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**SPECIFICATIONS - DETAILED PROVISIONS**  
**Section 02598 - Pond Lining - Clay and Flexible Membrane**

**C O N T E N T S**

<b>PART 1 - GENERAL</b> .....	<b>1</b>
1.01 DESCRIPTION .....	1
1.02 QUALITY ASSURANCE .....	1
1.03 SUBMITTALS .....	1
1.04 PRODUCT DELIVERY .....	1
1.05 JOB CONDITIONS .....	2
1.06 ALTERNATIVES .....	2
1.07 WARRANTY .....	2
1.08 EXPERIENCE OF CONTRACTOR.....	2
<b>PART 2 - PRODUCTS</b> .....	<b>2</b>
2.01 MATERIALS.....	2
2.02 MIXES.....	6
<b>PART 3 - EXECUTION</b> .....	<b>6</b>
3.01 INSPECTION.....	6
3.02 PREPARATION .....	7
3.03 INSTALLATION .....	8
3.04 FIELD QUALITY CONTROL.....	10
3.05 CLEAN-UP .....	10



**SECTION 02598  
POND LINING - CLAY AND FLEXIBLE MEMBRANE**

**PART 1 - GENERAL**

**1.01 DESCRIPTION**

Under these specifications, the contractor shall furnish all labor, material, and tools required for the complete installation of an impermeable storage pond liner as hereinafter described.

The types of liners in this specification are:

- A. Clay
- B. High Density Polyethylene Geo-membrane
- C. Composite Liner (Geo-Seal)

**1.02 QUALITY ASSURANCE**

Includes the requirements of this specification, the liner manufacturer, and the requirements of the latest revision of the following standards as applicable. Unless specifically stated otherwise, the most stringent requirement will govern when there is a conflict.

ASTM	A-564	ASTM	D-1505
	D-413		D-1557
	D-638		D-1593
	D-746		D-1603
	D-751		D-1693
	D-1004		D-2136
	D-1149		D-3083
	D-1203		FTSM-101B
	D-1204		

**1.03 SUBMITTALS**

The contractor shall submit for EMWD approval clay samples and samples of any material not specifically noted in the specifications. Unless the material is specifically noted in the specifications, a minimum of six (6) 8"x10" samples of fabricated liner material with material and performance properties shall be submitted. Laboratory tests shall accompany any clay sample indicating conformance to the specifications.

**1.04 PRODUCT DELIVERY**

All lining materials shall be delivered to the jobsite. During transit, all applicable rules and regulations must be followed. Jobsite storage and handling shall not create a nuisance nor damage the lining materials.

#### 1.05 JOB CONDITIONS

Lining materials shall not be fabricated, stored, or installed in climatic conditions that will adversely affect the quality of the finished lined storage pond.

#### 1.06 ALTERNATIVES

Linings other than those specified shall be submitted well in advance of bid opening with sufficient technical data for an item-by-item comparison of the material properties and performance characteristics. A list of users, including contact persons and phone numbers, is required for consideration of any fabricated lining material.

#### 1.07 WARRANTY

- A. Warranty of Lining Material. Fabricated flexible lining materials, shall be guaranteed in writing by the manufacturer or supplier on a pro-rata basis for a period of twenty (20) years. The guarantee shall be against manufacturing defects of workmanship and against deterioration due to ozone, ultraviolet or other normal weather aging. The guarantee shall be limited to replacement of material only and shall not cover installation of said material, vandalism, acts of animals, or earthquakes and other unusual acts of God.
  
- B. Guarantee of Work. The Contractor shall guarantee the entire Work constructed by him under the Contract to be free of defects in materials and workmanship for a period of two (2) years following the date of acceptance of the Work by the District. The Contractor shall agree to make, at his own expense, any repairs or replacements made necessary by defects in materials or workmanship in the Work which become evident within said guarantee period. The Contractor shall make repairs and replacements promptly upon receipt of written order from the District. If the Contractor fails to make the repairs and replacements promptly, the District may do so, and the Contractor shall be liable to the District for the cost of such repairs and replacements.

#### 1.08 EXPERIENCE OF CONTRACTOR

The Contractor installing fabricated flexible liner shall have demonstrated his ability to perform this Work by having previously successfully installed, in hydraulic structures, a minimum of 1,000,000 square feet of similar type flexible linings.

### **PART 2 - PRODUCTS**

#### 2.01 MATERIALS

- A. Clay shall be equivalent to that available at the Pacific Clay Products Plant in Alberhill, California, with the following properties:
  - 1. Unified Soil Classification "CL".

2. Liquid limit between 25 and 40.
3. Plasticity Index between 20 and 30.
4. Impervious to flow of water when a 12" thick layer is compacted to 90% relative compaction per ASTM D-1557.

B. High Density Polyethylene Geomembrane shall conform to 60 mil Poly-Flex, as available from Poly-America, Inc., Schlegel Lining Technology, Inc., Gundle Lining Systems or approved equal. The technical data is as follows:

<u>PROPERTY</u>	<u>TEST METHODS</u>	
1. Dimensions	ASTM D1593	60 ± 10 mils
2. Density (minimum)	ASTM D1505	.940
3. Tensile Properties	ASTM D638	
a) Tensile Strength at Yield (pounds/inch width)		150
b) Tensile Strength at Break (pounds/inch width)		240
c) Elongation at Break (percent)		600% min.
d) Elongation at Yield (percent)		10% min.
e) Modulus of Elasticity (pounds/square inch)		80,000
4. Tear and Impact Properties		
a) C-Tear Strength	ASTM D1004	90
b) Puncture Resistance	FTMS 101B	300
5. Seam and Adhesion Properties, Field Seam Peel Adhesion (pounds/inch minimum)	ASTM D413	FTB
6. Environmental Resistance Properties		
a. Low Temperature	ASTM D746	-70°

Pond Lining - Clay and Flexible Membrane  
 Section 02598 – 4

b.	Dimensional Stability (percent)	ASTM D1204 212 F,15 min.	± 1
c.	Volatile Loss (percent)	ASTM D1203	0.1
d.	Resistance to Soil Burial (% change max. in original value)	ASTM 3083	
	1. Tensile Strength at Break		10
	2. Tensile Strength at Yield		10
	3. Elongation at Break		10
	4. Elongation at Yield		10
	5. Modulus of Elasticity		10
7.	Ozone Resistance	ASTM D1149 7 days, 100 pphm 104 F, bent loop	No Cracks
8.	Environmental Stress Cracks	ASTM D-1693 Condition C	1000 +
9.	<u>Carbon Black.</u> The HDPE material shall contain not less than 2.0 percent carbon black as determined by ASTM D1603. No other compound ingredients shall be added to the HDPE resin.		
10.	<u>Extrusion Resin.</u> Resin used for extrusion joining of lining sheets and for repairs shall be HDPE produced from, and the same as, the sheet resin. Physical properties shall be the same as the lining sheets.		
11.	<u>Metal Battons, straps, or bars</u> shall be stainless steel, type 304 or better with prepunched slots.		
12.	<u>Anchor Bolts.</u> Anchor bolts shall be Hilti Kwik Bolt SS38-312 as shown on the Plans or approved equal. Nuts shall be copper-silicon alloy or age-hardened stainless steel. Age-hardened stainless steel shall conform to the requirements of ASTM standard A564-81, Type 630. Heat treatment shall be conducted at 900 degrees F. Washers shall be type 303 or 304 stainless steel.		

13. Caulk. Caulk shall be neoprene Gacoflex N-1004 as manufactured by Gaco Western, Inc., Seattle, Washington, or of a type recommended by the manufacturer for use with its material. It shall be delivered in original sealed containers with the brand and name of the manufacturer clearly identified on each.
14. Sponge Rubber. Sponge rubber shall be neoprene, closed cell medium, type SC-42, 1/4 inch thick.
15. Rubber Adhesive. Adhesive shall be neoprene, Python No. 1062, contact type, or of a type recommended by the lining manufacturer.
16. Safety Rope. Safety rope shall be polyester rope, 3/4-inch diameter, with knots tied at 18 inches on center. Ropes shall be secured to 4" x 4" redwood posts located at top of slope as shown on the Plans. The rope shall extend from the post to the toe of the slope.

C. Composite liner shall be Geoseal or equivalent, composite non-woven polypropylene fabric laminated to an impermeable polyethylene membrane. Geoseal is manufactured by Phillips 66 and installed by The Gagle Company, Tulsa, Oklahoma. The typical properties of Geoseal are:

Thickness (ASTM D-751), mils.....	45
Weight (oz./sq. yd.) .....	13.1
Tensile Properties (ASTM D-751)	
Elongation at break (%) .....	46
Breaking strength (lbs.) .....	210
Modulus (100% elongation, lbs.) .....	370
Effect of low temperatures (ASTM D-2136, 1/8" mandrel)	
After 4 hours exposure at 60 F .....	Pass
Effect of high temperatures (ASTM D-1204) on dimensional stability	
After 1 hour exposure at 212 F., % change .....	-0.4
Soil burial (ASTM D-3083)	
Breaking strength (%).....	+5
Elongation at break (%).....	-33
Modulus at 100% elongation (%).....	+23
Fabric breaking strength (%) .....	+5

Pond Lining - Clay and Flexible Membrane  
Section 02598 – 6

Hydrostatic resistance (lbs./inch, minimum) ASTM D-751 .....	350
Bonded seam strength (ASTM, D-751), lbs.....	210
Peel adhesion (ASTM D-413), lbs./in .....	No Peel
Bonded seam strength .....	No change

2.02 MIXES

- A. Clay shall be mixed with water to achieve the consistency recommended by the geotechnical engineer.
- B. Adhesives for all fabricated membranes shall be mixed in strict accordance with the manufacturer's recommendations.

**PART 3 - EXECUTION**

3.01 INSPECTION

- A. Pre-construction Inspection. The Contractor shall inspect the excavated basin prior to bidding. Any access problems, subgrade problems, any structures at pipe penetrations, or other problems that may interfere with or affect the performance of the liner system shall be addressed by the contractor and submitted for approval prior to installation.
- B. Pre-Installation Inspection. The contractor, accompanied by a manufacturer's representative, shall inspect the pond with EMWD's inspector immediately prior to the placement of fabricated liner to ensure mitigation of all factors that may be detrimental to the lining system performance.
- C. Post-Construction Inspection. The installation shall be inspected and certified by a Registered Engineer, to meet the requirements of the appropriate Regional Water Quality Control Board.
- D. Liner Material
  - 1. Clay shall be continuously inspected by a geotechnical engineer during placement.
  - 2. Fabricated liners - in addition to visual checks, all seams shall be tested as follows:
    - a) Metal Probe Test. The Contractor shall run a metal probe along the length of all joints and repairs to ensure that the weld is continuous and absent of leak paths. Defects shall be marked and repaired.

b) Additional Testing. The Contractor shall further test all joints in one of the following methods. All testing shall be done in the presence of the District or his representative. All defective areas shall be repaired to the satisfaction of the District.

(i) Ultrasonic Test. The Contractor shall perform ultrasonic testing by passing a high frequency sound wave through the thickness of the joint.

If any voids, foreign objects, or obstructions are detected, an audible signal shall notify the operator, and the defective area shall be marked for repair.

(ii) Vacuum Test. The Contractor shall perform vacuum testing in the following manner. The area to be tested shall be cleaned of all dust, debris, dirt and other foreign matter. A soap solution shall be applied to the test area with a paint roller and the vacuum box immediately placed over the area of the lining to be tested. A vacuum of 8-10 inches of Mercury (Hg) shall be held as long as necessary for the inspector to record any leaks, as evidenced by bubbles in the soap solution.

E. Hydrostatic Test. A leakage test will be performed on the ponds after the lining system has been installed. The District will fill the reservoir to the high water level. Any leakage through the lining shall be noted over a five day test period as measured at least twice daily using a gauge mounted within the pond. Measurement will be taken by the District.

The District will account for evaporation losses as estimated from an evaporation pan (12 square foot surface area and 8 to 12 inches deep) or similar device. If leakage occurs, the pond shall be drained, inspected and repaired; and the pond shall then be refilled and retested. This process shall be repeated until leakage has been eliminated, with all test costs for the retesting borne by the Contractor.

### 3.02 PREPARATION

All rough grading will be completed and the inlet-outlet piping installed by others prior to bidding. The contractor shall inspect the site prior to bidding and shall be responsible for repair of erosion damage, fine grading, and subgrade preparation necessary prior to and during the lining process. All preparation work necessary for the furnishing and installation of an impermeable liner at the elevations and grades shown shall be the responsibility of the contractor.

A. Clay. All surfaces to be lined with clay shall have all points projecting above subgrade removed and the surface shall be rolled or otherwise compacted to 90% relative compaction prior to placement of clay.

- B. High Density Polyethylene Liners shall have the surfaces prepared in accordance with the manufacturer's recommendations and according to the following. In the event of conflict, the most stringent requirements will govern:
1. Rolling and Compaction. Before final rolling and compaction, the earth subgrade shall be free from abrupt breaks, rocks, cobbles, boulders, debris and other foreign materials. Final rolling and compaction of the surface of earth subgrade shall be done with a vibrating roller or a steel wheel roller weighing not less than 200 pounds per linear inch of drum width. The surface shall be compacted to a minimum relative compaction of 90%. Areas not accessible to the roller shall be compacted by approved mechanical or hand tampers.
  2. Completed Surface. The surface of the completed earth subgrade shall be smooth, uniform and free from sudden changes in grade. Minimum acceptable radius at corners shall be 25 feet.
  3. Maintenance of the Completed Surface. The surface of earth subgrade shall be maintained in a smooth, uniform and compacted condition during installation of the lining. Excessive cracking of the surface shall be repaired as directed by the District. The lining contractor shall be responsible for, and pay for, any necessary repairs to the earth subgrade required as a result of operations of lining installation.
- C. Composite Liners shall have the surfaces prepared per manufacturer's recommendations and according to the following. In the event of a conflict, the most stringent requirements will govern. Erosion damage shall be repaired, and the subgrade shall be smooth and well compacted. It should be free of any angular rocks, stones over 2" in diameter, roots, and other foreign materials. All excess vegetation shall be removed.

### 3.03 INSTALLATION

- A. Clay
1. Shall be installed on the bottom of the pond.
  2. Geotechnical Engineers must supervise placement, water content, compaction and approve densities of placed clay.
  3. Clay shall be a minimum of 12-inches thick.
  4. Clay shall be densified to a minimum of 90 percent relative compaction per ASTM D-1557.

5. Additional clay shall be installed or stockpiled as recommended by the flexible lining contractor to enable construction of a watertight interface to the flexible lining.

B. High Density Polyethylene Geomembrane

1. Shall be installed on the slopes (sides) of the pond if Geoseal is not used.
2. The sheets shall be of lengths, widths, and placed to minimize field joining.
3. Sand Bags. Sand bags shall be used as required to hold the lining material in position during installation. Sand bags shall be sufficiently close-knit to preclude fines from working through the bottom, sides or seams of the bags. Paper bags, whether or not lined with plastic, will not be permitted. Burlap bags, if used, must be lined with plastic. Bags shall contain not less than 40 nor more than 60 pounds of sand, having 100 percent passing a number 8 screen and shall be tied closed after filling. Bags that are split, torn, or otherwise losing their contents shall be immediately removed from the work area and any spills immediately cleaned up.
4. Field Joints. Joints between the lining sheets shall be field welded using the manufacturer's recommended procedures and equipment. Field joints shall be made by overlapping adjacent sheets a minimum of four (4) inches.
5. Repairs. Any necessary repairs to the HDPE geomembrane shall be made with the same material as the lining, using the manufacturer's recommended procedures and equipment for field welding.
6. Anchoring. The liner shall be anchored in accordance with manufacturer's recommendations.

C. Composite liner. May be used in lieu of High Density Polyethylene Geomembrane on the pond slopes (sides).

1. Material Layout and Anchors. The panels shall be joined with the polyethylene side up and shall be anchored on a grid spacing not to exceed fifteen feet between anchor points. Unless otherwise stipulated, the outside edges of the panels shall be terminated along the top of the slope and placed in a peripheral trench no less than one foot deep and six inches wide. After placing the terminal end of the liner in a "J" configuration in the trench, it shall be secured by backfilling and compacting the excavated trench materials.

2. Field Joints. Seams shall be formed by matching the polyethylene surfaces and shall be stitched a minimum width of 1 inch from the outside edge, using polypropylene thread #207 or equivalent. The seam channel above the thread shall be cleared of all dirt and foreign material to ensure suitable bonding surface. The seams shall be made watertight by the application of extruded polyethylene.

When it is not possible to make a sewn joint, a butt joint can be substituted. A butt joint consists of joining the edges of the material together by securing a backup strip of the liner material, polypropylene sides together, with hot adhesive and then sealing the gap with the extruded polyethylene.

#### 3.04 FIELD QUALITY CONTROL

- A. Clay. All excavation, placement, moisture control, and densification shall be supervised by a Geotechnical Engineer. The clay at the fabricated liner interface shall be restored in accordance with both the geotechnical engineer's and fabricated liner manufacturer's recommendations.
- B. Fabricated Liners
  1. All joints and seals on completion of the Work shall be tightly bonded. Any lining surface showing injury due to scuffing or penetration by foreign objects or distresses shall be replaced or repaired as directed by the District.
  2. Visual Inspection. A visual inspection of the lining and joints shall be made by the Contractor as the installation progresses and again upon completion of the installation. Defective or questionable areas shall be clearly marked and repaired.

#### 3.05 CLEAN-UP

Clean-up within the work area shall be an ongoing responsibility of the Contractor throughout the course of the Work. Particular care shall be taken to ensure that no trash, tools, and other unwanted materials are trapped beneath the lining. Care shall be taken to ensure that all scraps of lining material are removed from the work area prior to completion of the installation.

**END OF SECTION 02598**