.
2. Acceptable Manufacturers:
    a. Press-Seal Gasket Corp., Concrete Products Supply Co.; PSX Seal.
    b. Or equal.

C. Modular, Mechanical Type Pipe Seal: Use modular, mechanical type pipe seal in making a core-drilled connection of piping to existing manholes or structures. Pipe seal construction as follows:
1. The seal shall consist of inter-locking synthetic rubber links shaped to continuously fill the annular space between the pipe and the wall opening.
2. The elastomeric element of the seal shall be sized and selected in accordance with the seal manufacturer's recommendations. Elastomeric element shall conform to ASTM 02000 requirements for EPDM material.
3. The hardware provided in the seal shall be as recommended by the seal manufacturer for buried service such as will exist at the project site.
4. Acceptable Manufacturers:
    a. Thunderline Corporation; Link-Seal.
    b. Or equal.

D. Wall Sleeves: Cast gray iron or ductile iron conforming to ANSI/AWWA CJ I 0/A21.10 requirements, rated for 250 psi working pressure, and provided with intermediate anchoring flange in center of sleeve.
1. Joints: Joint requirements shall match that of the connected piping except where indicated otherwise on the Drawings.
2. Acceptable Manufacturers:
    a. McWane Incorporated
    b. American Cast Iron Pipe Co.
    c. U.S. Pipe and Foundry Co.
    d. Or equal.

E. Flexible Pipe Coupling: Coupling shall consist of a steel middle ring or sleeve, two steel or malleable iron flange or follower rings, two wedge shaped resilient gaskets and sufficient number of track-head bolts and nuts.
1. Middle Ring or Sleeve: Steel construction conforming to ASTM A283, (Grade A) requirements, fabricated in a true circular section and free of surface defect.

2. Follower Rings or Flanges: Steel construction conforming to ASTM A47 (Grade 32510) requirements, fabricated in a true circular section and free of surface defect, and tested and sized after welding by cold expanding a minimum of one percent.
3. Bolts and Nuts: Steel bolt conforming to ASTM Al83 requirements, double radius head or buttonhead track type with rolled threads, conforming to ANSI B1.1 requirements; and steel nuts conforming to ANSI B 18.2.2 requirements, American Standard Heavy Dimension Series.
4. Gaskets: Resilient wedge-shaped of synthetic base compound designed for raw sewage and sludge service.
5. Shop Paint: Middle and follower rings shop painted with primer compatible with specified field coat for piping where coupling is located.
6. Acceptable Manufacturers:
    a. Dresser Manufacturing Division of Dresser Industries, Inc.; Dresser Style 38 or 138.
    b. Rockwell-International.
    c. R.H. Baker & Co., Inc.
    d. Or equal.

F. Repair Clamp: Single band full circle style repair clamp constructed of materials specified in the following:
    1. Lugs: Malleable cast iron conforming to ASTM A47 (Grade 325 I 0) requirements, or ductile cast iron conforming to ASTM A536 (Grade 60-40-18) requirements and designed with mutually supporting sliding fingers.
    2. Band: One piece stainless steel type 304, with bridge plate recessed flush and bonded into the gasket.
    3. Gasket: Specially compounded new rubber material suitable for use with salt solutions, mild acids, and bases as well as domestic sewage contact. Gasket designed to overlap and shall have a fine grid molded integrally and tapered ends.
    4. Hardware: Manufacturer's standard corrosion resistant malleable iron bolts and nuts conforming to ANSI/AWWA C111/A21.1 I standards.

5. Acceptable Manufacturers:

    a. Dresser Manufacturing Division of Dresser Industries, Inc.; Style 360.

    b. Rockwell International.

    c. Or equal.

G. Stainless Steel Pipe Supports: Fabricate pipe supports and pipe straps for exposed piping using Type 304 stainless steel conforming to ASTM A167. Individual pipe support and pipe strap designs are as indicated on the Drawings.

1. Anchors and Fasteners: Provide drilled-in type expansion anchors incorporating a one-piece stud (bolt) with integral expansion wedges, nut and washer as a UL Listed assembly and meeting physical requirements of Federal Specification FF- S-325, Group II, Type 4, Class 1. Stud of Type 303 or 304 stainless and nut and washer of Type 316 stainless.
2. Standard Bolts, Nuts and Washers: Type 304 stainless steel conforming to ASTM A320.

H. Cast-In-Place Concrete Products: As specified in Section 03300.

1. Use H.E.S. concrete materials unless indicated otherwise on the Drawings.

2.3 VALVES

A. Sewage Air Release Valve: Valve design shall automatically release air, gas or vapor under pressure during system operation. Valve design shall feature long body and float stem components so that the operating mechanism is kept free from contact with sewage during operation. Valve construction as follows:

1. Valve Body and Cover: Cast iron, conforming to ASTM A48, Class 35 requirements.
2. Inlet Size: 2-inches, NPT.
3. Outlet Size: 1/2-inch, NPT.
4. Maximum Working Pressure: 75 psi.
5. Vent Orifice: 5/16-inch.
6. Discharge Orifice Seat, Mechanism and Valve Stem: Stainless Steel.

7. Orifice Button: Stainless steel and Buna-N, Nitrile Rubber.
8. Mechanism Lever Pins and Float: High strength stainless steel, conforming to ASTM A240 requirements.
9. Backflushing and Cleaning Accessories: Factory assembled to the valve and consisting of a 2-inch shut-off valve at bottom inlet, an 1 -inch blow-off valve near the bottom of the valve body, quick disconnect couplings and Y,-inch shut-off valve at top of valve, and a section of rubber hose with quick disconnect coupling.
10. Acceptable Manufacturers:
    a. Val-Matic Valve and Manufacturing Corp.; Model No. 48 Series.
    b. Or equal.

B. Sewage Air and Vacuum Valve: Valve design shall automatically exhaust large quantities of air during the filling of a system and shall allow air to re-enter the system during draining or when a vacuum occurs. Valve design shall feature long body and float stem components so that the operating mechanism is kept free from contact with sewage during operation. Valve construction as follows:
    1. Valve Body and Cover: Cast iron, conforming to ASTM A48, Class 35 requirements.
    2. Inlet Size: 2-inches.
    3. Discharge Orifice: 2-inches.
    4. Float Stem and Guide: Bronze, conforming to ASTM B584 requirements.
    5. Floats: Stainless Steel, conforming to ASTM A240 requirements.
    6. Orifice Seat: Buna-N, Nitrile Rubber.
    7. Backflushing and Cleaning Accessories: Factory assembled to the valve and consisting of an inlet shut-off valve, a I-inch blow-off valve near the bottom of the valve body, quick disconnect couplings and a Vi-inch shut-off valve at the top of valve, and a section of rubber hose with quick disconnect coupling.
    8. Acceptable Manufacturers:
        a. Val-Matic Valve and Manufacturing Corp.; Model No. 300 Series.
        b. Or equal.

C. Sewage Combination Air Valves: Consisting of an air release valve and an air and vacuum valve factory piped into a compact assembly. The combination assembly shall automatically release air, gas or vapor under system operating pressure and shall also allow air to re-enter the system during draining or when a vacuum

occurs. Combination valve designs shall feature long bodies and float stem components so that the operating mechanisms are kept free from contact with sewage during operation. Valve construction as follows:

1. Valve Bodies and Covers: Cast iron, conforming to ASTM A48, Class 35 requirements.
2. Inlet Sizes: 2-inches.
3. Air Release Outlet Size: 1/2-inch, NPT.
4. Vacuum Discharge/Outlet Size: 2-inches.
5. Air Release Valve Maximum Working Pressure: 75 psi.
6. Air Release Valve Vent Orifice: 5/16-inch.
7. Air Release Valve Discharge Orifice Seat, Mechanism and Valve Stem: Stainless steel.
8. Air Release Valve Orifice Button: Stainless Steel and Buna-N, Nitrile Rubber conforming to ASTM SB800 requirements.
9. Air Release Valve Mechanism Lever Pins and Float: High strength stainless steel, conforming to ASTM A240 requirements.
10. I 0. Air and Vacuum Valve Float Stem and Guide: Bronze, conforming to ASTM B584 requirements.
11. Air and Vacuum Valve Floats: Stainless Steel, conforming to ASTM A240 requirements.
12. Air and Vacuum Valve Orifice Seat: Buna-N, Nitrile Rubber.
13. Backflushing and Cleaning Accessories: Factory assembled to the combination valves and consisting of two inlet shut-off valves, two blow-off valves, two clear water inlet valves, section of rubber hose and quick disconnect couplings.
14. Acceptable Manufacturers:
    a. Val-Matic Valve and Manufacturing Corp.; Model No. 48 or 49/300 Series.
    b. Or equal.

D. Hose End Gate Valve: Class 125 bronze gate valve having screw-in bonnet, non--rising stem, tapered solid wedge, and rated 200 psi non-shock cold water, oil or gas. Valve body shall indicate ratings and manufacturer identification. Design of valve stuffing box of such that repacking under pressure is possible. Valve construction requirements as follows:

1. Ends: Female standard pipe size to national standard hose.

2. Handwheel: Aluminum alloy conforming to ASTM B85 requirements, with zinc plated steel nut and aluminum identification plate (opening direction indicated).
3. Valve Stem: Silicon bronze alloy conforming to ASTM B371 requirements.
4. Packing Nut/Packing Gland: Sintered bronze conforming to ASTM B438 Grade I Type II requirements.
5. Packing: TFE impregnated asbestos.
6. Stuffing Box, Bonnet, Valve Body, Wedge and Hose Cap: Bronze conforming to ASTM B62 requirements.
7. Hose Cap Gasket: Rubber.
8. Safety Chain: Brass.
9. Acceptable Manufacturers:
    a. NJBCO, Inc.; Cat. No. T-113-HC.
    b. Crane Company.
    c. Wm. Powell Company.
    d. Or equal.

E. Iron Body Gate Valve: Designed for working water pressure of200 psi for valves 12- inch in diameter and smaller. Valve construction requirements as follows:
    1. General Requirements:
        a. Markings factory cast on the bonnet or body of each valve indicating manufacturer's name or mark, year of valve casting, size of valve, directional flow arrow and designation of working water pressure.
        b. Valves shall open to the left (counterclockwise). Valves operated by nut, handwheel, or otherwise as indicated on the Drawings. Operating nuts or wheels shall have cast thereon an arrow indicating the direction of opening.
        c. Valve ends as indicated on the Drawings and unless indicated otherwise shall conform to the following:
            1) Flanged: Conforming to ANSI B16.1 requirements.
            2) Mechanical: Conforming to ANSI/AWWA Cl 1 l/A2 l. l 1 requirements.
        d. Valves of rising stem type except when installed underground; or otherwise indicated on Drawings.

e. Valve stuffing box of such design that valve can be packed under pressure when in fully open position.

2. Design Working Water Pressure: 200 psi for valves 12 inches diameter and smaller, and 150 psi (high pressure) for valves 14 inches diameters and larger.

3. Valves 3-inches through 12-inches in Diameter: lron body, outside screw and yoke design, bronze mounted, with resilient-seated wedge conforming to requirements of AWWA C509.

   a. Resilient Seat: Composed of SBR or Urethane Rubber bonded to cast iron wedge.

   b. Stem Seals: 0-ring type.

   c. Finish Coatings: Exterior asphalt varnish or epoxy coated and interior ferrous metal parts epoxy coated, according to AWWA C550.

4. Acceptable Manufacturers:

   a. Clow Corporation.

   b. American Darling Valve.]

   c. Kennedy Valve.

   d. Or equal.

F. Tapping Valve: Provide valve of same basic construction as Iron Body Gate Valve with exceptions as follows:

1. Valve provided with oversized seat rings to accommodate tapping machine.

2. Valve provided with raised male face on flanged end for bolting to tapping sleeve.

3. Valve provided with flanged joint with slotted holes for bolting to tapping machine.

G. Tapping Sleeve: Provide 18-inch size, AWWA approved construction; split type sleeve, designed for 250 psi working pressure.

1. Body: Carbon steel conforming to ASTM A283, Grade C.

2. Flanges: AWWA C207 Class D; ANSI 150 pound drilling.

3. Gasket: Grade 60 Concave Wedge Gasket; gasket compounded to resist oil, natural gas, acids, alkalies, most (aliphatic) hydrocarbon fluids, water and many chemicals. Designed for operating temperatures up to 2123 degrees F.

4. Bolts and Nuts: ANSI/AWWA Cl I l/A2 l.l I, Type 304 stainless steel.
5. Finish: Manufacturer's standard fusion bonded epoxy, coated to 12 mills dry film thickness.
6. Acceptable Manufacturers:
    a. Rockwell International.
    b. Or equal.

H. Valve Boxes: Cast iron extension roadway type, three-piece construction, and of screw adjustment design.
1. Boxes shall have 4 1/4-inch minimum shaft diameter and cover marked SEWER.
2. Boxes hot coated inside and out with a tar or asphalt compound.
3. Box design shall be capable of receiving increment cast iron rings to raise the box in the future.

I. Inserting Valve: Inserting (control) valves, and the materials, machines, and related equipment necessary to insert control gate valves in fluid pipe lines while under pressure.

J. Inserting Valves: Double disc parallel seat type employing a compound side wedging mechanism and shall meet all requirements of the AWWA C500 Gate Valve Specification, and latest revisions thereto.
1. Manufacturer's Field Supervisor: Inserting valves shall require the services of the valve manufacturer's field supervisor. His services are a chargeable amount which charges will not be paid for separately or additionally to the Contract Price. Such charges will be considered incidental to the Work.
2. Acceptable Manufacturers:
    c. United States Pipe and Foundry Company; SMITH INSERTING VALVES.
    d. IPSCO.
    e. Kerr Engineering Service.
    f. Or equal.

2.4 PRECAST CONCRETE CHAMBERS

A. Air Release and Cleanout Chambers: As specified in Section 02082 for precast concrete manhole components.

1. Sump Frame and Grate: Light duty cast iron construction, conforming to ASTM A48 requirements.

2.5 CONTRACTOR OPTIONS IN PRODUCTS

A. Force Main Pipe and Fitting Options: The Contractor is allowed the option to provide DIP or PVC pipe to construct the force mains for the Project. However, the Bidder shall state in writing in the space provided in the Bid Form which particular type of pipe is proposed. Use only the type of pipe selected to construct the force mains for which the pipe material option is allowed.

1. Through 3 inch diameter:

a. Ductile Iron Pipe.

b. Polyvinyl Chloride Pipe.

c. High Density Polyethylene Pipe.

2. 4 inch through 8 inch diameter:

a. High Density Polyethylene Pipe.

b. Polyvinyl Chloride Pipe.

c. High Density Polyethylene Pipe.

B. Required Pipe Material Exception: Provide only ductile iron pipe and ductile iron or cast iron fittings within the air release and cleanout chambers.

C. Thrust Restraint Option: The option is allowed to provide concrete thrust blocks or restrained joints at changes of directions of pipe.

PART 3 EXECUTION

3.1 EXAMINATION

A. Field Inspection: Inspect each section of pipe and each pipe fitting before laying in conformance with the inspection requirements of the appropriate referenced standard.

B. Rejected Products: Remove rejected Products from the Project site and replace with new Products at no increase in Contract Price.

1. Pipe already laid and later found defective will not be accepted and shall require replacement at no increase in Contract Price.

3.2 PREPARATION

A. General Requirements: Clean piping interior prior to laying pipe and following pipe laying, and keep open ends of piping and pipe attachment openings capped or plugged until actual connection or actual pipe testing.

1. Provide the protective means to prevent water and debris from washing into the pipe.

B. Earthwork: Perform earthwork for force main installation as specified in Section 02324.

1. Bedding materials and concrete work for pipe bedding as specified in Section 02324.
2. Excavate trenches in rock at least 25-feet in advance of pipe laying. Protect pipe ends from rock removal operations.

3.3 CONSTRUCTION

A. General Requirements: Use proper and suitable tools and appliances for the proper and safe handling, lowering into trench and laying of pipes.

1. Lay pipe proceeding upgrade true to line and grades given. Lay bell and spigot pipe with bell end upgrade. No wedging or blocking permitted in laying pipe unless by written order of Engineer.
2. Unless indicated otherwise, piping shall be installed with not less than four feet of cover.
3. Exercise care to insure that each length abuts against the next in such manner that no shoulder or unevenness of any kind occurs along inside bottom half of pipe line.
4. Before joints are made, bed each section of pipe full length of barrel with recesses excavated so pipe invert forms continuous grade with invert of pipe previously laid. Do not bring succeeding pipe into position until the preceding length is embedded and securely in place. Dig bell holes sufficiently large to permit proper joint making and to insure pipe is firmly bedded full length of its barrel.

5. Walking or working on the installed force main, except as necessary in tamping and backfilling, not permitted until trench is backfilled one-foot deep over top of pipes.
6. Take up and relay pipe that is out of alignment or grade, or pipe having disturbed joints after laying.
7. Concrete Thrust Blocks: Provide concrete thrust blocks for each fitting, and at those locations where horizontal and vertical deflections are made in the joints of the force mains. Use H.E.S. concrete materials. Provide thrust blocks of the design indicated on the Detail Drawing.

B. Pipe Laying and Joining: Perform pipe laying and joining in strict accordance with manufacturer's installation instructions, reference standards as included, and such additional requirements as specified herein.

1. Arrange and pay for pipe manufacturer's representative to be present for first installation of pipe to instruct workmen on proper installation methods. ·
2. Make joints absolutely watertight and immediately repair detected leaks and defects. Methods of repair subject to Engineer's approval.
3. Laying/Joining Ductile Iron Pipe: Installation and joint assembly according to AWWA C600, and as follows:
    a. Pipe Cutting: Where necessary to field cut pipe use approved pipe cutter, milling cutter or abrasive wheel saw.
    b. Push-on Joints: To make ductile cast iron pipe push-on joints, properly seat sealing gasket, evenly and sufficiently lubricate the spigot end of pipe, and fully enter joint until joint line is visible. Make deflection, if required, only after the joint has been assembled properly.
    c. Mechanical Joints: To make ductile iron pipe mechanical joint, position sealing gasket and gland for bolting and then enter the spigot into pipe bell end until joint line is visible. Tighten bolts evenly maintaining approximate distance between gland and face of flange at all points around the socket. Do not exceed pipe manufacturer's specifications for maximum torque applied to bolts.
    d. Flanged Joints: For DIP shall be faced true, fitted with gaskets, and drawn up square and tight to ensure full gasket flow and satisfactory seal.
4. Joint Restraints: Install on buried DIP at changes in direction of pipe runs, and at terminal ends of pipe runs in accordance with the following table:

DUCTILE IRON PIPE RESTRAINED JOINT DIMENSIONS (In feet of straight pipe for each leg)				
Fitting Type	4 Inch Diameter Pipe	6 Inch Diameter Pipe	8 Inch Diameter Pipe	> 10 Inch Diameter Pipe
Plug	25	25	25	25
Tee	25	25	25	25
Lateral	25	25	25	25
90 Degree	25	25	25	25
45 Degree	15	15	15	15
22-1/2 Degree	15	15	15	15
11-1/4 Degree	15	15	15	15

5. Laying/Joining Specified Types of Plastic Pipe: Perform installation and joint assembly according to ASTM 02774 for Class I bedding material.

    a. Push-on Joints. To make PVC pipe push-on joints, properly seat sealing gasket, evenly and sufficiently lubricate the spigot end of pipe, and fully enter joint until joint line is visible.

    b. Joint Restraints: Install joint restraints at changes in direction of pipe runs and at terminal ends of pipe runs in accordance with the following table:

PVC PIPE RESTRAINED JOINT DIMENSIONS (In feet of straight pipe for each leg)	
Fitting Type	4 Inch and 6 Inch Diameter Pipe
Plug	25
Tee	25
Lateral	25
90 Degree	25
45 Degree	15
22-1/2 Degree	15
11-1/4 Degree	15

C. Connections of Piping to Existing Manholes or Structures: The option is allowed to construct pipe connections to existing manholes or structures by one of the methods stated herein, except where indicated otherwise on the Drawings. A mixture of connection methods is not allowed.

1. Cut-in Opening Utilizing PVC Waterstop and Grout: Cut required opening or openings by such methods so as to prevent cracking and spalling

concrete. Make openings of sufficient size to accommodate the pipe with PVC Waterstop installed and one inch of annular grout space. Grout annular space using Non- Shrink Non-Metallic Grout. Make connection watertight.

2. Core-drilled Opening Utilizing Sleeve Type Pipe Seal: Core-drill the required opening or openings using the proper equipment for the work. Make openings of sufficient size to accommodate the Pipe Seal.
3. Core-drilled Opening Utilizing Modular, Mechanical Type Pipe Seal: Core-drill the required opening or openings using the proper equipment for the work. Make · openings of sufficient size to accommodate the Pipe Seal.
4. New Invert Channel: Regardless of the connection to existing manhole option selected, form a new invert channel in the existing manhole base to properly conduct the flow through the existing manhole. Do not permit ground water, surface water or debris to enter the existing facilities through the new connection.
5. Drop Connections: Make drop connections as indicated on the Drawings, where drop in invert is two feet or more or as required by the Engineer.

D. Inserting Valve Installation: Perform installation of the valves in accordance with the installation instructions/training by and under the direct supervision of the valve manufacturer's field supervisor.

1. Preparation: Perform the required preparatory work prior to the arrival of the field supervisor, including the necessary excavation, excavation support work, valve foundation work, pipeline stabilizing and bracing work, and providing on- site the equipment and machinery required to place the valve and parts, and to operate the inserting machine.
2. Installation: The Contractor's crew shall perform the valve installation with the valve manufacturer's field supervisor providing "hands-on" guidance on how to assemble the valve and how to operate the inserting equipment. Nothing contained in these Contract Documents shall imply the valve manufacturer's field supervisor as being party to this Contract.

E. Setting Valves and Boxes:

1. Unless otherwise directed by the Engineer, set valves and boxes truly vertical.
2. Set valve and boxes neatly to grade and in such a way that the box does not transfer shock or stress to the valve. Exercise care to center the box over the wrench nut of the valve.

3.4 PRECAST CONCRETE CHAMBER CONSTRUCTION

A. Air Release and Cleanout Chamber Installations: As specified in precast concrete manholes and as indicated on the Drawings.

3.5 FIELD QUALITY CONTROL

A. General Requirements: Conduct tests specified herein so that each force main installed in the Project is tested to the Engineer's satisfaction.

1. The Contractor may elect to make a leakage test prior to backfilling the trenches, for its own purposes. However, the leakage tests of the force mains or sections thereof for acceptance, shall be conducted after the backfilling of the trenches has been completed.
2. Provide tools, materials (including water), apparatus and instruments necessary for force main testing.
3. When the length of the force main exceeds 1000 feet, test the force main in sections, the length of each section to be determined by the Engineer.
4. Conduct tests of every kind in the presence of and to the satisfaction of the Engineer.

B. Testing Equipment: Use testing apparatus equipped with a control panel with necessary piping, control valves and gauges to control pressures within the piping test section, and to monitor pressures throughout the test.

1. To prevent accidental overloading of piping test section, provide testing apparatus with an approved pressure relief device set to relieve at just over the expected operating pressure.
2. Provide an extra pressure gauge of known accuracy to frequently check test equipment and apparatus.
3. Testing equipment and associated testing apparatus subject to Engineer's approval.

C. Cleaning Prior to Tests: Before tests are conducted, flush piping with clean water until free of all forms of dirt and construction debris.

1. The water for the flush cleaning operation shall be from the Contractor's source.

D. Line Acceptance Test: After a force main or section thereof is constructed, backfilled, and successfully cleaned, perform a hydrostatic Line Acceptance Test as follows:

1. Seal force main at downstream end with a suitable pipe plug.
2. Fill force main with clear water.
3. Raise hydrostatic pressure to one and one halftimes the working pressure measured at the low point of the particular section of main being tested.
4. A preliminary test period for the removal or absorption of air from the lines before measuring the leakage will be permitted.
5. Maintain test pressure for a period of not less than four hours.
6. Consider force main Acceptable when measured leakage does not exceed ten gallons per day per mile per inch of pipe diameter.

E. Repair and Retest: When force main or sections of force main fails to meet test requirements specified previously, determine source or sources of leakage and repair or replace defective material, and if a result of improper workmanship, correct such.

1. Conduct such additional tests required to demonstrate that force main meets specified test requirements.

F. Owner's Tests: The Owner reserves the right to retest at its expense, any piping throughout the duration of the Construction Period.

1. Make repairs as Work of this Section to piping found defective by such Owner conducted tests.

****END OF SECTION 02324****

SECTION 02745

GEOTEXTILE

PART 1 – GENERAL

1.1 SUMMARY

A. This section describes the work necessary to install non-woven geotextiles (fabrics) in the liner system.

B. The work includes furnishing all labor, supervision, tools, construction equipment, and materials necessary to install the fabrics described by these Specifications and the Construction Drawings.

1.2 RELATED SECTIONS

A. Section 01300 – Submittals

B. Section 01410 – Quality Assurance Testing, Quality Control Testing, and Certificates of Compliance

C. Section 02200 – Earthwork

D. Section 02778 – Geomembrane

1.3 REFERENCES

A. ASTM D4533 – Standard Test Method for Trapezoid Tearing Strength of Geotextiles

B. ASTM D4632 – Standard Test Method for Grab Breaking Load and Elongation of Geotextiles

C. ASTM D4873 – Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples

D. ASTM D5261 – Standard Test Method for Measuring Mass per Unit Area of Geotextiles

E. Construction Quality Assurance (CQA) Plan

1.4 SUBMITTALS

A. Submittals shall conform to the requirements in Section 01300 - Submittals.

B. Certification Submittals: shall be submitted to the CQA Engineer for approval prior to shipment to the project site, including the following:

1. Manufacturer's written certification that the geotextiles meet the physical and hydraulic properties listed in Part 2 of this section.
2. Thread properties and seam and stitch details to be used for sewn seams.
3. Manufacturer's and Geosynthetics Contractor's qualifications.

C. Pre-Construction Submittals: shall be submitted to the CQA Engineer within 5 days of the intended shipment date.

1. Written list of the specific rolls to be shipped to the project site.
2. Manufacturer's Quality Control data for rolls to be shipped to the project site.

1.6 DELIVERY, STORAGE, AND HANDLING

Geotextile shall be protected from precipitation, inundation, ultraviolet exposure, dirt puncture, cutting, and other damaging or deleterious conditions, in accordance with ASTM D4873.

PART 2 - PRODUCTS

2.1 GENERAL

A. Contractor shall furnish materials whose "Minimum Average Roll Values", as defined by the Federal Highway Administration (FHWA), meet, or exceed the criteria listed in this section.

B. No Geotextiles shall be delivered until the requirements of Section 01410 have been met.

2.2 EQUIPMENT

The Geosynthetics Contractor shall furnish all necessary equipment required to accomplish the installation of the woven cushion geotextile and the non-woven filter fabric geotextiles specified herein.

2.3 MATERIALS

A. The geotextile, supplied by the Geosynthetics Supplier, shall be a non-woven, needle-punched, staple fiber or continuous filament, polypropylene or polyester material meeting the requirements of Table 02745-1.

2.4 GEOTEXTILE SEAMING THREAD

Geotextile seams shall be heat bonded or sewn with polymeric thread. The thread shall be capable of supplying a seam strength efficiency of 80% of the required tensile strength utilizing a Type 401 two-thread chain stitch with a "J" seam.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

A. All geotextiles shall be deployed in accordance with the Manufacturer's recommendations, standards, and guidelines.

B. Geotextile procurement, transportation, storage, handling, and installation shall be the responsibility of the Geosynthetics Contractor. Any damaged or unacceptable material shall be replaced at the sole expense of the Geosynthetics Contractor. During shipment and storage, the geotextile shall be protected from ultraviolet light exposure, precipitation or other inundation, mud, dirt, dust, puncture, cutting or any other damaging or deleterious conditions. To that effect, geotextile rolls shall be shipped and stored in relatively opaque and watertight wrappings, in accordance with ASTM D4873.

C. Geotextile rolls shall be handled in such a way that they are not damaged, in accordance with ASTM D4873.

D. During placement of filter fabric, care shall be taken not to entrap in the geotextile, stones, excessive dirt, or moisture that could damage the geomembrane or hamper subsequent seaming.

E. Geotextile shall not be exposed to precipitation prior to being installed. Wrappings protecting geotextile rolls shall be removed less than one hour prior to unrolling the geotextile. After the wrapping has been removed, the geotextile shall not be exposed to direct sunlight for more than 21 days (unless otherwise approved by the CQA Engineer).

3.2 SEAMING OF GEOTEXTILE

A. On slopes flatter than or equal to 10H: 1V, adjacent geotextile panels may be sewn, heat bonded or overlapped. All seaming, heat bonding or overlapping of sheets shall be done in accordance with the Manufacturer's recommendations. For overlapped seams, overlap distances shall be a minimum of 12 inches.

B. On slopes greater than 10H: 1V, adjacent panels shall be sewn, or heat bonded. All seams on such slopes shall be oriented parallel to (in the direction of) the slope.

C. Sewn seams shall use a Type 401 stitch. One or two rows of stitching may be used to achieve the required density in 3.2.G.

D. Seams may be heat bonded using hot plate, hot knife, or ultrasonic devices.

E. Adjacent panels shall be overlapped a minimum of 6 inches prior to heat bonding.

F. All sewing shall be done using polymeric thread with properties equal to or exceeding those of the geotextile.

G. The seam shall have 8 stitches per inch and the stitches shall be a minimum of 2 inches from the fabric edge.

3.3 REPAIRS

A. Holes or tears in the fabric shall be repaired as follows: A fabric patch made from the same geotextile shall be sewn or heat-bonded into place using a double sewn lock stitch (1/4 inch to 3/4 inch apart and sewn no closer than 1 inch from any edge). Provide a minimum overlap of 12 inches in all directions. Should any tear exceed 10 % of the width of the roll, that roll shall be removed from the slope and replaced.

B. Care shall be taken to remove any soil or other materials that may have penetrated the torn geotextile.

C. Log any defects, holes, and tears that are identified and repaired.

3.3 CONFORMANCE TESTING

A. Conformance testing shall be performed at the frequencies presented in the CQA Plan by the Owner's laboratory for conformance with properties listed in Part 2 of this Section. The Contractor shall assist in the collection of these samples. Samples shall be taken across the entire width of geotextile roll and shall not include the first 3 feet. Samples shall be 3 feet long by roll width. Machine direction shall be marked on the sample with an arrow.

B. Field quality assurance activities shall be performed in accordance with the CQA Plan and shall include visual field inspection by the CQA Engineer.

C. In the event that a portion of the material fails the conformance testing, the entire area represented by the failing test shall be removed and replaced.

D. Additional samples of geotextile delivered to the site may be collected for testing to confirm conformance with geotextile properties listed in Part 2 at the Design Engineer's discretion.

3.4 PROTECTION

Geotextiles shall be stored in such a manner to protect them from puncture, dirt, grease, water, mud, and exposure to the sun or excessive heat.

TABLE 02745-1

NONWOVEN FILTER FABRIC PROPERTIES

Properties	Test Method	Manufacturer QC Test Frequency	Required Test Values
Mass/Unit Area (min. ave.)	ASTM D5261	1 per 100,000 sf	7.2 oz/yd^2
Grab Strength (min. ave.)	ASTM D4632	1 per 100,000 sf	200 lbs
Puncture Strength (min. ave.)	ASTM D6241	1 per 100,000 sf	575 lbs
UV Resistance	ASTM D4355	1 per resin formulation	70%(1)

Notes:
(1) Ultraviolet (UV) resistance requirement is at 500 hours. Certification by manufacturer may be accepted.

****END OF SECTION 02745 ****

SECTION 02778

GEOMEMBRANE

PART 1 – GENERAL

1.1 SCOPE OF WORK

A. Manufacture, fabrication, and installation of 40 mil and 60-mil high-density polyethylene (HDPE) geomembrane as shown on the Construction Drawings.

B. Geomembrane shall have a conductive bottom surface for electronic leak location testing.

C. Manufacture, fabrication, and installation of all materials necessary for the installation and anchoring of an ultraviolet (UV) protection layer as shown on the Construction Drawings.

1.2 RELATED SECTIONS

A. Section 01300 - Submittals

B. Section 01410 - Quality Assurance Testing, Quality Control Testing, And Certificates Of Compliance

C. Section 02745 - Geotextile

D. Section 02779 - Geonet

1.3 REFERENCES

A. ASTM D792 – Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement

B. ASTM D1004 – Standard Test Method for Initial Tear Resistance (Graves Tear) of Plastic Film and Sheeting

C. ASTM D1238 – Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer

D. ASTM D1505 – Standard Test Method for Density of Plastics by the Density-Gradient Technique

E. ASTM D1603 – Standard Test Method for Carbon Black in Olefin Plastics

F. ASTM D2663 - Standard Test Methods for Carbon Black-Dispersion in Rubber

G. ASTM D3895 – Standard Test Method for Oxidative Induction Time of Polyolefins by Differential Scanning Calorimetry

H. ASTM D4218 – Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique

I. ASTM D4833 – Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products

J. ASTM D4873 – Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples

K. ASTM D5199 – Standard Test Method for Measuring the Nominal Thickness of Geosynthetics

L. ASTM D5397 (Appendix A) – Standard Test Method for Evaluation of Stress Crack Resistance of Polyolefin Geomembranes Using Notched Constant Tensile Load Test

M. ASTM D5596 - Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics

N. ASTM D5641 – Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber

O. ASTM D5721 - Standard Practice for Air-Oven Aging of Polyolefin Geomembranes

P. ASTM D5820 - Standard Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembranes

Q. ASTM D5885 - Standard Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by High-Pressure Differential Scanning Calorimetry

R. ASTM D5994 - Standard Test Method for Measuring the Core Thickness of Textured Geomembranes

S. ASTM D6392 - Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods

T. ASTM D6693 – Standard Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes

U. GRI GM13 – Test Methods, Test Properties and Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes

V. GRI GM19 – Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes

W. Construction Quality Assurance (CQA) Plan

1.4 SUBMITTALS

A. Submittals shall conform to the requirements of Section 01300 - Submittals.

B. Certification Submittals: Prior to delivery of materials to the site, submit the following to the Owner or Owner's Representative for approval:

1. Manufacturer’s certification and physical property tests for representative geomembrane material.

2. Statement that no reclaimed polymer is added to resin during manufacture of actual 40mil and 60-mil geomembrane to be used in this project.

3. Proposed Panel Layout Drawings shall be submitted prior to liner installation. These drawings shall be in sufficient detail to provide an accurate representation of the field seaming and anchor trench details that will be performed. The diagram shall be shown on a drawing with a one-inch equal to 60-feet scale (or larger), shall include the approved construction reference grid, bottom of slopes, anchor trench areas, North arrow, title of drawing, labeling of all features and any other information to define the work. It shall identify each sheet and panel by number. The layout shall conform to the following:

   a) Proposed field seams shall be shown.

   b) No horizontal seams (defined as less than 45 degrees from horizontal shall be allowed on slopes, unless approved by the Design Engineer.

   c) On side slopes, panels shall be aligned with long axis parallel to the line of maximum slope.

   d) All overlaps shall be in the downslope direction.

   e) Panel layout shall be established such that the total length of seam shall be minimized.

4. Proposed Panel Layout Drawing for the UV protection layer panel and sandbag configurations (if applicable) and method to tie them together, dimensions, details, location of seam overlaps, as well as any variance or additional details which deviate from the Construction Drawings shall be submitted prior to installation. The layout shall be adequate for use as a construction plan and shall include dimensions, details, etc. The layout drawings, as modified and/or approved by the Owner or Owner's Representative, shall become part of these specifications.

5. Proposed installation sequence and schedule.

6. Manufacturer's and Geosynthetics Contractor's Qualifications.

7. List of personnel performing field geomembrane seaming operation, along with pertinent experience information.

8. Description of the actual seaming apparatus proposed to be used and extrudate properties.

9. Detailed description of proposed field seaming and installation procedures and detailed description of proposed field seam testing methods.

10. The Geosynthetics Supplier shall arrange for a minimum 3-foot-wide by roll width sample of geomembrane, with the exception of the UV protection layer geomembrane, at the frequencies provided in the CQA Plan, to be shipped to the Owner or Owner's Representative for the completion of the pre-construction geosynthetic materials testing, to be conducted by the Owner's laboratory.

C. Pre-Construction Submittals: Submit the following to the Owner or Owner's Representative at least 10 working days prior to the intended shipment date of the geomembrane rolls.

1. Written list of the lot numbers and specific rolls to be shipped to the project site.
2. Manufacturer's Quality Control data for rolls to be shipped to the site indicating compliance with requirements of Part 2.
3. Manufacturer's data for raw materials:
    a) Copy of quality control certificates issued by resin suppliers.
    b) HDPE resin production date(s).
    c) Results of Manufacturer's quality control tests indicating the quality of resin used to manufacture geomembrane rolls assigned to the site conforms with the requirements in Part 2 of this specification.

D. Construction Submittals: Submit the following to the Owner or Owner's Representative for review on a weekly basis during geomembrane installation.

1. Daily subgrade acceptance by Geosynthetics Contractor.
2. Quality Control documentation by Geosynthetics Contractor.
3. Revised Panel Layout Drawings (field sketches).
4. Updated Installation Schedules.

E. Post-Construction Submittals:

1. Geomembrane Warranty.
2. Record Documentation as detailed in Part 3 of this Section.

1.5 CONSTRUCTION QUALITY CONTROL

A. Geomembrane Quality Control by the Geosynthetics Contractor shall include:

1. Visual inspection for installation damage and conformance with the Specifications.
2. Non-destructive/destructive seam testing in accordance with this section.

B. Conformance Testing

1. Conformance testing shall be performed by the CQA Engineer based on the frequencies presented in the CQA Plan. The sample shall be randomly selected and sent to the Owner's laboratory for conformance testing. Random selection shall be on-site or prior to delivery by choosing roll numbers from shipment lists. Conformance tests shall be as listed in the CQA Plan.
2. Samples shall be taken across the entire width of the geomembrane roll and shall not include the outer wrap. Samples shall be 3 feet long by the roll width and fully identified including machine direction. Samples shall

be rolled and not folded for transfer to the laboratory. Samples may be cut for shipping purposes.

3. The Geosynthetics Contractor shall bear any additional costs due to failing any of the required tests.

4. In the event that a portion of the material fails the quality control criteria, the Geosynthetics Contractor shall remove non-conforming rolls from the job site. The Geosynthetics Contractor may elect to perform additional conformance testing to better delineate failing materials at the expense of the Geosynthetics Contractor.

5. In the event the material failing the quality control criteria has already been installed, the Geosynthetics Contractor shall remove and replace the entire area failing the test at the sole expense of the Geosynthetics Contractor.

1.6 QUALIFICATIONS

A. Manufacturer:

1. Manufacturer shall have at least 5 years continuous experience in the manufacture of HDPE geomembrane rolls or similar products. The Manufacturer must demonstrate, by submitting a list of previous projects, a minimum of 15 million square feet of manufacture of HDPE geomembrane or similar products.

B. Geosynthetics Contractor:

1. Geosynthetics Contractor shall have at least 5 years continuous experience in installation of polyethylene geomembrane or similar products. The Geosynthetics Contractor must demonstrate a minimum of 5 million square feet of HDPE geomembrane installed for at least 10 completed facilities.

2. Personnel performing seaming operations shall have demonstrated expertise on previous geomembrane installations. Each welder shall have experience seaming a minimum of 1 million square feet of polyethylene geomembrane within the last three years. All seaming personnel shall have experience seaming textured polyethylene material.

1.7 DELIVERY, STORAGE AND HANDLING

A. Packing and Shipping:

1. Geomembrane shall be packaged and shipped by appropriate means to prevent damage to the material and to facilitate off-loading.

2. Geomembrane rolls shall be marked or tagged with the following information:

a) Product identification information (Manufacturer’s name and address, brand product code).

b) Lot, number, and roll number.

c) Roll thickness, length, and width.

3. Geosynthetics Contractor shall prepare a full inventory of materials delivered to the site and submit the inventory to the Owner or Owner's Representative within 2 days of receipt.

4. Perform in accordance with ASTM D4873.

B. Storage and Protection:

1. The Geosynthetics Contractor shall provide on-site storage area(s) for geomembrane rolls from time of delivery until installation.

2. Store and protect geomembrane rolls from puncture, dirt, grease, vandalism, ultraviolet light exposure, and other sources of damage.

a) Place geomembrane rolls on smooth, level, elevated surfaces.

b) Cover geomembrane rolls with heavy, waterproof tarpaulin.

3. Geosynthetics Contractor shall preserve integrity and readability of geomembrane roll labels.

4. Geomembrane that is received that does not have proper Manufacturer's documentation shall be stored at a separate location until all documentation has been received, reviewed, and accepted.

C. On-site Handling:

1. Unloading, on-site handling, and storage of the geomembrane is the responsibility of the Geosynthetics Contractor.

2. Use appropriate handling equipment when unloading or moving geomembrane rolls from one place to another. Follow the Manufacturer's recommendations for handling geomembrane rolls so as not to cause damage.

3. Report any observed damage to the Owner or Owner's Representative.

PART 2 - PRODUCTS

2.1 40-MIL AND 60-MIL GEOMEMBRANE

A. 40-mil and 60-mil HDPE geomembrane shall be provided. The geomembrane shall be produced in sufficient quantities to complete the work per these Specifications and the Construction Drawings. Geomembranes shall also be produced in rolls free of holes, blisters, striations, undispersed raw materials, or any sign of contamination by foreign matter. Geomembrane shall have a conductive backing for leak testing.

B. Resin used in the manufacturing of the Geomembrane shall be new, first-quality, virgin polyethylene resin. The addition of reworked polymer (from the manufacturing process) to resin shall be permitted if it does not exceed 2% by weight, contains no encapsulated scrim, and is performed with appropriate cleanliness. The addition of post-consumer resin shall not be permitted.

C. Geomembrane shall be manufactured from a pure polyethylene resin having a minimum density in accordance with Table 02778-1. The resin shall be mixed with the specified amount of carbon black. The carbon black shall be pre-blended with the resin prior to melting.

D. The geomembrane shall exhibit the minimum physical properties listed in Table 02778-1. Manufacturer quality control testing shall be performed in accordance with the frequencies presented in Table 02778-1.

E. Geomembrane seams shall meet the minimum requirements listed in GRI Test Method GM-19a, shown in Table 02778-2. Frequency of seam testing shall be in accordance with the CQA Plan.

F. Resin used for extrusion welding shall be produced from the same resin type as the geomembrane. Physical properties of the welding resin shall be the same as those of the resin used in the geomembrane.

TABLE 02778-1
60-MIL TEXTURED HDPE GEOMEMBRANE PROPERTIES

Properties	Test Method	Manufacturer QC Test Frequency	Required Test Values[10]
Thickness (min. ave.) Lowest individual for 8 out of 10 values Lowest individual for any of the 10 values	ASTM D5994	1 per Roll	57 mil 54 mil 51 mil
Formulated Density (min ave.)	ASTM D792 or ASTM D1505	1 per 200,000 lb	0.940 g/cc
Tensile Properties [1] (min. ave.) • Yield strength • Break strength • Yield elongation • Break elongation	ASTM D6693 Type IV	1 per 20,000 lb	 126 lb/in 228 lb/in 12% 700%
Tear Resistance (min. ave.)	ASTM D1004	1 per 45,000 lb	42 lbs
Puncture Resistance (min. ave.)	ASTM D4833	1 per 45,000 lb	108 lbs
Stress Crack Resistance [2]	ASTM D5397 (App.)	per GRI GM 10	500 hours
Carbon Black Content (range)	ASTM D4218[3]	1 per 20,000 lb	2.0-3.0%
Carbon Black Dispersion[4]	ASTM D5596	1 per 45,000 lb	A1,A2,B1 Category 1, 2, or 3 [4]

TABLE 02778-1 (cont.)

Properties	Test Method	Manufacturer QC Test Frequency	Required Test Values[10]
Oxidative Induction Time (OIT) (min. ave.)[5] Std. OIT, or High Pressure OIT	 ASTM D8117 ASTM D5885	1 per 200,000 lb	 100 min. 400 min.
Oven Aging at 85°C [5][6] Std. OIT (min. ave.), % retained after 90 days, or High Pressure OIT (min. ave.), % retained after 90 days	ASTM D5721 ASTM D8117 ASTM D5885	per each formulation	 55% 80%
UV Resistance [7] Std. OIT (min. ave.), or High Pressure OIT (min. ave.) % retained after 1600 hrs [9]	ASTM D7238 ASTM D8117 ASTM D5885	per each formulation	 (8) 50%

Notes:

(1) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction.

Yield elongation is calculated using a gage length of 1.3 inches.

Break elongation is calculated using a gage length of 2.0 inches.

(2) The SP-NCTL test is not appropriate for testing geomembranes with textured or irregular rough surfaces. Test should be conducted on smooth edges of textured rolls or on smooth sheets made from the same formulation as being used for the textured sheet materials.

(3) Other methods such as D 1603 (tube furnace) or D6370 (TGA) are acceptable if an appropriate correlation to D4218 (muffle furnace) can be established.

(4) Carbon black dispersion (only near spherical agglomerates) for 10 different views:

9 in Categories 1 or 2, and

1 in Category 3.

(5) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.

(6) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90-day response.

(7) The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.

(8) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.

(9) UV resistance is based on percent retained value regardless of the original HP-OIT value.

(10) Based on GRI GM13, Rev. 16, 3/17/2021.

TABLE 02778-2
MINIMUM HDPE SEAM PROPERTIES

Property	Qualifier	Unit	Specified Value 60-mil HDPE	Test Method
Shear Strength (at yield point)	Minimum	lb./in. width	120 and FTB[1]	ASTM D6392
Shear Elongation at break(2)	Maximum	%	50	ASTM D6392
Peel Adhesion Fusion	Minimum	lb./in. width	91 and FTB[1]	ASTM D6392
Peel Adhesion Extrusion	Minimum	lb./in. width	78 and FTB[1]	ASTM D6392
Peel Separation	Maximum	%	25	ASTM D6392

(1) FTB[1] = Film Tear Bond per NSF Standard 54, Part 5 Figures A-2 and A-4. Film tear bond is defined as failure of one of the sheets by tearing, instead of separating from the other sheet at the weld interface area (i.e., sheet fails before the weld fails).

(2) Elongation measurements should be omitted for field testing.

PART 3 - EXECUTION

3.1 EQUIPMENT

A. Front-end loaders, cranes, or other approved heavy equipment used for geomembrane deployment shall not be operated over geotextile.

B. Panel deployment shall utilize a spreader-bar or similar equipment to prevent slings from damaging the roll edges.

C. Equipment used shall not contaminate or damage geotextile or geomembrane by handling, trafficking, spilling of hydrocarbons (such as gasoline or oil) or other means. Defects in material installation arising from the use of equipment shall be repaired at the sole expense of the Geosynthetics Contractor.

D. Direct equipment contact with components of the geosynthetic liner system shall be minimized. The geomembrane shall be protected by geotextile “rub sheets”, scrap geomembranes, or other suitable materials, in trafficked areas or other areas requiring geomembrane protection.

3.2 PLACEMENT

A. General:

1. Place geotextile and geomembrane as shown on the construction drawings.
2. Personnel working on the geomembrane shall not smoke, wear damaging shoes, or engage in other activities that could damage the geomembrane.
3. Methods used to unroll panels shall not cause scratches or crimps in the geomembrane.
4. Methods used to place panels shall minimize wrinkles (especially differential wrinkles between adjacent panels).
5. The geomembrane shall be securely anchored and then rolled in such a manner as to continually keep the geomembrane in tension to preclude folding.
6. The geomembrane shall be weighted with sandbags or the equivalent ballast materials, to prevent movement caused by wind. Such sandbags shall be installed during placement and shall remain until replaced with subsequent liner system materials and cover soils and/or other materials capable of providing sufficient ballast against wind uplift. In case of high winds, continuous loading is recommended along edges of panels to minimize risk of wind uplift of panels.
7. Verify that the surface beneath the geomembrane has not deteriorated since the previous acceptance.

B. Install panels as follows:

1. Follow instructions on boxes or wrapping containing geomembrane materials to ensure panels are unrolled in proper direction for seaming.
2. On slopes 10H: 1V and steeper, deploy geomembrane panel’s down-slope, in a controlled manner, with panels parallel to the slope.
3. Panel sizes shall be detailed in the Geosynthetics Contractor's Panel Layout Drawing showing dimensions, panel numbering and installation details.
    a) Field panel is roll or portion of roll cut in field.
    b) When placed, designate each roll with panel number (identification code) consistent with layout plan. Panel is unit area of geomembrane to be seamed in field (e.g., one roll may be cut into several panels). Position panels on-site as shown in Panel Layout Drawings.
4. Place panels one at a time. Deploy no more panels than can be seated on the same day. No more than one panel shall be unrolled prior to seaming, unless authorized by the Owner or Owner’s Representative.

5. Install 60-mil geomembranes in locations indicated on the Construction Drawings.

C. Weather Conditions:

1. Do not place panels at ambient temperature below or above the Manufacturer's suggested ambient temperature range for installation.

2. Do not place during precipitation, in presence of excessive moisture (e.g., fog, dew), in areas of ponded water, or during excessive winds, as determined by the Owner or Owner's Representative.

D. Damage:

1. Any panel which, in judgment of the Owner or Owner's Representative, becomes seriously damaged (such as torn or twisted permanently) shall be replaced at sole expense of the Geosynthetics Contractor. Less serious damage shall be repaired as approved by the Owner or Owner's Representative.

2. Remove rejected damaged panels or portions of rejected damaged panels from work area.

E. Materials in Contact with Geomembrane:

1. Carefully install materials in contact with geomembrane surfaces to minimize potential damage. Geotextile materials may be temporarily placed loosely on top of the geomembrane for protection, if approved by the Owner or Owner's Representative.

2. Clamps, clips, bolts, nuts, or other fasteners used to secure geomembrane to each appurtenance shall have life span equal to or exceeding that of the geomembrane.

3. Pipes and Other Appurtenances:

a) Install geomembrane around any appurtenances, such as pipes, protruding through geomembrane as shown on the Construction Drawings. Unless otherwise specified, initially install geomembrane sleeve or apron around each appurtenance prior to geomembrane installation.

b) After material is placed and seamed, complete final field seam connection between appurtenance sleeve or apron and geomembrane. Maintain sufficient initial overlap of appurtenance sleeve so shifts in location of geomembrane can be accommodated.

c) Extreme care shall be taken while seaming around appurtenances because both nondestructive and destructive seam testing might not be feasible. Do not damage geomembrane while making connections to appurtenances.

3.3 GEOMEMBRANE FIELD SEAMING

A. Seam Layout:

1. In general, orient seams parallel to line of maximum slope, i.e., oriented along, not across the slope. In corners and odd-shaped geometric locations, minimize numbers of field seams.

2. No horizontal seams (defined as less than 45 degrees from horizontal shall be allowed on the slopes, unless approved by the Design Engineer.

B. Overlapping and Temporary Bonding:

1. Overlap panels a minimum of 3 inches unless otherwise recommended by the geomembrane Manufacturer.

2. Procedure used to temporarily bond adjacent panels together for extrusion welding, shall not damage geomembrane; in particular, temperature of air at nozzle of any spot-welding apparatus shall be controlled such that the geomembrane is not damaged.

3. No solvent or adhesive shall be used unless the product is approved in writing by the Owner or Owner's Representative (samples shall be submitted for testing and evaluation).

C. Seam Preparation:

1. Prior to seaming, seams shall be clean and free of moisture, dust, dirt, debris of any kind, and foreign material.

2. If seam overlap grinding is required, the process shall be completed according to Manufacturer's instructions and in a way not damaging to geomembrane.

3. Align seams with the least possible number of wrinkles and "fish mouths".

D. Seaming Equipment and Products:

1. General:

a) Approved processes for field seaming are fusion welding and extrusion welding. Proposed alternate processes shall be documented and submitted to the Design Engineer and/CQA Engineer for approval prior to use. Extrusion welding shall be restricted to repairs and welding applications not possible by the fusion process.

b) Only use apparatus specifically approved by geomembrane Manufacturer.

c) Seams shall meet the specifications contained in Part 2 of this Section.

2. Fusion Process:

   a) Use automated, vehicular-mounted fusion welding apparatus suitable for HDPE geomembranes that will prevent seams defects such as puckering.

   b) Equip apparatus with gauges indicating applicable temperatures and pressures.

   c) Maintain at least one spare operable seaming apparatus on-site. Equipment used for seaming shall not damage geomembrane. Protect geomembrane from damage, particularly in heavily trafficked areas.

   d) In all locations where the GCL is not present, use movable protective layer directly below each overlap of geomembrane that is to be seamed to prevent build-up of moisture between panels to be welded.

   e) Place the electric generator on smooth base. Place smooth insulating plate or fabric beneath hot welding apparatus after use. When protective material is in place, sudden stops or starts, sharp turns, and stationary churning of vehicles shall be strictly prohibited.

3. Extrusion Process:

   a) Complete grinding no more than one hour prior to seaming.

   b) Exposed grinding marks shall not extend more than 1/4 inch from the seamed area.

   c) Use only clean and dry welding rods.

   d) Use apparatus equipped with gauges giving temperature in apparatus and at nozzle.

   e) Provide documentation of extrudate to the Owner or Owner's Representative and certify that extrudate is compatible with specifications and is comprised of same resins as geomembrane.

   f) Maintain at least one spare operable extrusion seaming apparatus on-site. Equipment used for seaming shall not damage geomembrane. Protect geomembrane from damage in heavily trafficked areas.

   g) Purge extruder prior to beginning seam until all heat-degraded extrudate has been removed from barrel.

   h) Place electric generator on smooth base. Place smooth insulating plate or fabric beneath hot welding apparatus after use.

   i) Grind edges of cross seams to an incline prior to welding.

E. Weather Conditions for Seaming:

1. No seaming shall be attempted below 0°C (32°F) or above 43°C (110°F) without approval of the Owner or Owner's Representative.

2. Below 0°C (32°F), seaming shall be performed in accordance with GRI GM-9 “Cold Weather Seaming of Geomembranes.”

3. Geomembrane shall be dry and protected from wind.

4. In the event of seaming below 0°C (32°F) or above 43°C (110°F), certify in writing that low-temperature or high-temperature seaming procedures does not cause any physical or chemical modification to geomembrane that will generate any short or long-term damage to geomembrane.

F. General Seaming Procedures:

1. Use double hot wedge welding for installation seaming wherever possible.

2. Seaming shall extend to the outside edge of panels to be placed in anchor trench.

3. If required, provide firm substrate by using flat board, conveyor belt or similar hard surface directly under seam overlaps to achieve proper support.

4. Cut "fish mouths" or wrinkles at seam overlaps along ridge of wrinkle in order to achieve flat overlap. Seam cut "fish mouths" or wrinkles. Patch any portion where overlap is inadequate with oval or round patch of same geomembrane extending a minimum of 6 inches beyond cut in each direction.

5. Patch tee seams (location where more than one seam crosses or connects) with oval or round patch of same geomembrane extending a minimum of 6 in. beyond tee in each direction.

G. Trial Seams:

1. Before the start of geomembrane welding and during welding operations, trial welds shall be made by each seamer for each piece of seaming equipment to be used during production seaming on fragment pieces of geomembrane to confirm seaming conditions are adequate. Trial seams shall be made at the beginning of each seaming period and at mid-shift for each seaming apparatus used that day. Also, each seamer shall make at least one trial seam each day. The Owner or Owner's Representative may, at their discretion, require additional trial welds.

2. The trial weld sample shall be at least 42 inches long by 1 foot wide with seam centered lengthwise. Six random test specimens will be cut, each 1-inch wide from trial seam sample. Test Specimens shall be tested for bonded seam strength and peel adhesion (shear and peel strengths; 3 specimens for shear and 3 specimens for peel) using a digital field tensiometer. All specimens must meet the required seam properties

provided in Table 02778-2. One specimen failure shall result in a failure for the entire seam sample. If an additional trial seam fails, the seaming apparatus and seamer shall not be accepted and shall not be used for seaming until deficiencies are corrected and two consecutive successful full trial seams are achieved.

3. Results of peel and shear tests shall be recorded on a trial weld form.

4. Trial welds must be completed under conditions similar to those under which geomembrane panels will be welded.

5. Trial welds shall be allowed to cool before being tested.

6. An additional trial weld shall be performed if a wide change in temperature (±30ºF), humidity, or wind speed occurs since the previous trial weld.

H. Nondestructive Seam Continuity Testing:

1. Nondestructively test field seams over their full length using vacuum test unit or air pressure (for double hot wedge fusion process). Continuity testing shall be done as seaming work progresses, not at completion of field seaming.

2. Complete required repairs.

3. The following procedures shall apply to locations where seams cannot be nondestructively tested, as determined by the Owner or Owner's Representative:

a) If the seam is accessible to testing equipment prior to final installation, the seam shall be nondestructively tested prior to final installation.

b) All such seams shall be cap-stripped with the same geomembrane where possible.

c) If seam cannot be tested prior to final installation, seaming and cap-stripping operations shall be observed by Owner or Owner's Representative for uniformity and completeness.

4. Vacuum testing shall be performed in accordance with ASTM D5641.

5. Air Pressure testing for dual track hot wedge fusion seams shall be performed in accordance with ASTM D5820 and the following:

a) Seal both ends of seam to be tested.

b) Insert needle or other approved pressure feed device into tunnel created by double hot wedge fusion weld. Place protective cushion between air pump and geomembrane.

c) Energize air pump to a pressure between 27 and 37 pounds per square inch (psi) for 60-mil geomembrane, close valve, and sustain pressure for 5 minutes.

d) If pressure loss of more than 3 psi for 60-mil thick geomembrane is noticed, locate faulty area and repair (or as otherwise directed in ASTM D5820).

e) At the end of test, puncture the end of air channel opposite from the end with the pressure gauge and observe release of pressure to ensure air channel is not blocked. If the channel does not depressurize, find and repair the portion of the seam containing the blockage per Subpart J.3 of this Section. Repeat the air pressure test on the resulting segments of the original seam created by the repair and the ends of the seam. Repeat the process until the entire length of seam has successfully passed pressure testing or contains a repair. Repairs shall also be non-destructively tested per Subpart J.3 of this Section.

f) Remove needle or other approved pressure feed device, and all penetration holes in accordance with Subpart J.3 of this Section.

I. Destructive Seam Strength Testing:

1. Field Testing:

a) Cut a 1-inch-wide strip sample at the beginning and the completion of all seams. Cut samples from areas that do not require patching, if possible, for example at anchor trench areas or runouts beyond slopes.

b) Field test samples. If the field test passes, proceed with the destructive test, if the field test fails, follow the Destructive Test Seam Failure procedure described within this section.

2. Location and Frequency:

a) Conduct a minimum of one test per 1,000 feet of seam length (at non-critical locations such as anchor trench locations whenever possible).

b) Maximum frequency of test locations shall be agreed upon by Geosynthetics Contractor and Owner or Owner's Representative prior to commencement of installation.

c) Additional test locations shall be determined during seaming at Owner or Owner's Representative’s discretion. Selection of such locations may be prompted by adverse weather conditions, insufficient overlap, failing tests, extrusion welding, presence of excessive wrinkling in the seam area, suspicion of excess crystallinity, weld contamination, offset welds, suspect seaming equipment or techniques, or other considerations.

d) Geosynthetics Contractor will not be informed in advance of locations where seam samples will be taken.

e) Specimens shall not be taken from areas that will be subject to prolonged future leachate contact (e.g., leachate collection sumps) without prior approval by Owner or Owner's Representative.

f) Destructive seam testing shall not be required for UV protection layer geomembrane.

3. Sampling Procedure:

a) Cut samples as seaming progresses in order to obtain laboratory test results prior to completion of geomembrane installation. Number each sample and identify sample number and location on Panel Layout Drawings.

b) Immediately repair holes in geomembrane resulting from destructive seam sampling. Test continuity of new seams in repaired area using the vacuum box method of non-destructive testing (ASTM D5641).

c) Cut two 1-inch x 12-inch samples with seam centered parallel to the width with a distance between the strips of 44 inches. Field test the strips for peel and shear with a digital field tensiometer capable of quantitatively measuring shear and peel strengths.

d) For double wedge welding, test both welds for peel and shear strength for conformance with the seam strength requirements of this section.

e) If one or both of the 1-inch specimens fail in either peel or shear strength, implement procedures specified in Part I.6 of this section.

f) If the samples pass the field test remove a 12-inch wide by 42-inch-long section between the two samples. Cut section into three parts and distribute as follows:

i) One portion to the Geosynthetics Contractor for laboratory testing, 12-inch x 12 inch

ii) One portion for the Owner's independent laboratory testing, 12-inch x 18 inch

iii) One portion to the Owner for archive storage, 12-inch x 12 inch

4. Geosynthetics Contractor's Laboratory Testing:

a) Submit test results to CQA Engineer and Owner or Owner's Representative as soon as they become available.

5. Independent Laboratory Testing:

a) Test for "seam strength" and "peel adhesion" according to ASTM D6392. Minimum acceptable values are indicated in Table 02778-2 of Part 2. Test at least five replicate specimens for

each test method. To be acceptable, four of the five replicates shall pass seam strength and peel adhesion criteria in Part 2. Report test results to Owner or Owner's Representative no more than 24 hours after laboratory receives samples.

6. Procedures for Destructive Test Seam Failure:

   a) The following procedures shall apply whenever a destructive seam sample fails field destructive testing:

      i) Reconstruct seam between any two passed test locations; or

      ii) Retrace welding path to intermediate location, at 10 feet minimum from location of failed test in each direction and take samples for additional field tests. If the second test passes, then seam shall be either reconstructed or cap stripped between the two passed locations. If any sample fails, the process shall be repeated.

      iii) The boundary samples shall be tested in the same manner as the original sample.

   b) In any case, acceptable seams shall be bounded by two passed test locations (i.e., above procedure shall be followed in both directions from original failed location), and one sample for laboratory destructive testing shall be taken within reconstructed area.

   c) In event that seam sample fails laboratory destructive test (whether conducted by Owner's independent laboratory or by Geosynthetics Contractor's laboratory), then above procedures shall be followed considering laboratory tests exclusively. Because the final seam must be bounded by two passing test locations, it may then be necessary to take one or more samples for laboratory testing in addition to one required in reconstructed seam area.

J. Defects and Repairs:

1. Identification: Broom or wash geomembrane if amount of dust, mud, or other debris inhibits inspection.

2. Evaluation: Nondestructively test each suspect location in seam and non-seam areas. Repair each seam, pinhole, damaged area or defect location that fails nondestructive testing.

3. Repair Procedures:

   a) Patching: Used to repair holes, tears, panel defects, undispersed raw materials, welds, contamination by foreign matter, and destructive sample locations.

   b) Extrusion: Used to repair pinholes or other small defects (e.g., scratches, crimps). In general, this procedure should be used for defects less than 1/8 inch in largest dimension.

c) Capping (Cap Strip): Used to repair lengths of failed welds or to cover seams where welds cannot be destructively tested. Cap strips 150 feet in length or greater shall be destructively tested.

d) Removal: used to replace area with large defects where preceding methods are not appropriate. Also used to remove excess material from the installed geomembrane (e.g., "fishmouths", wrinkles, etc.). Areas of removal shall be patched or capped.

e) Surfaces of geomembrane to be patched shall be abraded no more than 1 hour prior to extrusion repair.

f) Seams used in repairs shall be approved extrusion or fusion welded seams and may be subject to the same destructive test procedure as outlined for other seams.

g) Patches or caps shall be round or oval in shape, made of same geomembrane, extend a minimum of 6 in. beyond edge of defects, and applied using approved methods only.

4. Seam Reconstruction Procedures:

a) Seam reconstruction for fusion welded seams shall be achieved by welding a top cover cap strip, 12-inches in width and centered over the seam in question.

b) Seam reconstruction for extrusion process shall be achieved by grinding and re-welding small seam sections, or by capping for large seam sections.

5. Verification of Repairs:

a) Test each repair nondestructively.

b) Repairs passing nondestructive test shall be taken as indication of adequate repair.

c) Failed tests indicate repair shall be redone and re-tested until passing tests result.

3.4 PREPARATION FOR ELECTRICAL LEAK LOCATION SURVEY

A. Contractor shall perform an Electrical Leak Location Survye (ELLS) on both the 40-mil and 60-mil HDPE geomembranes.

B. Preparation for the Electrical Leak Location Survey (ELLS) consists of all work necessary to prepare the liner system for an ELLS per ASTM 7002 and ASTM D7007.

C. If the ELLS identifies potential damages and/or leaks in the liner, the Contractor is responsible for all work and costs necessary to expose

the liner, repair the damages or leaks in the liner, and reconstruct the necessary layers of the liner system.

D. Construction of the remaining portion of the liner system can commence after successful completion of the ELLS and once the repair of all damaged liner and/or leaks are completed to the satisfaction of the CQA Engineer.

3.5 GEOMEMBRANE ACCEPTANCE

Geosynthetics Contractor shall retain ownership and responsibility for geomembrane until the Final Acceptance of the work by the Owner or Owner's Representative.

3.6 RECORD DOCUMENTATION

Record documentation specific to geomembrane installation, shall be provided as follows:

A. Installation Report - The Geosynthetics Contractor shall provide a report to the Owner or Owner's Representative at the conclusion of the work, including the following:

1. Complete identification of membrane material, including type of resin, batch numbers, roll numbers, Manufacturer, and thickness.

2. Complete identification of field seaming, including extrudate material, seaming method, seaming temperature, and date of fabrication of field seams.

3. The quality control tests used as specified and/or directed.

4. Complete description of field sampling procedure, number of test specimens, and size of test specimens.

5. Type of test machine used, grip separation, and crosshead speed.

6. Method of recording, loading, and determining stresses for destructive test methods.

7. Peel and shear test values for individual specimens in pounds per inch of width, and also the average load value for each group of specimens.

8. Manufacturer’s quality control testing, test results, certifications, etc.

9. Type of failure in all destructive testing, that is, within the seam, within the sheet material, clamp edge, seam edge, etc., for each individual specimen.

10. For non-destructive testing: type of non-destructive test, results, identification of failures, date of re-testing, and repairs.

11. Seam length.

12. Length of seam welded.

13. Identity of seamer.

14. Identity of seam testers.

15. Weather conditions at the time of seaming and any mitigative measures taken to address heat, cold, or wind.

16. Record Drawings, in AutoCAD® (.dwg) and Adobe® Acrobat® (.pdf) formats, showing actual layout of geomembrane sheets, and anchor trench details. Each repair shall be identified on Record Drawings.

17. Documentation of the ELLS for 40-mil and 60 mil HDPE geomembranes.

18. Manufacturer's and Geosynthetics Contractor's warranties.

B. HDPE Geomembrane Supplemental Record Drawing: The Geosynthetics Contractor shall prepare a Record panel diagram locating and identifying seams, individual rolls, and panels as they have been placed within the facility, and liner penetrations. The Geosynthetics Contractor shall also indicate in that diagram, or accompanying list, the date each seam was made. Record Drawings shall also show destructive test locations, pipe penetrations and where any repairs were made to the geomembrane. The Record Drawings shall include the size, cause, and date of repair.

D. Letter of Certification: Upon completion of the geomembrane installation, the Geosynthetics Contractor shall provide a letter of certification that the installation was properly performed and in compliance with all Construction Drawings and Specifications. A detailed Record Panel Diagram shall accompany this certification.

****END OF SECTION 02778****

SECTION 02779

GEONET

PART 1 - GENERAL

1.1 SCOPE OF WORK

Installing geonet material to provide drainage between the 40-mil and 60-mil High Density Polyethylene (HDPE) geomembrane.

1.2 RELATED WORK

A. Section 01300 - Submittals

B. Section 01410 - Quality Assurance Testing, Quality Control Testing, And Certificates Of Compliance

C. Section 02200 – Earthwork

D. Section 02745 - Geotextile

E. Section 02778 - Geomembrane

1.3 REFERENCES

A. ASTM D751 – Standard Test Methods for Coated Fabrics

B. ASTM D792 – Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement

C. ASTM D1238 – Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer

D. ASTM D1505 – Standard Test Method for Density of Plastics by the Density-Gradient Technique

E. ASTM D1603 – Standard Test Method for Carbon Black in Olefin Plastics

F. ASTM D4716 - Standard Test Method for Determining the (In-Plane) Flow Rate per Unit Width and Hydraulic Transmissivity of a Geosynthetic using a Constant Head

G. ASTM D4873 - Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples

H. ASTM D5199 – Standard Test Method for Measuring the Nominal Thickness of Geosynthetics

1.4 SUBMITTALS

A. Submittals shall conform to the requirements in Section 01300 - Submittals.

B. Certification Submittals: shall be submitted to the CQA Engineer, for approval, prior to shipment to the project site, including the following:

1. Manufacturer's written certification that the geonet meets the physical and hydraulic properties listed in Part 2 of this Section.

2. Manufacturer's and Geosynthetics Contractor's qualifications.

C. Pre-Construction Submittals: shall be submitted to the CQA Engineer within 10 working days prior to the intended shipment date.

1. Written list of the specific rolls to be shipped to the project site.

2. Manufacturer's Quality Control data for rolls to be shipped to the project site.

1.5 QUALIFICATIONS

A. The Manufacturer of the geonest shall have a minimum of 5 years of continuous experience in the manufacture of geonet The Manufacturer must demonstrate a minimum of 15 million square feet of manufacturing experience.

B. The Geosynthetics Contractor shall have a minimum of 5 years of continuous experience in the installation of geonet or similar products. The Geosynthetics Contractor must demonstrate a minimum of 1 million square feet of geonet installed in at least 5 completed facilities.

1.6 DELIVERY, STORAGE AND HANDLING

A. Packing and Shipping:

1. Geonet shall be supplied in rolls wrapped individually in relatively impermeable and opaque protective covers.

2. Geonet rolls shall be marked or tagged with the following information:

a. Product identification information (Manufacturer's name and address, brand product code).
b. Lot number and roll number.
c. Roll length, width, and weight.

3. Geosynthetics Contractor shall prepare a full inventory of materials delivered to the site and submit the inventory to the Owner or Owner's Representative within 2 days of receipt.

B. Storage and Protection:

1. Unloading, on-site handling, and storage of the geonet are the responsibility of the Geosynthetics Contractor.

2. The Owner shall provide on-site storage area(s) for geonet rolls from time of delivery until installation.

3. Store and protect geonet from mud, dirt, dust, water, exposure to ultraviolet light, heat, and other sources of damage.

4. Preserve integrity and readability of geonet roll labels.

5. Perform in accordance with ASTM D4873.

PART 2 – PRODUCTS

A. The geonet shall meet the properties listed in Table 02279-1

TABLE 02279-1
GEONET PROPERTIES

Properties	Test Method	Manufacturer QC Test Frequency	Required Test Values
Thickness (min. ave.)	ASTM D751 or ASTM D5199	1 per 100,000 sf	200 mil(4)
Density (min. ave)	ASTM D792 or ASTM D1505	1 per 100,000 sf	0.95 g/cc
Carbon Black Content (range)	ASTM D1603(1)	1 per 100,000 sf	1.5-3%
Tensile Strength (MD)	ASTM D5035/7179	1 per 100,000 sf	45 lb/in
Transmissivity(2)	ATSM 4716	1 per project	9.66 gal/min/ft
Transmissivity(3)	ATSM 4716	1 per project	2.9 gal/min/ft

Notes:
(1) Other methods such as D 4218 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to ASTM D1603 (tube furnace) can be established.
(2) Gradient of 0.1, normal load of 2,500 psf, water at 70 degrees F, between steel plates for 15 min.
(3) Gradient of 0.1, normal load of 2,500 psf, water at 70 degrees F, between steel plates for 100 hours.
(4) Thicker geonet may be required based on transmissivity requirements, see Table 02246-3.

PART 3 – EXECUTION

3.1 GENERAL

A. Handle geonet in such a manner as to ensure that neither it nor the other liner components are damaged.

B. During deployment of geonet on exposed slopes, geonet panels shall be weighted with sandbags or equivalent. Such sandbags shall be installed during placement and shall remain until replaced with specified cover materials.

3.2 GEONET PLACEMENT AND HANDLING

A. Handle all geonet panels in such a manner as to ensure they are not damaged.

B. Do not drive vehicles directly on the geomembrane or geonet panels. Damage to the geonet or the geomembrane shall be the responsibility of the Geosynthetics Contractor.

C. Place geonet directly on top of the geomembrane.

D. On slopes steeper than 10H: 1V, single-sided geonet sheets shall be placed in one piece from the anchor trench all the way down to the base of the slope. **No transverse seams (across-slope) will be allowed on these slopes.**

E. Geonet panels shall be anchored at the top of all side slopes and subsequently deployed by rolling each panel as a continuous sheet down the slope to the bottom of the slope in such a manner as to continually keep the material in tension.

F. In the presence of wind, geonet panels shall be weighted with sandbags or equivalent. Such sandbags shall be installed during placement and shall remain until replaced with the subsequent layer material. The Geosynthetics Contractor shall be responsible for any damage to materials caused by wind uplift.

G. Geonet panels shall be cut using an approved cutter only. If in place, special care must be taken to protect adjacent geomembrane from damage that could be caused during the cutting of geonets.

H. During geonet panel placement, care shall be taken not to entrap stones or moisture that could hamper subsequent seaming. If geonet and underlying geomembrane are not free of debris and soil prior to installation, Geosynthetics Contractor shall clean geomembrane prior to installation.

I. Any potentially harmful foreign objects on the geonet surface shall be removed by Geosynthetics Contractor.

J. Geonet panels shall not be welded or tack welded to the underlying geomembrane.

3.3 GEONET PANEL SEAMS AND OVERLAPS

A. Adjacent edges of geonet shall be butted up to each other and joined by colored plastic ties every 4 feet along longitudinal (downslope) and transverse (across-slope) seams or overlapped a minimum of 3 inches. Transverse seams are not allowed on slopes 10H: 1V and greater (except butt seams as noted below).

B. Roll Ends

1. Geonet butt seams (at the ends of a roll) on slopes 10H: 1V and less shall be butted up to each other and joined by colored plastic ties every 12 inches.

3.4 GEONET REPAIR

Any holes or tears in geonet shall be repaired as follows:

A. Overlap a minimum of 6 inches and secure with colored plastic ties every 12 inches.

3.5 CONFORMANCE TESTING

A. Testing by Owner’s Laboratory:

1. Prior to delivery to the site, samples shall be tested for conformance with the properties present in Table 02279-3, Part 2 of this section and at the frequencies presented in the CQA Plan. The Geosynthetics Supplier shall assist in the collection of all samples.

2. Samples shall be taken across entire width of the geonet roll and shall not include the outer wrap of material. Samples shall be 3 ft long by the full roll width and fully identified including machine direction. Identification of sample shall be marked directly on each sample with indelible marker or attached label tag, along with the date when the sample was taken.

3. The Owner or Owner's Representative may, at any time during the Contract, request additional testing of geonet delivered to the site to ensure conformance with the properties presented in Tables 02279-1, 02279-2 and 02279-3, Part 2 of this Section. The Geosynthetics Supplier shall bear the costs of any failing tests.

4. Geonet samples that do not comply with the properties specified in this Section shall result in:

a. Rejection of the roll from which the sample was obtained. The Geosynthetics Contractor shall remove and replace any rejected rolls at no additional cost to the Owner.

b. An additional conformance test, at no additional cost to the Owner, of a sample obtained from a roll within the same lot as the rejected roll(s), bounded by rolls with acceptable Manufacturer's Quality Control testing or conformance testing.

B. Additional sample testing may be performed, at the Owner or Owner's Representative's discretion and the Geosynthetics Contractor's expense, to identify any non-complying rolls more closely and/or the quality of the rolls, when there is a question as to the integrity of the materials.

****END OF SECTION 02779****

SECTION 03400

CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. The Contractor shall furnish all labor, materials, tools, transportation, and equipment necessary to construct a cast-in-place as shown on the Construction Drawings and as specified herein.

B. The Work shall include, but not be limited to, procurement, delivery, subgrade preparation, formwork, concrete placement, control joints, surface treatment, and curing.

1.2 RELATED SECTIONS

None

1.3 REFERENCES

A. Construction Quality Assurance Plan, (CQA Plan)

B. Latest version of American Concrete Institute (ACI) standards:

1. ACI 117 Tolerances for Concrete Construction and Materials
2. ACI 211.1 Selecting Proportions for Normal, Heavyweight, and Mass Concrete
3. ACI 301 Structural Concrete for Buildings
4. ACI 304R Measuring, Mixing, Transporting, and Placing Concrete
5. ACI 308 Standard Practice for Curing Concrete
6. ACI 318 Building Code Requirements for Reinforced Concrete
7. ACI 347R Formwork for Concrete

C. Latest version of the ASTM International (ASTM) standards:

1. ASTM A615 Standard Specifications for Deformed and Plain Carbon Steel Bars for Concrete Reinforcement
2. ASTM C33 Standard Specifications for Concrete Aggregates

3. ASTM C39 Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

4. ASTM C94 Standard Test Method for Ready-Mixed Concrete

5. ASTM C127 Standard Test Method for Density, Relative Density (Specific Gravity) and Absorption of Coarse Aggregate

6. ASTM C128 Standard Test Method for Density, Relative Density (Specific Gravity) and Absorption of Fine Aggregate

7. ASTM C143 Standard Test Method for Slump of Hydraulic Cement Concrete

8. ASTM C150 Standard Specifications for Portland Cement

9. ASTM C171 Standard Specifications for Sheet Materials for Curing Concrete

10. ASTM C192 Standard Practices for Making and Curing Concrete Test Specimens in the Laboratory

11. ASTM C309 Standard Specifications for Liquid Membrane - Forming Compounds for Curing Concrete

12. ASTM C403 Standard Test Method for Time of Setting of Concrete Mixtures by Penetration Resistance

13. ASTM C494 Standard Test Method for Chemical Admixtures for Concrete

14. ASTM C618 Standard Specifications for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete

1.4 SUBMITTALS

A. Provide the following submittals in accordance with the requirements in Section 01300 Submittals:

B. At least 7 days prior to construction of the concrete, Contractor shall submit a mix design for the type of concrete. Submit a complete list of materials including types, brands, sources, amount of cement, fly ash, pozzolans, retardants, and admixtures, and applicable reference specifications for the following:

1. Slump design based on total gallons of water per cubic yard.

2. Type and quantity of cement.

3. Brand, type, ASTM designation, active chemical ingredients, and quantity of each admixture.

4. Compressive strength based on 28-day compression tests.

C. Delivery Tickets:

1. Provide duplicate delivery tickets with each load of concrete delivered, one for Contractor's records and one for the CQA Engineer, with the following information:

a. Date and serial number of ticket.

b. Name of ready-mixed concrete plant, operator, and job location.

c. Type of cement, admixtures, if any, and brand name.

d. Cement content, in bags per cubic yard (CY) of concrete and mix design.

e. Truck number, time loaded, and name of dispatcher.

f. Amount of concrete, reported in CY per load delivered.

g. Gallons of water added at job, if any, and slump of concrete after water was added.

D. Delivery

1. The Concrete Manufacturer shall be liable for all damage to the materials incurred prior to and during transportation to the Site.

1.5 MANUFACTURER QUALITY CONTROL (MQC)

A. Aggregates shall be sampled and tested in accordance with ASTM C33.

B. Concrete test specimens shall be made, cured, and stored in conformity with ASTM C192 and tested in conformity with ASTM C39.

C. Slump shall be determined in accordance with ASTM C143.

1.6 LIMITING REQUIREMENTS

A. Unless otherwise specified, each concrete mix shall be designed, and concrete shall be controlled within the following limits:

1. Concrete slump shall be kept as low as possible, consistent with proper handling and thorough compaction. Unless otherwise authorized by the CQA Engineer, slump shall not exceed 5 inches.

2. The admixture content, batching method, and time of introduction to the mix shall be in accordance with the Manufacturer's recommendations for minimum shrinkage and for compliance with this Section. A water-reducing admixture may be included in concrete.

PART 2 - MATERIALS

2.1 PROPORTIONING AND DESIGN MIXES

A. Concrete shall have the following properties, unless otherwise noted on the Construction Drawings.

1. 2,500 psi, 28-day compressive strength.

2. Slump range of 1 to 5 inches.

3. Coarse Aggregate Gradation, ASTM C33, Number 57 or 67.

B. Retarding admixture in proportions recommended by the Manufacturer to attain additional working and setting time from 1 to 5 hours.

2.2 CONCRETE MATERIALS

A. Cement shall conform to ASTM C150 Type II.

B. Water shall be fresh, clean, and potable, free from oils, acids, alkalis, salts, organic materials, and other substances deleterious to concrete.

C. Aggregates shall conform to ASTM C33. Aggregates shall not contain any substance which may be deleteriously reactive with the alkalis in the cement and shall not possess properties or constituents that are known to have specific unfavorable effects in concrete.

D. The Contractor may use a water reducing chemical admixture. The water reducing admixture shall conform to ASTM C494, Type A. The chemical admixture shall be approved by the CQA Engineer.

2.3 REINFORCING

A. The reinforcing shall be glass fiber.

PART 3 - EXECUTION

3.1 BATCHING, MIXING, AND TRANSPORTING CONCRETE

A. Batching shall be performed according to ASTM C94, ACI 301, and ACI 304R, except as modified herein. Batching equipment shall be such that the concrete ingredients are consistently measured within the following tolerances: 1 % for

cement and water, 2% for aggregate, and 3% for admixtures. Concrete Manufacturer shall furnish mandatory batch ticket information for each load of ready-mix concrete.

B. Machine mixing shall be performed according to ASTM C94 and ACI 301. Mixing shall begin within 30 minutes after the cement has been added to the aggregates. Concrete shall be placed within 90 minutes of either addition of mixing water to cement and aggregates or addition of cement to aggregates. Additional water may be added, provided that both the specified maximum slump and water-cement ratio are not exceeded. When additional water is added, an additional 30 revolutions of the mixer at mixing speed is required. Dissolve admixtures in the mixing water and mix in the drum to uniformly distribute the admixture throughout the batch.

C. Transport concrete from the mixer to the forms as rapidly as practicable. Prevent segregation or loss of ingredients. Clean transporting equipment thoroughly before each batch. Do not use aluminum pipe or chutes. Remove concrete which has segregated in transporting and dispose of as directed.

3.2 SUBGRADE PREPARATION

A. Subgrade shall be prepared in accordance with Section 02120.

B. Subgrade shall be graded to the lines and elevations as shown on the Construction Drawings.

C. Standing water, mud, debris, and foreign matter shall be removed before concrete is placed.

3.3 PLACING CONCRETE

A. Place concrete in accordance with ACI 301, ACI 318, and ACI 304R. Place concrete as soon as practicable after the forms and the reinforcement have been approved by the CQA Engineer. Do not place concrete when weather conditions prevent proper placement and consolidation, in uncovered areas during periods of precipitation, or in standing water. Prior to placing concrete, remove dirt, construction debris, and water from within the forms. Deposit concrete as close as practicable to the final position in the forms. Place concrete in one continuous operation from one end of the structure towards the other

B. Ensure reinforcement is not disturbed during concrete placement.

C. Do not allow concrete temperature to decrease below 50 degrees F while curing. Cover concrete and provide sufficient heat to maintain 50 degrees F minimum adjacent to both the formwork and the structure while curing. Limit the rate of cooling to 5 degrees F in any 1 hour and 50 degrees F per 24 hours after heat application.

D. Do not spread concrete with vibrators. Concrete shall be placed in final position without being moved laterally more than five feet.

E. When placing of concrete is temporarily halted or delayed, provide construction joints.

F. Concrete shall not be dropped a distance greater than five feet.

G. Place concrete with aid of internal mechanical vibrator equipment capable of 9,000 cycles/min. Transmit vibration directly to concrete.

H. Hot Weather:

1. Comply with ACI 304R.

2. Concrete temperature shall not exceed 90°F.

3. At air temperatures of 80°F or above, keep concrete as cool as possible during placement and curing. Cool forms by water wash.

4. Evaporation reducer shall be used in accordance with Manufacturer recommendations (Subpart 2.03).

3.4 CURING AND PROTECTION

A. Immediately after placement, protect concrete from premature drying, excessively hot or cold temperatures, and mechanical injury in accordance with ACI 308.

B. Immediately after placement, protect concrete from plastic shrinkage by applying evaporation reducer in accordance with Manufacturer recommendations (Subpart 2.03).

C. Maintain concrete with minimal moisture loss at relatively constant temperature for period necessary for hydration of cement and hardening of concrete (Subpart 2.03).

D. Protect from damaging mechanical disturbances, particularly load stresses, heavy shock, and excessive vibration.

E. Membrane curing compound shall be spray applied at a coverage of not more than 300 square ft per gallon. Unformed surfaces shall be covered with curing compound within 30 minutes after final finishing. If forms are removed before the end of the specified curing period, curing compound shall be immediately applied to the formed surfaces before they dry out.

F. Curing compound shall be suitably protected against abrasion during the curing period.

G. Film curing will not be allowed.

3.5 FORMS

A. Formwork shall prevent leakage of mortar and shall conform to the requirements of ACI 347R.

B. Do not disturb forms until concrete is adequately cured.

C. Form system design shall be the Contractor's responsibility.

3.6 CONTROL JOINTS

A. Control joints shall consist of plastic strips set flush with finished surface or ¼ inch wide joints formed with a trowel immediately after pouring or cut with a diamond saw within 12 hours after pouring.

B. Control joints shall be installed in a 15-foot x 15-foot grid spacing along the slab unless otherwise approved by the CQA Engineer. Control joints shall be no greater than 1 ½ inch below the surface.

3.7 SLAB FINISHES

A. Unformed surfaces of concrete shall be screeded and given an initial float finish followed by additional floating and troweling where required.

B. Concrete shall be broom finished.

3.8 SURVEY

A. The Surveyor shall locate the features of the concrete structure. The dimensions, locations and elevations of the features shall be presented on the Surveyor's Record Drawings.

****END OF SECTION 03400****

Atlantica
Sustainable Infrastructure

10.4 Construction Quality Assurance Plan (CQA)

CONSTRUCTION QUALITY ASSURANCE PLAN

for the construction of

MOJAVE SOLAR PROJECT
ALPHA AND BETA EVAPORATION PONDS

Prepared for:

Atlantica Sustainable Infrastructure
ASI Operations, Inc.
42134 Harper Lake Road
Hinkley, California 92347

Prepared by:

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Geotechnical and Earthquake Engineers
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Irvine, CA

November 2023

CERTIFICATION PAGE

CONSTRUCTION QUALITY ASSURANCE (CQA) PLAN
for the construction of

MOJAVE SOLAR PROJECT
ALPHA AND BETA EVAPORATION PONDS

The Engineering material and data contained in this CQA Plan were prepared under the supervision and direction of the undersigned, whose seal as a registered Professional Engineer is affixed below.

Ben Hushmand, P.E.
Engineer of Record

TABLE OF CONTENTS

TABLES

1. INTRODUCTION

1.1 Terms of Reference

Hushmand Associates, Inc. (HAI) has prepared this Construction Quality Assurance (CQA) Plan for the construction of the Alpha and Beta Evaporation Ponds at the Mojave Solar Project. This CQA Plan was prepared by Dr. Ben Hushmand, P.E., of HAI.

1.2 Purpose and Scope of the Construction Quality Assurance Plan

The purpose of the CQA Plan is to address the CQA procedures and monitoring requirements for construction of the project. The CQA Plan is intended to: (i) define the responsibilities of parties involved with the construction; (ii) provide guidance in the proper construction of the major components of the project; (iii) establish testing protocols; (iv) establish guidelines for construction documentation; and (v) provide the means for assuring that the project is constructed in conformance to the *Technical Specifications*, permit conditions, applicable regulatory requirements, and *Construction Drawings*. This CQA Plan addresses the earthworks and geosynthetic components of the liner system for the project. This CQA Plan delineates procedures to be followed for monitoring construction utilizing these materials. The CQA protocols applicable to manufacturing, shipping, handling, and installing all geosynthetic materials are also included. However, this CQA Plan does not specifically address installation specifications of earthworks and geosynthetic materials as these requirements are addressed in the *Technical Specifications*.

1.3 References

The CQA Plan includes references to test procedures in the latest editions of the American Society for Testing and Materials (ASTM).

1.4 Organization of the Construction Quality Assurance Plan

The remainder of the CQA Plan is organized as follows:

- Section 2 presents definitions relating to CQA;
- Section 3 describes the CQA personnel organization and duties;
- Section 4 describes site and project control requirements;
- Section 5 presents CQA documentation;
- Section 6 presents CQA of the earthworks;
- Section 7 presents CQA of the geomembrane;
- Section 8 presents CQA of the geonet
- Section 9 presents CQA of the cast-in place concrete;
- Section 10 presents CQA surveying; and
- Appendices A-K field documentation forms.

2. DEFINITIONS RELATING TO CQA

This CQA Plan is devoted to Construction Quality Assurance. In the context of this document, Construction Quality Assurance and Construction Quality Control are defined as follows:

Construction Quality Assurance (CQA) - A planned and systematic pattern of means and actions designed to assure adequate confidence that materials and/or services meet contractual and regulatory requirements and will perform satisfactorily in service. CQA refers to means and actions employed by the CQA Consultant to assure conformity of the project "Work" with this CQA Plan, the *Drawings*, and the *Technical Specifications*. CQA testing of geosynthetic components is provided by the CQA Consultant.

Construction Quality Control (CQC) - Actions which provide a means to measure and regulate the characteristics of an item or service in relation to contractual and regulatory requirements. Construction Quality Control refers to those actions taken by the Contractor, Manufacturer, or Geosynthetic Installer to verify that the materials and the workmanship meet the requirements of this CQA Plan, the *Drawings*, and the *Technical Specifications*. In the case of the geosynthetic components of the Work, CQC is provided by the Manufacturer, Geosynthetic Installer, and Contractor.

2.1 Owner

The Owner of this project is Atlantica Sustainable Infrastructure.

2.2 Construction Manager

Responsibilities

The Construction Manager is responsible for managing the construction and implementation of the *Drawings*, and *Technical Specifications* for the project work. The Construction Manager is selected/appointed by the Owner.

2.3 Engineer

Responsibilities

The Engineer is responsible for the design, *Drawings*, and *Technical Specifications* for the project work. In this CQA Plan, the term "Engineer" refers to HAI.

Qualifications

The Engineer of Record shall be a qualified engineer, registered as required by regulations in the State of California.

The Engineer should have expertise, which demonstrates significant familiarity with geosynthetics, as appropriate, including design and construction experience related to liner systems.

2.4 Contractors

Responsibilities

In this CQA Plan, Contractor refers to an independent party or parties, contracted by the Owner, performing the work in general accordance with this CQA Plan, the Drawings, and the Technical Specifications. The Contractor (s) will be responsible for the installation of the earthworks, concreate and geosynthtic liner system and construction of the liner anchoring systems as shown on the drawing details. This work will include preparation of the existing liner surface, installation of the geomembranes and geonet, welding of the extension geomembrane to the existing geomembrane, and construction of the anchor trench.

The Contractor will be responsible for constructing the liner system and appurtenant components in general accordance with the *Drawings* and complying with the quality control requirements specified in the *Technical Specifications*.

Qualifications

Qualifications of the Contractor are specific to the construction contract. The Contractor should have a demonstrated history of successful liner system construction and shall maintain current state and federal licenses as appropriate.

2.5 Resin Supplier

Responsibilities

The Resin Supplier produces and delivers the resin to the Geosynthetics Manufacturer.

Qualifications

Qualifications of the Resin Supplier are specific to the Manufacturer's requirements. The Resin Supplier will have a demonstrated history of providing resin with consistent properties.

2.6 Manufacturers

Responsibilities

The Manufacturers are responsible for the production of finished material (geomembrane and geonet) from appropriate raw materials.

Qualifications

The Manufacturer(s) will be able to provide sufficient production capacity and qualified personnel to meet the demands of the project. The Manufacturer(s) must be a well-established firm(s) that meets the requirements identified in the *Technical Specifications*.

2.7 Geosynthetic Installer

Responsibilities

The Geosynthetic Installer is responsible for field handling, storage, placement, seaming, ballasting or anchoring against wind uplift, and other aspects of the geosynthetic material installation. The Geosynthetic Installer may also be responsible for specialized construction tasks (i.e., including construction of anchor welds for the geosynthetic materials).

Qualifications

The Geosynthetic Installer will be trained and qualified to install the geosynthetic materials of the type specified for this project. The Geosynthetic Installer shall meet the qualification requirements identified in the *Technical Specifications*.

2.8 CQA Consultant

Responsibilities

The CQA Consultant is a party, independent from the Owner, Contractor, Manufacturer, and Geosynthetic Installer, who is responsible for observing, testing, and documenting activities related to the CQC and CQA of the earthwork, piping, and geosynthetic components used in the construction of the Project as required by this CQA Plan and the *Technical Specifications*. The CQA Consultant will also be responsible for issuing a CQA report at the completion of the Project construction, which documents construction and associated CQA activities. The CQA report will be signed and sealed by the CQA Officer who will be a Professional Engineer registered in the State of California.

Qualifications

The CQA Consultant shall be a well-established firm specializing in geotechnical and geosynthetics engineering who possess the equipment, personnel, and licenses necessary to conduct the geotechnical and geosynthetic tests required by the project plans and *Technical Specifications*.

The CQA Consultant will provide qualified staff for the project, as necessary, which will include, at a minimum, a CQA Officer and a CQA Site Manager. The CQA Officer will be a professionally licensed engineer as required by State of California regulations. The CQA Consultant will be experienced with installation of geosynthetic materials similar to those materials used in construction of the Project. The CQA Consultant will be experienced in

the preparation of CQA documentation including CQA Plans, field documentation, field testing procedures, laboratory testing procedures, construction specifications, construction *Drawings*, and CQA reports.

The CQA Site Manager will be specifically familiar with the construction of geosynthetic lining systems. The CQA Manager will be trained by the CQA Consultant in the duties as CQA Site Manager.

2.9 Surveyor

Responsibilities

The Surveyor is a party, independent from the Contractor, Manufacturer, and Geosynthetic Installer, that is responsible for surveying, documenting, and verifying the location of all significant components of the Work, if required. The Surveyor's work, if required, is coordinated and employed by the Engineer.

Qualifications

The Surveyor will be a well- established surveying company with at least 3 years of surveying experience in the State of California. The Surveyor will be a licensed professional as required by the State of California regulations. The Surveyor shall be fully equipped and experienced in the use of total stations and the recent version of AutoCAD. All surveying will be performed under the direct supervision of the Engineer.

2.10 COA Laboratory

Responsibilities

The CQA Laboratory is a party, independent from the Contractor, Manufacturer, Geosynthetic Installer, that is responsible for conducting tests in general accordance with ASTM and other applicable test standards on samples of geosynthetic materials, soil, and in the field and in either an on-site or off-site laboratory.

Qualifications

The CQA Laboratory will have experience in testing soils and geosynthetic materials and will be familiar with ASTM and other applicable test standards. The CQA Laboratory will be capable of providing test results within a maximum of seven days of receipt of samples and will maintain that capability throughout the duration of earthworks construction and geosynthetic materials installation.

The CQA Laboratory will also be capable of transmitting geosynthetic destructive test results within 24 hours of receipt of samples and will maintain that capability throughout the duration of geosynthetic material installation.

2.11 Deficiency Identification and Rectification

If a defect is discovered in the work, the CQA Engineer will evaluate the extent and nature of the defect. If the defect is indicated by an unsatisfactory test result, the CQA Engineer will determine the extent of the deficient area by additional tests, observations, a review of records, or other means that the CQA Engineer deems appropriate.

After evaluating the extent and nature of a defect, the CQA Engineer will notify the Construction Manager and schedule appropriate re-tests when the work deficiency is corrected by the Contractor. The Contractor will correct the deficiency to the satisfaction of the CQA Engineer. If a project specification criterion cannot be met, or unusual weather conditions hinder work, then the CQA Engineer will develop and present to the Design Engineer suggested solutions for approval. Defect corrections will be monitored and documented by CQA personnel prior to subsequent work by the Contractor in the area of the deficiency.

3. CQA CONSULTANTS PERSONNEL ORGANIZATION AND DUTIES

3.1 Overview

The CQA Officer will provide supervision within the scope of work of the CQA Consultant. The scope of work for the CQA Consultant includes monitoring of construction activities including the following:

- construction of the earthworks to support the liner extension;
- preparation of the existing liner surface;
- installation of manholes and associates works for the leak detection system;
- installation of geomembranes and geonet.

Duties of CQA personnel are discussed in the remainder of this section.

3.2 COA Personnel

The CQA Consultant's personnel will include:

- the CQA Officer, who works from the office of the CQA Consultant and who conducts periodic visits to the site as required; and
- the CQA Site Manager, who is located at the site.

3.3 COA Officer

The CQA Officer shall supervise and be responsible for monitoring and CQA activities relating to the construction of the earthworks, piping, and installation of the geosynthetic materials of the Project. Specifically, the CQA Officer:

- reviews the project design, this CQA Plan, *Drawings*, and *Technical Specifications*;
- attends Pre-Construction Meetings as needed;
- administers the CQA program (i.e., provides supervision of and manages on-site CQA personnel, reviews field reports, and provides engineering review of CQA related activities);
- provides quality control of CQA documentation and conducts site visits;
- reviews the *Record Drawings*; and
- with the CQA Site Manager, prepares the CQA report documenting that the project was constructed in general accordance with the Construction Documents.

3.4 COA Site Manager

The CQA Site Manager:

- acts as the on-site representative of the CQA Consultant;
- attends CQA-related meetings (e.g., pre-construction, daily, weekly (or designates a representative to attend the meetings);
- oversees the ongoing preparation of the *Record Drawings*;
- reviews test results provided by Contractor;
- assigns locations for testing and sampling;
- oversees the collection and shipping of laboratory test samples;
- reviews results of laboratory testing and makes appropriate recommendations;
- reviews the calibration and condition of on-site CQA equipment;
- prepares a daily summary report for the project;
- reviews the Manufacturers QC documentation;
- reviews the Geosynthetic Installer's personnel Qualifications for conformance with those pre-approved for work on site;
- notes on-site activities in daily field reports and reports to the CQA Officer and Construction Manager;
- reports unresolved deviations from the CQA Plan, *Drawings*, and *Technical Specifications* to the Construction Manager; and
- assists with the preparation of the CQA report.

Note: To facilitate documentation of the work this CQA Plan includes forms (extracted from the GSE Geomembrane CQA Manual) in Appendices A-K for use, as appropriate, by the CQA Manager.

4. SITE AND PROJECT CONTROL

4.1 Project Coordination Meetings

Meetings of key project personnel are necessary to assure a high degree of quality during installation and to promote clear, open channels of communication. Therefore, Project Coordination Meetings are an essential element in the success of the project. Several types of Project Coordination Meetings are described below, including: (i) pre-construction meetings; (ii) progress meetings; and (iii) problem or work deficiency meetings.

4.1.1 Pre-Construction Meeting

A Pre-Construction Meeting will be held at the site prior to construction of the Project. At a minimum, the Pre-Construction Meeting will be attended by the Contractor, the Geosynthetic Installer's Superintendent, the CQA Consultant, and the Construction Manager.

Specific items for discussion at the Pre-Construction Meeting include the following:

- appropriate modifications or clarifications to the CQA Plan;
- the *Drawings* and *Technical Specifications*;
- the responsibilities of each party;
- lines of authority and communication;
- methods for documenting and reporting, and for distributing documents and reports;
- acceptance and rejection criteria;
- protocols for testing;
- protocols for handling deficiencies, repairs, and re-testing;
- the time schedule for all operations;
- procedures for packaging and storing archive samples;
- panel layout and numbering systems for panels and seams;
- seaming procedures;
- repair procedures; and
- soil stockpiling locations.

The Construction Manager will conduct a site tour to observe the current site conditions and to review construction material and equipment storage locations. A person in attendance at the meeting will be appointed by the Construction Manager to record the discussions and decisions of the meeting in the form of meeting minutes. Copies of the meeting minutes will be distributed to all attendees.

4.1.2 Progress Meetings

Progress meetings will be held between the CQA Site Manager, the Contractor, Construction Manager, and other concerned parties participating in the construction of the project. This meeting will include discussions on the current progress of the project, planned activities for the next week, and revisions to the work plan and/or schedule. The meeting will

be documented in meeting minutes prepared by a person designated by the CQA Site Manager at the beginning of the meeting. Within 2 working days of the meeting, draft minutes will be transmitted to representatives of parties in attendance for review and comment. Corrections and/or comments to the draft minutes shall be made within 2 working days of receipt of the draft minutes to be incorporated in the final meeting minutes.

4.1.3 Problem or Work Deficiency Meeting

A special meeting will be held when and if a problem or deficiency is present or likely to occur. The meeting will be attended by the Contractor, the Construction Manager, the CQA Site Manager, and other parties as appropriate. If the problem requires a design modification, the Engineer should either be present at, consulted prior to, or notified immediately upon conclusion of this meeting. The purpose of the work deficiency meeting is to define and resolve the problem or work deficiency as follows:

- define and discuss the problem or deficiency;
- review alternative solutions;
- select a suitable solution agreeable to all parties; and
- implement an action plan to resolve the problem or deficiency.

The Construction Manager will appoint one attendee to record the discussions and decisions of the meeting. The meeting record will be documented in the form of meeting minutes and copies will be distributed to all affected parties. A copy of the minutes will be retained in facility records.

5. DOCUMENTATION

5.1 Overview

An effective CQA Plan depends largely on recognition of all construction activities that should be monitored and on assigning responsibilities for the monitoring of each activity. This is most effectively accomplished and verified by the documentation of quality assurance activities. The CQA Consultant will document that quality assurance requirements have been addressed and satisfied.

The CQA Site Manager will provide the Construction Manager with signed descriptive remarks, data sheets, and logs to verify that monitoring activities have been carried out. The CQA Site Manager will also maintain, at the job site, a complete file of *Drawings* and *Technical Specifications*, a CQA Plan, checklists, test procedures, daily logs, and other pertinent documents.

5.2 Daily Recordkeeping

Preparation of daily CQA documentation will consist of daily field reports prepared by the CQA Site Manager which may include CQA monitoring logs and testing data sheets. This information may be regularly submitted to and reviewed by the Construction Manager. Daily field reports will include documentation of the observed activities during each day of activity. The daily field reports may include monitoring logs and testing data sheets. At a minimum, these logs and data sheets will include the following information:

- the date, project name, location, and other identification;
- a summary of the weather conditions;
- a summary of locations where construction is occurring;
- equipment and personnel on the project;
- a summary of meetings held and attendees;
- a description of materials used and references of results of testing and documentation;
- identification of deficient work and materials;
- results of re-testing corrected “deficient work;”
- an identifying sheet number for cross referencing and document control;
- descriptions and locations of construction monitored;
- type of construction and monitoring performed;
- description of construction procedures and procedures used to evaluate construction;
- a summary of test data and results;
- calibrations or re-calibrations of test equipment and actions taken as a result of re-calibration;
- decisions made regarding acceptance of units of work and/or corrective actions to be taken in instances of substandard testing results;
- a discussion of agreements made between the interested parties which may affect the work; and

- signature of the respective CQA Site Manager.

5.3 Construction Problems and Resolution Data Sheets

Construction Problems and Resolution Data Sheets, to be submitted with the daily field reports prepared by the CQA Site Manager, describing special construction situations, will be cross-referenced with daily field reports, specific observation logs, and testing data sheets and will include the following information, where available:

- an identifying sheet number for cross-referencing and document control;
- a detailed description of the situation or deficiency;
- the location and probable cause of the situation or deficiency;
- how and when the situation or deficiency was found or located;
- documentation of the response to the situation or deficiency;
- final results of responses;
- measures taken to prevent a similar situation from occurring in the future; and
- signature of the CQA Site Manager and a signature indicating concurrence by the Construction Manager.

The Construction Manager will be made aware of significant recurring nonconformance with the *Drawings*, *Technical Specifications*, or CQA Plan. The cause of the nonconformance will be determined and appropriate changes in procedures or specifications will be recommended. These changes will be submitted to the Construction Manager for approval. When this type of evaluation is made, the results will be documented and any revision to procedures or specifications will be approved by the Contractor and Engineer. A summary of supporting data sheets, along with final testing results and the CQA Site Manager's approval of the work, will be required upon completion of construction.

5.4 Photographic Documentation

Photographs will be taken and documented in order to serve as a pictorial record of work progress, problems, and mitigation activities. These records will be presented to the Construction Manager upon completion of the project. Photographic reporting data sheets, where used, will be cross-referenced with observation and testing data sheet(s), and/or construction problem and solution data sheet(s).

5.5 Design and/or Specifications Changes

Design and/or specifications changes may be required during construction. In such cases, the CQA Site Manager will notify the Engineer. Design and/or specification changes will be made with the written agreement of the Engineer and will take the form of an addendum to the *Drawings* and *Technical Specifications*.

5.6 COA Report

At the completion of the Project, the CQA Consultant will submit to the Owner a CQA report signed and sealed by the Professional Engineer licensed in the State of California. The CQA report will acknowledge: (i) that the work has been performed in compliance with the *Drawings* and *Technical Specifications*; (ii) physical sampling and testing has been conducted at the appropriate frequencies; and (iii) that the summary document provides the necessary supporting information. At a minimum, this report will include:

- MQC documentation;
- a summary report describing the CQA activities and indicating compliance with the *Drawings* and *Technical Specifications* which is signed and sealed by the CQA Officer;
- a summary of CQA/CQC testing, including failures, corrective measures, and retest results;
- Contractor and Installer personnel resumes and qualifications as necessary;
- documentation that the geomembrane trial seams were performed in general accordance with the CQA Plan and *Technical Specifications*;
- documentation that field seams were non-destructively tested using a method in general accordance with the applicable test standards;
- documentation that nondestructive testing was monitored by the CQA Consultant, that the CQA Consultant informed the Geosynthetic Installer of any required repairs, and that the CQA Consultant monitored the seaming and patching operations for uniformity and completeness;
- records of sample locations, the name of the individual conducting the tests, and the results of tests;
- *Record Drawings* as provided by the CQA Engineer; and
- daily field reports.

The *Record Drawings* will include scale drawings depicting the location of the construction and details pertaining to the extent of construction (e.g., plan dimensions and appropriate elevations). These documents will be prepared by the CQA Consultant and included as part of the CQA Report.

6. EARTHWORKS

6.1 Introduction

This section prescribes the CQA activities to be performed to monitor that earthwork components are constructed in general accordance with *Drawings* and *Technical Specifications*. The earthworks construction procedures to be monitored by the CQA monitor(s) include:

- Placement and compaction of soil berm materials;
- Preparation of subgrade for geosynthetic liner materials;
- Subgrade preparation for berm and concrete wall;
- Placement and compaction of soil for anchor trench.

6.2 Testing and Monitoring Activities

Soil observation/testing will be performed for material qualification, material conformance, and construction quality assurance (CQA). These stages of testing/observation are defined as follows:

- Material qualification tests or observations are used to evaluate the conformance of a proposed soil source to the material specifications for qualification of the source prior to construction.
- CQA tests are performed on completed portions of the earthwork during construction to demonstrate that the placement procedures are resulting in a product that meets or exceeds both material and performance specifications.

Soil testing will be conducted in general accordance with the current versions of the corresponding American Society for Testing and Materials (ASTM) test procedures.

6.2.1 Sample Frequency

The frequency of soils observation/testing for material qualification, conformance, and CQA will correspond to the minimum frequencies presented in the table below. Actual frequency of observation/testing required will be increased by the CQA Consultant as necessary if variability of materials is noted at the site, during adverse conditions, or to isolate failing areas of the construction.

Earth (Structural) Fill Construction Conformance Testing

Properties	ASTM Test Method	Frequency (Engineered Fill)(1)	Frequency (Bench Fill/Trench)
Moisture-Density	D1557	1 Per 20,000 CY or Each Material Type (minimum of 2)	1 Per Material Type
Nuclear Moisture/Density	D6938	1 Per 1,500 CY	1 Per Lift Per 200 Linear Feet
Visual Classification	D2488	As Appropriate	As Appropriate

(1) Moisture-density tests shall be performed on an even grid to provide adequate testing coverage. For large fill areas, the testing frequency shall be increased as necessary to ensure testing for each lift of soil.

6.2.2 Sample or Test Location Selection

Testing locations will be selected by the CQA Monitor(s). The CQA Monitor must document testing locations so that failing areas can be immediately isolated.

Additional testing for suspected areas will be considered when:

- rollers slip during rolling operation;
- lift thickness is greater than specified;
- fill is at improper and/or variable moisture content;
- less than typical number of passes are made;
- dirt-clogged rollers are used to compact the material;
- rollers may not have used optimum ballast;
- fill materials differ substantially from those specified;
- the degree of compaction is doubtful; and
- as directed by the Construction Manager or the CQA Monitor(s).

The frequency of observations/testing may also be increased in the following situations:

- adverse weather conditions;
- breakdown of equipment;
- at the start and finish of grading;
- material fails to meet specifications; and
- the work area is reduced.

6.3 COA Monitoring Activities

6.3.1 Existing Liner Surface Inspection

The CQA Monitor shall inspect the surface of the existing liner prior to placement of the overlay lining system. Any sharp protrusions or clumps larger than 2 inches shall be brought to the attention of the Contractor for his repair/removal.

6.3.2 Select Soil Fill and Anchor Trench Backfill

Monitoring the earthworks placement and anchor trench backfill material specifically includes the following:

- monitoring soil for maximum particle size and deleterious materials;
- observing that the berm/trench is prepared with slightly rounded corners where the geomembrane will be in contact with the soil
- monitoring the thickness of lifts during placement of the materials;
- monitoring compaction operations and equipment used;
- observing the number of passes of the compaction equipment and moisture content of the soil result in a firm and unyielding berm
- or if observations dictate, measuring and recording the field density and the field moisture content of the in-place material.

6.4 Deficiencies

If a defect is discovered in the earthwork product, the CQA Managing Engineer will immediately determine the extent and nature of the defect. If the defect is indicated by an unsatisfactory test result, the CQA Managing Engineer will determine the extent of the deficient area by additional tests, observations, a review of records, or other means that the CQA Managing Engineer deems appropriate. If the defect is related to adverse site conditions the CQA Managing Engineer will define the limits and nature of the defect.

6.4.1 Notification

After evaluating the extent and nature of a defect, the CQA Monitor(s) will notify the Construction Manager and Contractor and schedule appropriate re-tests when the work deficiency is to be corrected.

6.4.2 Repairs and Re-Testing

At locations where the field observation or testing of the soil indicates that the compacted unit weight, moisture content, or other criteria do not meet the requirements presented in the *Technical Specifications,* the failing area will be reworked as indicated below. The Contractor will correct the deficiency to the satisfaction of the CQA Consultant. If a project specification criterion cannot be met, or unusual weather conditions hinder work, then the CQA Consultant will develop and present to the Engineer of Record and/or Construction Manager suggested solutions for his approval.

All re-tests recommended by the CQA Consultant must verify that the defect has been corrected before any additional work is performed by the Contractor in the area of the deficiency. The CQA Consultant will also verify that installation requirements are met and that submittals are provided.

Corrective Action

- Perform two additional tests of the same type in the vicinity of the failed test. If either of the two additional tests results in a failure, then this area will be considered in nonconformance and will be removed, reworked, and recompacted to meet the requirements specified in the Technical Specifications.
- Obtain samples of soil material from nonconforming areas for potential laboratory testing to evaluate differences in soil properties that could contribute to the nonconforming test results.

Criteria to be used for determination of acceptability will be as identified in the *Technical Specifications* and this CQA Plan.

7. GEOMEMBRANE

7.1 General

This section discusses and outlines the CQA activities to be performed for high density polyethylene (HDPE) geomembrane installation. The CQA Site Manager will review the *Drawings*, *Technical Specifications*, and any approved Addenda regarding this material.

7.2 Geomembrane Material Conformance

7.2.1 Introduction

The CQA Site Manager will document that the geomembrane delivered to the site meets the requirements of the *Technical Specifications* prior to installation. The CQA Site Manager will:

- review the manufacturer's submittals for compliance with the *Technical Specifications*;
- document the delivery and proper storage of geomembrane rolls; and
- conduct conformance testing of the rolls before the geomembrane is installed.

The following sections describe the CQA activities required to verify the conformance of geomembrane.

7.2.2 Review of Quality Control

7.2.2.1 Material Properties Certification

The Manufacturer will provide the Construction Manager and the CQA Site Manager with the following:

- Property data sheets, including, at a minimum, all specified properties, measured using test methods indicated in the *Technical Specifications*, or equivalent;
- Sampling procedures and results of testing. The CQA Site Manager will document that: the property values certified by the Manufacturer meet all of the requirements of the *Technical Specifications*; and the measurements of properties by the Manufacturer are properly documented and that the test methods used are acceptable.

7.2.2.2 Geomembrane Roll MQC Certification

Prior to shipment, the Manufacturer will provide the Construction Manager and the CQA Site Manager with MQC certificates for every roll of geomembrane provided.

The MQC certificates will be signed by a responsible party employed by the Geomembrane Manufacturer, such as the production manager. The MQC certificates shall include:

- roll numbers and identification; and
- results of MQC tests - as a minimum, results will be given for thickness, specific gravity, carbon black content, carbon black dispersion, tensile properties, and puncture resistance evaluated in general accordance with the methods indicated in the *Technical Specifications* or equivalent methods approved by the Construction Manager.

The CQA Site Manager will document that:

- MQC certificates have been provided at the specified frequency, and that the certificates identify the rolls related to the roll represented by the test results; and
- review the MQC certificates and monitor that the certified roll properties meet the specifications.

7.2.3 Conformance Testing

The CQA Site Manager shall obtain conformance samples (at the manufacturing facility or site) at the specified frequency and forward them to the Geosynthetics CQA Laboratory for testing to monitor conformance to both the *Technical Specifications* and the list of properties certified by the Manufacturer. The test procedures will be as indicated in Table 1. Where optional procedures are noted in the test method, the requirements of the *Technical Specifications* will prevail.

Samples will be taken across the width of the roll and will not include the first linear 3 ft of material. Unless otherwise specified, samples will be 3 ft long by the roll width. The CQA Site Manager will mark the machine direction on the samples with an arrow along with the date and roll number. The required minimum sampling frequencies are provided in Table 1.

The CQA Site Manager will examine results from laboratory conformance testing and will report any non-conformance to the Construction Manager and the Geosynthetic Installer. The procedures prescribed in the *Technical Specifications will* be followed in the event of a failing conformance test.

7.3 Delivery

7.3.1 Transportation and Handling

The CQA Site Manager will document that the transportation and handling does not pose a risk of damage to the geomembrane.

Upon delivery of the rolls of geomembrane, the CQA Site Manager will document that the rolls are unloaded and stored on site as required by the Technical Specifications. Damage caused by unloading will be documented by the CQA Site Manager and the damaged material shall not be installed.

7.3.2 Storage

The Geosynthetic Installer will be responsible for the storage of the geomembrane on site. The Contractor will provide storage space in a location (or several locations) such that on-site transportation and handling are optimized, if possible, to limit potential damage.

The CQA Site Manager will document that storage of the geomembrane provides adequate protection against sources of damage.

7.4 Geomembrane Installation

7.4.1 Introduction

The CQA Consultant will document that the geomembrane installation is carried out in general accordance with the *Drawings, Technical Specifications,* and Manufacturer's recommendations.

7.4.2 Existing Liner Surface Preparation

7.4.2.1 Surface Preparation

The CQA Site Manager will document that:

- the prepared surface meets the requirements of the *Technical Specifications* and has been approved; and
- placement of the overlying materials does not damage, create large wrinkles, or induce excessive tensile stress in any underlying geosynthetic materials.

The Geosynthetic Installer will certify in writing that the surface on which the geomembrane will be installed is acceptable.

The Certificate of Acceptance, as presented in the *Technical Specifications*, will be signed by the Geosynthetic Installer and given to the CQA Site Manager prior to commencement of geomembrane installation in the area under consideration.

After the existing liner surface has been accepted by the Geosynthetic Installer, it will be the Geosynthetic Installer's responsibility to indicate to the Construction Manager any change in the surface that may require repair work. If the CQA Site Manager concurs with the Geosynthetic Installer, then the CQA Site Manager shall monitor and document that the existing liner surface is repaired before geosynthetic installation begins.

At any time before and during the geomembrane installation, the CQA Site Manager will indicate to the Construction Manager locations that may not provide adequate support to the geomembrane.

7.4.2.2 Geosynthetic Termination

The CQA Site Manager will document that the geosynthetic terminations (welds to existing liners) have been constructed in general accordance with the *Drawings*.

7.4.3 Geomembrane Placement

7.4.3.1 Panel Identification

A field panel is the unit area of geomembrane which is to be seamed in the field, i.e., a field panel is a roll or a portion of roll cut in the field. It will be the responsibility of the CQA Site Manager to document that each field panel is given an "identification code" (number or letter-number) consistent with the Panel Layout Drawing. This identification code will be agreed upon by the Construction Manager, Geosynthetic Installer and CQA Site Manager. This field panel identification code will be as simple and logical as possible. Roll numbers established in the manufacturing plant must be traceable to the field panel identification code.

The CQA Site Manager will establish documentation showing correspondence between roll numbers, and field panel identification codes. The field panel identification code will be used for all CQA records.

7.4.3.2 Field Panel Placement

Location

The CQA Site Manager will document that field panels are installed at the location indicated in the Geosynthetic Installer's Panel Layout Drawing, as approved or modified by the Construction Manager.

Installation Schedule

Field panels may be installed using one of the following schedules:

- all field panels are placed prior to field seaming in order to protect the subgrade from erosion by rain;
- field panels are placed one at a time and each field panel is seamed after its placement (in order to minimize the number of unseamed field panels exposed to wind); and
- any combination of the above.

If a decision is reached to place all field panels prior to field seaming, it is usually beneficial to begin at the high point area and proceed toward the low point with "shingle" overlaps to facilitate drainage in the event of precipitation. It is also usually beneficial to proceed in the direction of prevailing winds. Accordingly, an early decision regarding installation scheduling should be made if and only if weather conditions can be predicted with reasonable certainty. Otherwise, scheduling decisions must be made during installation, in general accordance with varying conditions. In any event, the Geosynthetic Installer is fully responsible for the decision made regarding placement procedures.

The CQA Site Manager will evaluate every change in the schedule proposed by the Geosynthetic Installer and advise the Construction Manager on the acceptability of that change. The CQA Site Manager will document that the condition of the subgrade soil has not changed detrimentally during installation.

The CQA Site Manager will record the identification code, location, and date of installation of each field panel.

Weather Conditions

Geomembrane placement will not proceed unless otherwise authorized when the ambient temperature is below 40°F or above 122°F. In addition, wind speeds and direction will be monitored for potential impact to geosynthetic installation. Geomembrane placement will not be performed during any precipitation, in the presence of excessive moisture (e.g., fog, dew), and/or in an area of ponded water.

The CQA Site Manager will document that the above conditions are fulfilled. Additionally, the CQA Site Manager will document that the subgrade soil has not been damaged by weather conditions. The Geosynthetics Installer will inform the Construction Manager if the above conditions are not fulfilled.

Method of Placement

The CQA Site Manager will document the following:

- equipment used does not damage the geomembrane by handling, trafficking, excessive heat, leakage of hydrocarbons or other means;
- the surface underlying the geomembrane has not deteriorated since previous acceptance, and is still acceptable immediately prior to geomembrane placement;

- geosynthetic elements immediately underlying the geomembrane are clean and free of debris;
- personnel working on the geomembrane do not smoke, wear damaging shoes, or engage in other activities which could damage the geomembrane;
- the method used to unroll the panels does not cause scratches or crimps in the geomembrane and does not damage the supporting soil;
- the method used to place the panels minimizes wrinkles (especially differential wrinkles between adjacent panels); and
- adequate temporary loading and/or anchoring (e.g., sand bags, tires), not likely to damage the geomembrane, has been placed to prevent uplift by wind (in case of high winds, continuous loading, e.g., by adjacent sand bags, is recommended along edges of panels to minimize risk of wind flow under the panels).

The CQA Site Manager will inform the Construction Manager if the above conditions are not fulfilled.

Damaged panels or portions of damaged panels that have been rejected will be marked and their removal from the work area recorded by the CQA Site Manager. Repairs will be made in general accordance with procedures described in Section 7.4.5.

7.4.4 Field Seaming

This section details CQA procedures to document that seams are properly constructed and tested in general accordance with the Manufacturer's specifications and industry standards.

7.4.4.1 Requirements of Personnel

All personnel performing seaming operations will be qualified by experience or by successfully passing seaming tests, as outlined in the *Technical Specifications*. The most experienced seamer, the "Master Seamer", will provide direct supervision over less experienced seamers.

The Geosynthetic Installer will provide the Construction Manager and the CQA Site Manager with a list of proposed seaming personnel and their experience records. These documents will be reviewed by the Construction Manager and the Geosynthetics CQA Manager.

7.4.4.2 (top and bottom) prior to welding;

- the electric generator is placed on a smooth cushioning base such that no damage occurs to the geomembrane from ground pressure or fuel leaks;
- a smooth insulating plate or fabric is placed beneath the hot welding apparatus after usage; and
- the geomembrane is protected from damage in heavily trafficked areas.

7.4.4.3 Seam Preparation

The CQA Site Manager will document that:

- prior to seaming, the seam area is clean and free of moisture, dust, dirt, debris, and foreign material; and
- seams are aligned with the fewest possible number of wrinkles and "fishmouths."

7.4.4.4 Weather Conditions for Seaming

The normally required weather conditions for seaming are as follows unless authorized in writing by the Engineer:

- seaming will only be approved between ambient temperatures of 40°F and 122°F.

If the Geosynthetic Installer wishes to use methods that may allow seaming at ambient temperatures below 40°F or above 122°F, the Geosynthetic Installer will demonstrate and certify that such methods produce seams which are entirely equivalent to seams produced within acceptable temperature, and that the overall quality of the geomembrane is not adversely affected.

The CQA Site Manager will document that these seaming conditions are fulfilled and will advise the Geosynthetics Installer if they are not.

7.4.4.5 Overlapping and Temporary Bonding

The CQA Site Manager will document that:

- the panels of geomembrane have a finished overlap of a minimum of 3 in. for both extrusion and fusion welding;
- no solvent or adhesive bonding materials are used; and
- the procedures utilized to temporarily bond adjacent panels together does not damage the geomembrane.

The CQA Site Manager will log appropriate temperatures and conditions, and will log and report non-compliances to the Construction Manager.

7.4.4.6 Trial Seams

Trial seams shall be prepared with the procedures and dimensions as indicated in the *Technical Specifications*. The CQA Site Manager will observe trial seam procedures and will document the results of trial seams on trial seam logs. Each trial seam samples will be assigned a number.

The CQA Site Manager, will log the date, time, machine temperature(s), seaming unit identification, name of the seamer, and pass or fail description for each trial seam sample tested. Separate trial seaming logs shall be maintained for fusion welded and extrusion welded trial seams.

7.4.4.7 General Seaming Procedure

Unless otherwise specified, the general production seaming procedure used by the Geosynthetic Installer will be as follows:

- Fusion-welded seams are continuous, commencing at one end to the seam and ending at the opposite end.
- Cleaning, overlap, and shingling requirements shall be maintained.
- If seaming operations are carried out at night, adequate illumination will be provided at the Geosynthetic Installer's expense.
- Seaming will extend to the outside edge of panels to be placed in the anchor trench.

The CQA Site Manager shall document geomembrane seaming operations on seaming logs. Seaming logs shall include, at a minimum:

- Seam identifications (typically associated with panels being joined);
- Seam starting time and date;
- Seam ending time and date;
- Seam length;
- Identification of person performing seam; and
- Identification of seaming equipment.

Separate logs shall be maintained for fusion and extrusion welded seams. In addition, the CQA Site Manager shall monitor during seaming that:

- Fusion-welded seams are continuous, commencing at one end of the seam and ending at the opposite end.
- Cleaning, overlap, and shingling requirements are maintained.

7.4.4.8 Nondestructive Seam Continuity Testing

Concept

The Geosynthetic Installer will non-destructively test field seams over their length using a vacuum test unit, air pressure test (for double fusion seams only), or other method approved by the Construction Manager. The purpose of nondestructive tests is to check the continuity of seams.

It does not provide information on seam strength. Continuity testing will be carried out as the seaming work progresses, not at the completion of field seaming.

The CQA Site Manager will:

- observe continuity testing;
- record location, date, name of person conducting the test, and the results of tests; and
- inform the Geosynthetic Installer of required repairs.

The Geosynthetic Installer will complete any required repairs in general accordance with Section 7.4.5.

The CQA Site Manager will:

- observe the repair and re-testing of the repair;
- mark on the geomembrane that the repair has been made; and
- document the results.

The following procedures will apply to locations where seams cannot be non-destructively tested:

All such seams will be cap-stripped with the same geomembrane.

- If the seam is accessible to testing equipment prior to final installation, the seam will be non-destructively tested prior to final installation.
- If the seam cannot be tested prior to final installation, the seaming and cap-stripping operations will be observed by the CQA Site Manager and Geosynthetic Installer for uniformity and completeness.

The seam number, date of observation, name of tester, and outcome of the test or observation will be recorded by the CQA Site Manager.

Vacuum Testing

Vacuum testing shall be performed utilizing the equipment and procedures specified in the *Technical Specifications*.

The CQA Site Manager shall observe the vacuum testing procedures and document that they are performed in accordance with the *Technical Specifications*. The result of vacuum testing shall be recorded on the CQA seaming logs. Results shall include, at a minimum, the personnel performing the vacuum test and the result of the test (pass or fail), and the test date. Seams failing the vacuum test shall be repaired in accordance with the procedures listed in the *Technical Specifications*. The CQA Site Manager shall document seam repairs in the seaming logs.

Air Pressure Testing

Air channel pressure testing shall be performed on double-track seams created with a fusion welding device, utilizing the equipment and procedures specified in the *Technical Specifications*. The CQA Site Manager shall observe the vacuum testing procedures and document that they are performed in accordance with the *Technical Specifications*. The result of air channel pressure testing shall be recorded on the CQA seaming logs. Results shall include, at a minimum, personnel performing the air pressure test, the starting air pressure and time, the final air pressure and time, the drop in psi during the test, and the result of the test (pass or fail). Seams failing the air pressure test shall be repaired in accordance with the procedures listed in the *Technical Specifications*. The CQA Site Manager shall document seam repairs in the seaming logs.

7.4.4.9 Destructive Testing

Concept

Destructive seam testing will be performed on site and at the independent CQA laboratory in general accordance with the *Drawings* and the *Technical Specifications*. Destructive seam tests will be performed at selected locations. The purpose of these tests is to evaluate seam strength. Seam strength testing will be done as the seaming work progresses, not at the completion of all field seaming.

Location and Frequency

The CQA Site Manager will select locations where seam samples will be cut out for laboratory testing. Those locations will be established as follows.

- The frequency of geomembrane seam testing is a minimum of one destructive sample per 500 feet of weld. The minimum frequency is to be evaluated as an average taken throughout the entire facility.
- A minimum of one test per seaming machine over the duration of the project.
- Additional test locations may be selected during seaming at the CQA Site Manager's discretion. Selection of such locations may be prompted by suspicion of excess crystallinity, contamination, offset welds, or any other potential cause of imperfect welding.

The Geosynthetic Installer will not be informed in advance of the locations where the seam samples will be taken.

Sampling Procedure

Samples will be marked by the CQA Site Manager following the procedures listed in the *Technical Specifications*.

Preliminary samples will be taken from either side of the marked sample and tested before obtaining the full sample per the requirements of the *Technical Specifications*. Samples shall be obtained by the Geosynthetic Installer. Samples shall be obtained as the seaming progresses in order to have laboratory test results before the geomembrane is covered by another material. The CQA Site Manager will:

- observe sample cutting and monitor that corners are rounded;
- assign a number to each sample, and mark it accordingly;
- record sample location on the Panel Layout Drawing; and
- record reason for taking the sample at this location (e.g., statistical routine, suspicious feature of the geomembrane).

Holes in the geomembrane resulting from destructive seam sampling will be immediately repaired in general accordance with repair procedures described in Section 7.4.5. The continuity of the new seams in the repaired area will be tested in general accordance with Section 7.4.4.8.

Size and Distribution of Samples

The destructive sample will be 12 in. (0.3 m) wide by 42 in. (1.1 m) long with the seam centered lengthwise. The sample will be cut into three parts and distributed as follows:

- one portion, measuring 12 in. × 12 in. (30 cm × 30 cm), to the Geosynthetic Installer for field testing;
- one portion, measuring 12 in. × 18 in. (30 cm × 45 cm), for CQA Laboratory testing; and
- one portion, measuring 12 in. × 12 in. (30 cm × 30 cm), to the Construction Manager for archive storage.

Final evaluation of the destructive sample sizes and distribution will be made at the Pre-Construction Meeting.

Field Testing

Field testing will be performed by the Geosynthetic Installer using a gauged tensiometer. Prior to field testing the Geosynthetic Installer shall submit a calibration certificate for gauge tensiometer to the CQA Consultant for review. Calibration must have been performed within one year of use on the current project.

The destructive sample shall be tested according to the requirements of the *Technical Specifications*. The specimens shall not fail in the seam and shall meet the strength requirements outlined in the *Technical Specifications*. If any field test specimen fails, then the procedures outlined in *Procedures for Destructive Test Failures* of this section will be followed.

The CQA Site Manager will witness field tests and mark samples and portions with their number. The CQA Site Manager will also document the date and time, ambient

temperature, number of seaming unit, name of seamer, welding apparatus temperatures and pressures, and pass or fail description.

CQA Laboratory Testing

Destructive test samples will be packaged and shipped, if necessary, under the responsibility of the CQA Site Manager in a manner that will not damage the test sample. The Construction Manager will be responsible for storing the archive samples. This procedure will be outlined at the Pre-construction Meeting. Samples will be tested by the CQA Laboratory. The CQA Laboratory will be selected by the CQA Site Manager with the concurrence of the Engineer.

Testing will include "Bonded Seam Strength" and "Peel Adhesion." The minimum acceptable values to be obtained in these tests are given in the *Technical Specifications*. At least five specimens will be tested for each test method. Specimens will be selected alternately, by test, from the samples (i.e., peel, shear, peel, shear...). A passing test will meet the minimum required values in at least four out of five specimens.

The CQA Laboratory will provide test results no more than 24 hours after they receive the samples. The CQA Site Manager will review laboratory test results as soon as they become available, and make appropriate recommendations to the Construction Manager.

Geosynthetic Installer's Laboratory Testing

The Geosynthetic Installer's laboratory test results will be presented to the Construction Manager and the CQA Site Manager for comments.

Procedures for Destructive Test Failure

The following procedures will apply whenever a sample fails a destructive test, whether that test conducted by the CQA Laboratory, the Geosynthetic Installer's laboratory, or by gauged tensiometer in the field.

The Geosynthetic Installer has two options:

- The Geosynthetic Installer can reconstruct the seam between two passed test locations.

- The Geosynthetic Installer can trace the welding path to an intermediate location at 10 ft (3 m) minimum from the point of the failed test in each direction and take a small sample for an additional field test at each location. If these additional samples pass the test, then full laboratory samples are taken. If these laboratory samples pass the tests, then the seam is reconstructed between these locations. If either sample fails, then the process is repeated to establish the zone in which the seam should be reconstructed.

Acceptable seams must be bounded by two locations from which samples passing laboratory destructive tests have been taken. Repairs will be made in general accordance with Section 7.4.5.

The CQA Site Manager will document actions taken in conjunction with destructive test failures.

7.4.5 Defects and Repairs

This section prescribes CQA activities to document that defects, tears, rips, punctures, damage, or failing seams shall be repaired.

7.4.5.1 Identification

Seams and non-seam areas of the geomembrane shall be examined by the CQA Site Manager for identification of defects, holes, blisters, undispersed raw materials and signs of contamination by foreign matter. Because light reflected by the geomembrane helps to detect defects, the surface of the geomembrane shall be clean at the time of examination.

7.4.5.2 Evaluation

Potentially flawed locations, both in seam and non-seam areas, shall be non-destructively tested using the methods described in Section 7.4.4.8 as appropriate. Each location that fails the nondestructive testing will be marked by the CQA Site Manager and repaired by the Geosynthetic Installer. Work will not proceed with any materials that will cover locations which have been repaired until laboratory test results with passing values are available.

7.4.5.3 Repair Procedures

Portions of the geomembrane exhibiting a flaw, or failing a destructive or nondestructive test, will be repaired. Several procedures exist for the repair of these areas. The final decision as to the appropriate repair procedure will be at the discretion of the CQA Consultant with input from the Construction Manager and Geosynthetic Installer.

The procedures available include:

- patching, used to repair large holes, tears, undispersed raw materials, and contamination by foreign matter;
- grinding and re-welding, used to repair small sections of extruded seams;
- spot welding or seaming, used to repair small tears, pinholes, or other minor, localized flaws;
- capping, used to repair large lengths of failed seams;
- removing bad seam and replacing with a strip of new material welded into place (used with large lengths of fusion seams).

In addition, the following provisions will be satisfied:

- surfaces of the geomembrane which are to be repaired will be abraded no more than 20 minutes prior to the repair;
- surfaces must be clean and dry at the time of the repair;
- all seaming equipment used in repairing procedures must be approved;
- the repair procedures, materials, and techniques will be approved in advance by the CQA Consultant with input from the Engineer and Geosynthetic Installer;
- patches or caps will extend at least 6 in. (150 mm) beyond the edge of the defect, and all corners of patches will be rounded with a radius of at least 3 in. (75 mm); and
- cuts and holes to be patched shall have rounded corners

7.4.5.4 Verification of Repairs

The CQA Monitor shall monitor and document repairs. Records of repairs shall be maintained on repair logs. Repair logs shall include, at a minimum:

- panel containing repair and approximate location on panel;
- approximate dimensions of repair;
- repair type, i.e. fusion weld or extrusion weld
- date of repair;
- seamer making the repair; and
- results of repair non-destructive testing (pass or fail).

Each repair will be non-destructively tested using the methods described herein, as appropriate. Repairs that pass the non-destructive test will be taken as an indication of an adequate repair. Large caps may be of sufficient extent to require destructive test sampling, per the requirements of the *Technical Specifications*. Failed tests shall be redone and re-tested until passing test results are observed.

7.4.5.5 Large Wrinkles

When seaming of the geomembrane is completed (or when seaming of a large area of the geomembrane liner is completed) and prior to placing overlying materials, the CQA Site Manager will observe the geomembrane wrinkles. The CQA Site Manager will indicate to the Geosynthetic Installer which wrinkles should be cut and re-seamed. The seam thus produced will be tested like any other seam.

7.5 Electrical Leak Location Survey

An electrical leak location survey (ELLS) shall be completed on the entire lined area of the lined pond following the installation of the geomembrane (ASTM D7240 and ASTM 7002). The CQA Engineer/Monitor shall ensure that the liner is properly prepared for the ELLS

and shall verify that adequate moisture is added to the liner prior to conducting the test. All edges of the liner must be "electrically isolated" prior to completing the test. The ELLS shall conform to the applicable requirements of ASTM D7240 and ASTM 7002.

In the event the ELLS identifies anomalies that are potentially indicative of a defect in the liner system, the CQA Monitor shall document the location of the suspect area, and then observe and document the exposure of the liner system and any subsequent repairs that may be necessary. The CQA Monitor will photograph the area after it is exposed, and after any repairs are completed. The ELLS Surveyor shall submit a report detailing the procedures used and the results of their survey.

7.6 Lining System Acceptance

The Geosynthetic Installer and the Manufacturer(s) will retain all responsibility for the geosynthetic materials in the liner system until acceptance by the Construction Manager.

The geosynthetic liner system will be accepted by the Construction Manager when:

- the installation is finished;
- verification of the adequacy of all seams and repairs, including associated testing, is complete;
- all documentation of installation is completed including the CQA Site Manager's acceptance report and appropriate warranties; and
- CQA report, including "as built" drawing(s), sealed by a registered professional engineer has been received by the Construction Manager.

The CQA Site Manager will document that installation proceeded in general accordance with the *Technical Specifications* for the project.

8. GEONET

8.1 Introduction

This section of the CQA Plan outlines the CQA activities to be performed for the geonet installation. The CQA Consultant will review the *Drawings*, and the *Technical Specifications*, and any approved addenda or changes.

8.2 Manufacturing

The Manufacturer will provide the CQA Consultant with a list of certified "minimum average roll value" properties for the type of geonet to be delivered. The Manufacturer will also provide the CQA Consultant with a written certification signed by a responsible representative of the Manufacturer that the geonet actually delivered have "minimum average roll values" properties which meet or exceed all certified property values for that type of geonet.

The CQA Consultant will examine the Manufacturers' certifications to document that the property values listed on the certifications meet or exceed those specified for the particular type of geonet. Deviations will be reported to the Construction Manager.

8.3 Labeling

The Manufacturer will identify all rolls of geonet with the following:

- Manufacturer's name;
- product identification;
- lot number;
- roll number; and
- roll dimensions.

The CQA Site Manager will examine rolls upon delivery and deviation from the above requirements will be reported to the Construction Manager.

8.4 Shipment and Storage

During shipment and storage, the geonet will be protected from mud, dirt, dust, puncture, cutting or any other damaging or deleterious conditions. The CQA Site Manager will observe rolls upon delivery to the site and deviation from the above requirements will be reported to the Construction Manager. Damaged rolls will be rejected and replaced.

The CQA Site Manager will observe that geonet is free of dirt and dust just before installation. The CQA Site Manager will report the outcome of this observation to the Construction Manager, and if the geonet is judged dirty or dusty, they will be cleaned by the Geosynthetic Installer prior to installation.

8.5 Conformance Testing

8.5.1 Tests

The geonet material will be tested for thickness (ASTM D5199 (, density (ASTM D1505), mass/unit area (ASTM D 5261), Transmissibity (ASTM 4716) and for Carbon Black Content (ASTM D1603) at the frequencies presented in Table 2.

8.5.2 Sampling Procedures

Upon delivery of the geonet rolls, the CQA Site Manager will document that samples are obtained from individual rolls at the frequency specified in this CQA Plan. The geonet samples will be forwarded to the CQA Laboratory for testing to evaluate conformance to both the *Technical Specifications* and the list of physical properties certified by the Manufacturer.

Samples will be taken across the width of the roll and will not include the first 3 linear ft. unless otherwise specified, samples will be 3 ft long by the roll width. The CQA Consultant will mark the machine direction on the samples with an arrow.

8.5.3 Test Results

The CQA Site Manager will examine results from laboratory conformance testing and compare results to the *Technical Specifications*. The criteria used to evaluate acceptability are presented in the *Technical Specifications*. The CQA Site Manager will report any nonconformance to the Construction Manager.

8.5.4 Conformance Test Failure

The following procedure will apply whenever a sample fails a conformance test that is conducted by the CQA Laboratory:

- The Manufacturer will replace every roll of geonet that is in nonconformance with the *Technical Specifications* with a roll that meets specifications; or
- The Geosynthetic Installer will remove conformance samples for testing by the CQA Laboratory from the closest numerical rolls on both sides of the failed roll. These two samples must conform to the *Technical Specifications*. If either of these samples fail, the numerically closest rolls on the side of the failed sample that is not tested, will be tested by the CQA Laboratory. These samples must conform to the *Technical Specifications*.

If any of these samples fail, every roll of geonet on site from this lot and every subsequently delivered roll that is from the same lot must be tested by the CQA Laboratory for conformance to the *Technical Specifications*.

The CQA Site Manager will document actions taken in conjunction with conformance test failures.

8.6 Handling and Placement

The Geosynthetic Installer will handle all geonet in such a manner as to document they are not damaged in any way. The Geosynthetic Installer will comply with the following:

- If in place, special care must be taken to protect other materials from damage, which could be caused by the cutting of the geonet.
- The Geosynthetic Installer will take any necessary precautions to prevent damage to underlying layers during placement of the geonet.
- During placement of geonet, care will be taken to prevent entrapment of dirt or excessive dust that could cause clogging of the drainage system, and/or stones that could damage the adjacent geomembrane. If dirt or excessive dust is entrapped in the geonet, it should be cleaned prior to placement of the next material on top of it. In this regard, care should be taken with the handling or sandbags, to prevent rupture or damage of the sandbag.
- A visual examination of the geonet will be carried out over the entire surface, after installation to document that no potentially harmful foreign objects are present.

The CQA Site Manager will note noncompliance and report it to the Construction Manager.

8.7 Geonet Seams and Overlaps

Adjacent geonet panels will be joined in general accordance with *Construction Drawings* and *Technical Specifications*. As a minimum, the adjacent rolls will be overlapped and tied with colored plastic ties in general accordance with the *Technical Specifications*. The CQA Consultant will note any noncompliance and report it to the Construction Manager.

8.8 Repair

Holes or tears in the geonet will be repaired by placing a patch extending 2 ft beyond edges of the hole or tear.

If the hole or tear width across the roll is more than 50 percent of the width of the roll, the damaged area will be cut out and the two portions of the geonet will be joined in general accordance with Section 8.7. The CQA Site Manager will observe repairs, note non-compliances with the above requirements and report them to the Construction Manager.

9. CONSTRUCTION QUALITY ASSURANCE FOR CAST-IN-PLACE CONCRETE

9.1 Acceptance Testing and Certification

The Contractor shall provide written certificates of compliance certifying that the cement, fine and coarse aggregate, admixtures, mix design(s), and compressive strength meet the requirements listed in the Specifications and that admixtures used in the same concrete mix are compatible with each other and the aggregates. The certificates of compliance shall be accompanied by certified laboratory test results showing that the concrete delivered to the job site was tested in accordance with and meets the Specifications. The certificates of compliance shall be signed by responsible personnel employed by the Contractor and submitted to the CQA Manager at least 14 calendar days prior to shipment to the job site. The certificates of compliance shall include the following:

- The test procedures and the results of the laboratory evaluation.
- Certification that the tests described in the Specifications and herein were performed and that test results conform with the Specifications.

9.2 Conformance Testing

The CQA Monitor will collect field cylinder concrete specimens at his/her discretion upon the arrival of concrete at the job site, in compliance with ASTM C31. Selected specimens will be tested by a third-party testing laboratory. The number of sets of concrete cylinder specimens taken of each class of concrete placed each day shall not be less than one set, nor less than one set for each 50 cubic yards of concrete. Specimens taken will be tested for compressive strength per ASTM C39. Test results shall conform to the requirements of the Specifications.

10. SURVEYING

10.1 Survey Control

Survey control will be performed by the Surveyor as needed. A permanent benchmark will be established for the site(s) in a location convenient for daily tie-in. The vertical and horizontal control for this benchmark will be established within normal land surveying standards.

10.2 Precision and Accuracy

A wide variety of survey equipment is available for the surveying requirements for these projects. The survey instruments used for this work should be sufficiently precise and accurate to meet the needs of the projects.

10.3 Lines and Grades

The following structures will be surveyed to verify and document the lines and grades achieved during construction of the Project:

- geomembrane terminations; and
- centerlines of pipes.

10.4 Frequency and Spacing

A line of survey points no further than 50 ft apart must be taken at the top of pipes or other appurtenances to the liner.

10.5 Documentation

Field survey notes should be retained by the Land Surveyor. The findings from the field surveys should be documented on a set of Survey *Record Drawings*, which shall be provided to the Construction Manager in AutoCAD format or other suitable format as directed by the Construction Manager.

TABLE 1

GEOMEMBRANE CONFORMANCE TESTING REQUIREMENTS

TEST NAME	TEST METHOD	FREQUENCY
Specific Gravity	ASTM D 792 Method A or ASTM D 1505	200,000 ft^2 or minimum of 2
Thickness	ASTM D 5199	200,000 ft^2 or minimum of 2
Tensile Strength at Yield	ASTM D 638	200,000 ft^2 or minimum of 2
Tensile Strength at Break	ASTM D 638	200,000 ft^2 or minimum of 2
Elongation at Yield	ASTM D 638	200,000 ft^2 or minimum of 2
Elongation at Break	ASTM D 638	200,000 ft^2 or minimum of 2
Carbon Black Content	ASTM D 1603	200,000 ft^2 or minimum of 2
Carbon Black Dispersion	ASTM D 5596	200,000 ft^2 or minimum of 2

TABLE 2

GEOTEXTILE CONFORMANCE TESTING REQUIREMENTS

TEST NAME	TEST METHOD	MINIMUM FREQUENCY
Thickness	ASTM D5199	1 test per 200,000 ft^2 or minimum of 2
Density	ASTM D1505	1 test per 200,000 ft^2 or minimum of 2
Mass/Unit Area	ASTM D 5261	1 test per 200,000 ft^2 or minimum of 2
Carbon Black Content	ASTM D 1603	1 test per 200,000 ft^2 or minimum of 2
Transmissvity	ASTM D 4716	1 test per 200,000 ft^2 or minimum of 2