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1.0 SCOPE AND REQUIREMENTS

1.1 Work Scope

The work scope of these Technical Specifications is to set out the requirements and procedures necessary to complete the construction of earthwork, geosynthetics, and pipework for the Eagle Gold heap leach pad (HLP). Any alternatives or exceptions to these Specifications shall be submitted in writing to the Owner and shall require approval in writing from the Owner prior to implementation of the Work.

The work scope generally includes the following: site preparation, fill placement, geosynthetics installation, and pipework installation. The process solution pumps and facilities, ore delivery and heap stacking equipment, and their associated structures are not part of these Technical Specifications. Specific features of the work scope include, but are not limited to the following:

- Mobilization/demobilization of all equipment and material required for the work;
- Installation of temporary and permanent diversions for surface water control;
- Clearing, grubbing and stripping in required areas;
- Excavation in required areas;
- Development of borrow areas within and outside the HLP limits;
- Construction of temporary and permanent access roads;
- Foundation preparation for site grading fill and liner placement;
- Fill placement and compaction;
- Installation of geosynthetic materials for liner, drainage and leak detection systems;
- Installation of leach pad gravity flow drain pipework (solution collection piping); and
- Placement of liner cover drain fill; and
- Furnishing and installing all materials and constructing all items appurtenant and incidental to the above.

The construction plans and the quality of the constructed leach pad and collection ponds are important aspects of this project. All earthwork and geosynthetic construction Quality Assurance/Quality Control (QA/QC) test locations and results shall be summarized in an as-built report, a copy of which shall be kept in the Owner's files at the completion of each phase of the HLPF.

1.2 General Technical Requirements

The general technical requirements specified herein shall apply to all activities and operations relating to carrying out the Work or as required by the Engineer or the Owner.

In the event of a contradiction in the Technical Specifications and Drawings, the Contractor shall refer all questions to the Engineer for final decision. Work that concerns the contradiction shall not be performed until the contradiction is remedied or explained by the Engineer. In all events, the decision of the Engineer is final.

1.3 Submittals

Any alternatives or exceptions to these Technical Specifications shall be submitted in writing with the Contractor's bid.

The Contractor shall provide the Owner and Engineer with the procedures and equipment to be used for surveying and construction, and the material specifications. This is required for review and approval prior to the Work being allowed to commence and the materials brought to the Site.

1.4 Definition of Terms

"Owner" is defined as an authorized representative of Victoria Gold Corp.

"Engineer" is defined as representative appointed and authorized by the Owner. The Engineer shall be a Registered Professional Engineer or a designated site representative under the supervision of a Registered Professional Engineer.

"Contractor" is defined as the party which has executed a contract agreement with the Owner for the specified Work.

"Technical Specifications" is defined as this document, prepared by Tetra Tech (Tt), and all supplemental addenda.

"Drawings" are defined as the Drawings, in conjunction with these Technical Specifications, entitled "Final Design Drawings, Heap Leach Pad Facility, Eagle Gold Project" prepared by Tt and dated November 2011.

"Work" is defined as the entire completed construction, or the various separately identifiable parts thereof, required to be furnished under the Contract Documents.

"Site" is defined as the project area where the Work is to be performed.

"Contract Documents" are defined as the Agreement, Addenda, Contractor's Bid (when attached as an Exhibit to the Agreement), Bonds, General Conditions, Special Conditions, Technical Specifications, Drawings, and all modifications issued after execution of the Agreement.

"Modifications" are defined as changes made to the Technical Specifications or the Drawings that are approved by the Owner and Engineer in writing after the Technical Specifications and Drawings have been finalized.

2.0 MOBILIZATION AND DEMOBILIZATION

2.1 Mobilization

The Contractor shall mobilize to the Site sufficient labor, materials, and equipment to allow commencement of the Work. The Contractor shall bring onto the Site, as and when necessary, any additional equipment, labor, and materials which may be required to complete the remainder of the Work in the time specified in the General Terms and Conditions.

2.2 Contractor's Workshops, Stores, and Offices

The Contractor shall erect, in the area designated by the Owner and Engineer, adequate workshops, offices, and other buildings and structures for the completion of the Work as designated in the Contract Documents. Such workshops, offices, etc. shall be maintained in a neat and tidy condition throughout the duration of the Work to the satisfaction of the Engineer and Owner.

2.3 Sanitation

The Contractor shall provide and maintain adequate sanitary facilities for the personnel at the Site, including the Contractor's offices and Engineer's offices, in compliance with local health regulations and to the satisfaction of the Engineer and Owner.

2.4 Construction Roads

All temporary construction roads, which the Contractor may require to complete the Work, shall be constructed at the Contractor's expense. The location of any temporary roads, or portions thereof, on the Site shall be subject to the Owner's and Engineer's approval prior to construction. Unless otherwise approved by the Owner, all temporary roads shall be reclaimed at the Contractor's expense upon completion of the Work.

2.5 Drainage

Adequate drainage facilities in the form of ditches, culverts, or other conduits shall be installed as necessary to protect the Work and to maintain temporary construction or access roads. These temporary drainage facilities shall be constructed to the satisfaction of the Engineer and Owner.

2.6 Demobilization

Upon completion of the Work, the Contractor shall remove all of the Contractor's equipment and materials from the Site. The Site shall be left in a clean and tidy state to the satisfaction of the Engineer and Owner. All waste and refuse shall be disposed of in a manner acceptable to the Owner.

3.0 CLEARING, GRUBBING, STRIPPING, AND STOCKPILING

The natural ground surface shall be cleared, grubbed and stripped of all organic and objectionable materials by the Earthwork Contractor to the limits shown on the Drawings or as required by the Owner. The limits of stripping shall generally be 3 m outside of the Work activity areas as shown on the Drawings. All usable topsoil, as determined by the Owner, shall be properly stockpiled in locations shown on the Drawings or designated by the Owner.

Clearing and grubbing shall mean the removal of vegetation and roots. Stripping shall mean the removal of topsoil, which shall be defined as soil of any gradation or degree of plasticity that contains significant quantities of visually identifiable vegetable matter, sod, roots, or humus as determined by the Engineer, or that can be used as growth medium. The depth of topsoil to be removed will be determined by the Engineer based on the character and thickness of material encountered. Clearing and grubbing may generally be conducted as a single operation together with stripping.

Prior to stripping, the topsoil may require moisture conditioning to the satisfaction of the Engineer in order to prevent the loss of fines and to maintain dust control. The Earthwork Contractor shall allow sufficient time after pre-wetting for the moisture to be evenly distributed throughout the topsoil layer prior to removal. The topsoil may need to be ripped prior to moisture conditioning to allow the moisture to be evenly distributed throughout the topsoil layer. The decision of when to rip the topsoil and how often for the purpose of moisture conditioning shall be determined by the Engineer. Additional moisture conditioning may be required on stockpiled materials as determined by the Engineer.

Stripping shall be carried out using whatever method deemed necessary providing it is consistent with producing an acceptable end result as determined by the Owner. Any stripping beyond the limits shown on the Drawings, or as required by the Owner, shall be subject to the approval of the Owner. Unapproved stripping will be subject to remediation at the sole expense of the Earthwork Contractor.

After stripping of the required area, the ground surface shall be treated as specified on the Drawings or in these Technical Specifications. This activity can involve trimming and shaping the surface, scarifying, moisture conditioning, and compacting fill material. Prior to any surface treatment on a stripped area, the Engineer shall be notified to inspect the stripped area and designate the method of treatment.

3.1 Excavation

Excavation shall consist of excavating to the lines and grades shown on the Drawings and hauling materials to designated fill, stockpile, or waste areas. Excavation methods, techniques, and procedures shall be developed by the Earthwork Contractor with due consideration of the nature of the materials to be excavated and shall include all precautions that are necessary to preserve, in an undisturbed condition, all areas outside the lines and grades shown on the Drawings or required by the Owner. The work shall be carried out by whatever method considered most suitable providing it is consistent with producing an acceptable end result as determined by the Engineer.

No excavation beyond the lines and grades shown on the Drawings, or as required by the Engineer, shall be done without the prior written approval of the Owner. If such additional excavation is done without the prior written approval of the Owner and, in the opinion of the Engineer, requires backfilling in order to satisfactorily complete the Work, such backfilling shall

be completed at the Contractor's expense. All such backfilling will be subject to approval by the Engineer.

Pockets of unsuitable materials within the limits of an excavation shall be removed and disposed of as directed by the Owner and Engineer. Unsuitable materials may include, but not be limited to, ash, boulder or gravel zones, soft saturated zones, highly organic zones, drilling mud pits, and other deleterious material.

Topsoil and waste stockpiles shall be leveled, trimmed, and shaped as required by the Owner to prevent the occurrence of ponding or concentrations of surface runoff and to provide a neat appearance. Finished slopes of the topsoil stockpiles shall be graded to 2.5H:1V (horizontal: vertical) for interim reclamation. All surface water runoff shall be directed to existing surface water management structures.

3.2 Subgrade Preparation

After clearing, grubbing, stripping, and excavating, the exposed subgrade surface shall be inspected and evaluated by the Engineer for the presence of loose or soft areas or unsuitable material prior to fill placement or geomembrane installation. Evaluation methods will depend on the location and the materials that will be placed over the subgrade and on the prevailing field conditions. Evaluation methods may include proof-rolling with a loaded dump truck or similar pneumatic-tired equipment to ensure that the surface is firm and smooth. Probing with a metal rod may also be performed. Soft or yielding areas delineated by the evaluation that cannot be stabilized by compacting shall be removed and replaced with site grading fill. Unsuitable materials shall also be removed and replaced with site grading fill as directed by the Engineer. The subgrade shall be prepared to the satisfaction of the Engineer.

If deemed necessary by the Engineer, evaluation of the subgrade soils may include excavating test pits to allow the Engineer to designate the method of surface treatment, as needed. The Earthwork Contractor shall, under the direction of the Engineer, excavate shallow test pits oriented as directed by the Engineer. The pits may cover the entire Work area and any other area designated by the Engineer and shall be spaced as directed by the Engineer. The pits may be excavated by whatever method the Contractor deems necessary provided it produces a clearly visible cut face in the soils. After the pits have been examined and logged by the Engineer, they are to be backfilled by backfilling the excavated material back into the pits and compacting in layers to the surface to the satisfaction of the Engineer.

Stripped rock subgrade surfaces and rock outcrops in at-grade areas shall be cleared of loose rock fragments greater than 50 mm in size and wetted in preparation for foundation preparation. Foundation preparation shall consist of placing and compacting granular soil fill material in varying thicknesses to suit field conditions to support the leach pad and collection ponds liner systems. The granular fill shall be placed and compacted as specified in the Site Grading Fill Placement Section of these Technical Specifications.

Soil subgrade surface receiving site grading fill or geomembrane shall be scarified to a minimum depth of 6 in, moisture conditioned if necessary to within plus or minus two (±2) percent of the optimum moisture content as determined by the Standard Proctor test (ASTM D-698), and recompacted to a minimum of 95 percent of the maximum dry density (ASTM D-698).

Soil subgrade surface receiving geosynthetics shall be prepared such that it is smooth and free of protruding rocks, vegetation, or any other materials, or objects deemed unsuitable by the Engineer. In areas where rocks larger than 38 mm are protruding, the rocks shall be removed

and replaced with compacted fine-grained soil material. This may also be performed in other areas to produce a relatively smooth surface suitable for installation of the liner system.

The Contractor shall modify (smooth) the existing contours such that the finished subgrade surface approximately conforms to the dimensions shown on the Drawings. While exact contours are not required, the Contractor shall maintain positive drainage and ensure that there are no abrupt changes in grade that would prohibit placement of, or create stress in, the overlying liner systems. No site-grading fill shall be placed, until the stripped and reworked areas have been inspected and approved by the Engineer.

3.3 Borrow Development

The majority of the site grading fill will consist of rockfill excavated from mine pre-stripping operations that will generate quality, clean re-crystallized limestone. The Contractor shall also excavate, haul, place and compact site grading cut materials from required excavations within the limits of the HLP including leach pad, collection ditch, conveyor corridors, collection ponds, and diversion channels, as shown on the Drawings. In addition, the Owner will designate borrow areas and limits outside the HLP for the Contractor to excavate, haul, place and compact site grading fill and clay soil liner fill, as needed. The Owner plans to stockpile crushed ore materials adjacent to the pad limits for the Contractor to haul and place as drain cover fill above the pad liner.

The Contractor may select and use any Owner/Engineer approved borrow area for his construction materials provided the materials meet the Specification requirements for the intended use. Representative tests shall be conducted by the Engineer on the borrow materials in the field or at an offsite laboratory to determine the materials' suitability for use as fill. It shall be the Contractor's responsibility to notify the Engineer of changes in borrow materials in advance of development to allow time for representative testing without unduly interrupting construction activities.

Should a borrow material prove to be unsuitable for fill, a new borrow source shall be designated by the Owner, or the Contractor's processing operations shall be adjusted to produce acceptable fill material meeting the Specifications.

The Contractor shall liaise with the Owner, as needed, to schedule and coordinate the production and/or stockpiling of acceptable borrow materials from the mine pit area and other sources onsite and offsite for the execution of the Contractor's work.

Acceptable borrow areas shall be cleared, grubbed, and stripped in stages, as approved by the Owner/Engineer, to minimize ground disturbance. Each stage of stripping shall be sufficient in areal extent for the Contractor to operate conventional earthwork equipment for conditioning and excavating materials acceptable for fill placement. Moisture conditioning in preparation for fill placement, if required, shall be done in the borrow areas as much as practical.

The final surfaces of all borrow areas developed by the Contractor shall be left in reasonably smooth, even conditions and graded to drain for long-term stability. Final surface grading shall be by dozer or grader blade operations, as approved by the Engineer. Final cut slopes shall be no steeper than 2H:1V unless approved by the Engineer. The Contractor shall replace stripped topsoil cover over the final borrow cuts, unless otherwise approved by the Owner.

3.4 General Fill Placement Procedures

All materials used for fill shall be loaded and hauled to the placement site, dumped, spread, and leveled to the specified layer thickness, moisture conditioned if required, and compacted to form a dense integral fill in accordance with these Technical Specifications and to the approval of the Owner and Engineer.

Under most conditions, the fill shall be constructed in near horizontal layers with each layer being completed over the full length and breadth of the zone before placement of subsequent layers. Each zone shall be constructed with materials meeting the specified requirements and shall be free from lenses, pockets, and layers of materials that are substantially different in gradation from the surrounding material in the same zone as determined by the Engineer. All fill placed shall be free from organic debris, frozen soil, ice, or other unsuitable materials. All oversized material shall be removed from the fill material either prior to it being placed or after it is dumped and spread but prior to compaction.

All particles that have dimensions that will interfere with compaction in the specified layer thickness, as determined by the Engineer, shall be removed from the zone in which they were placed either prior to or during compaction.

As approved by the Engineer, fill may be compacted by routing the hauling and spreading equipment approximately parallel to the long axis of fill. The hauling equipment shall be routed in such a manner that they do not follow the same paths but spread their traveled paths evenly over the surface of the fill.

Moisture conditioning is the operation required to increase or decrease the moisture content of material to within the specified limits. If moisture conditioning is necessary, it shall be carried out by whatever method the Earthwork Contractor deems suitable provided it produces the moisture content specified in these Technical Specifications or designated by the Engineer. The moisture shall be distributed uniformly throughout each layer of material being placed immediately prior to compaction. Measures shall be adopted as necessary to ensure that the designated moisture content is preserved after compaction and until the succeeding layer is placed.

Should the surface of the fill become rutted or uneven subsequent to compaction, it shall be regraded and recompacted before the next layer of fill is placed. To permit suitable bonding with the subsequent layer if necessary, the surface material shall be loosened by scarifying or disk harrowing, as approved by the Engineer, and if necessary, it shall be moisture conditioned before an additional layer is placed.

Compaction of each layer of fill shall proceed in a systematic, orderly, and continuous manner approved by the Engineer to ensure that each layer receives the compaction specified. The rolling pattern for compaction of all zone boundaries or construction joints shall be such that the full number of roller passes required in one of the adjacent zones, or on one side of the construction joint, extends completely across the boundary or joint.

Fill shall not be placed on frozen soil or when air temperatures drop below 0°C unless otherwise approved by the Engineer.

3.4.1 Compaction Equipment

Sufficient compaction equipment shall be provided as necessary for compaction of the various fill materials. Compaction equipment shall be maintained in good working condition at all times to ensure that the amount of compactive effort obtained is a maximum for the equipment.

Before commencing Work with the proposed compaction equipment, the Owner and the Engineer shall be provided with a list of each piece of equipment to be used together with the Manufacturer's specifications.

If alternative equipment than initially proposed is to be used, a submittal shall be made to the Engineer for approval of the equipment, and the submittal shall give complete details of such equipment and the methods proposed for its use. The Engineer's approval of the use of alternative equipment may be dependent upon completion of suitable test fills, to the satisfaction of the Engineer, to confirm that the alternative equipment will compact the fill materials to the specified density.

The use of mine haul trucks or scrapers as compaction equipment shall be acceptable provided that test fills confirm the fill materials can be adequately compacted with the proposed equipment.

The following compaction equipment and specifications may be considered.

3.4.2 Smooth Steel Drum Vibratory Roller

Smooth steel drum vibratory rollers shall be equipped with a suitable cleaning device to prevent the accumulation of material on the drum during rolling. Each roller shall have a total static weight of not less than 9,000 kg at the drum when the roller is standing on level ground. The drum shall be not less than 1.5 m in diameter and 2 m in width. The vibration frequency of the roller drum during operation shall be between 1,100 and 1,500 vibrations per minute, and the centrifugal force developed by the roller, at 1,250 vibrations per minute, shall not be less than 170 kN. The power of the motor driving the vibrator shall be sufficient to maintain the specified frequency and centrifugal force under the most adverse conditions, which may be encountered during the compaction of the fill.

3.4.3 Tamping Foot Roller

The tamping foot roller shall be a self-propelled, fully ballasted, standard tamping foot design developing 75 kN per linear m of width at rest on level ground, or equivalent, as approved by the Engineer.

3.4.3.1 Special Compactors

Special compactors and compaction measures shall be used to compact materials that, in the opinion of the Engineer, cannot be compacted properly by the specified roller because of location or accessibility. Such special compactors and measures may include hand-held vibratory compactors or other methods approved by the Engineer to compact fill in trenches, around structures, and in other confined areas that are not accessible to the larger vibratory roller or tamping foot roller. All compaction shall be to the specified density.

3.5 Site Grading Fill

Site grading fill will be placed within the HLP limits to achieve the desired final grades as shown on the Drawings.

3.5.1 Material Requirement

Material for compacted site grading fill may consist of any material which, when compacted, is suitable for use in the various parts of the Work. The site grading fill material will have a wide

range of Unified Soil Classifications and may contain significant variations in gradation and compaction properties. Materials that contain or are contaminated by organic matter are not suitable for use as site grading fill. Site grading fill will be placed in areas where the material is not required to be of uniform character and engineering properties. The site grading fill will be obtained from several sources including from required excavation or regrading activities within the HLP limits (leach pad, collection ditch, collection ponds, and diversion channels), and from borrow areas.

Site grading rockfill shall be used to fill the valleys at the toe and along the east side of the leach pad to the lines and grades shown on the Drawings. Site grading rockfill shall also be used to construct the collection ponds embankments. The rockfill will have more than 30 percent particles larger than 19 mm, and the maximum rock particle size shall be no more than two thirds the loose thickness of the fill lift. The rockfill shall generally have 300-mm maximum rock particle size and oversized rocks larger than 300 mm shall be removed to the exterior fill slopes. Rocks larger than 300 mm may be incorporated in thicker fill lifts provided the rocks do not protrude from the lift surfaces after compaction, and the required compaction of the lifts is proven achievable by a test fill.

Site grading soil fill shall generally include inorganic soils with less than 30 percent particles larger than 19 mm and a maximum 150-mm particle size. Soft, weathered rock that breaks down during the excavation, hauling, and processing operations to form essentially a soil and compacts without excessive voids may be used for site grading soil fill, as approved by the Engineer. Materials containing large size, sound rock or cobbles and gravels from required excavations may be used as site grading fill subject to the Engineer's approval and provided the rock is reasonably graded such that large void spaces do not result. The maximum particle size in the fill shall be no larger than two-thirds the fill compacted lift thickness, unless otherwise approved by the Engineer. Oversized materials shall be removed from the fill.

3.5.2 Placement

The surface upon which site grading fill is placed shall be prepared as specified in the Subgrade Preparation Section of these Technical Specifications.

The site grading soil fill material shall be placed and spread in the fill to form lifts which shall not exceed 0.3 m in loose thickness unless otherwise specified by the Engineer and proven to achieve the specified compaction in a test fill. The actual lift thickness may need to be less than 0.3 m in loose thickness to meet the compaction requirement. Cobbles and boulders that are large enough to interfere with the construction of the designated lift thickness shall be removed and disposed of in areas specified by the Owner.

After spreading, the site grading soil fill material shall be moisture conditioned, if necessary, by sprinkling and disk harrowing until a uniform distribution of moisture is obtained. Material that is too wet may be spread on the fill area and permitted to dry, assisted by disking and harrowing if necessary, until the moisture is reduced to an amount within the specified limits. The Contractor shall utilize all measures necessary to achieve a moisture content for site grading soil fill within plus or minus two (±2) percent of the optimum moisture content as determined by the Standard Proctor test (ASTM D-698), distributed uniformly throughout the lift of material being placed, immediately prior to compaction. The Contractor shall utilize whatever measures necessary to ensure that the designated moisture content is preserved after compaction until the succeeding lift is placed. The Engineer may specify deviation from the moisture content limits provided the required compaction is achieved. Each site grading soil fill lift shall be compacted to a minimum of 95 percent of the maximum dry density (ASTM D-698).

The site grading rockfill material shall also be spread in individual lifts and shall be conditioned, placed and compacted according to the specifications derived from the results of a test fill. The rockfill lifts shall generally not exceed 0.5 m in loose thickness unless otherwise specified by the Engineer and proven to achieve the specified compaction in the test fill. The actual lift thickness may need to be less than 0.5 m in loose thickness to meet the compaction requirement. The test fill procedures are outlined in the following section.

3.5.3 Test Fills

Test fills shall be conducted according to US Army Corps of Engineers standards to establish the specifications for the proper placement and compaction of site grading rockfill having more than 30 percent particles larger than 19 mm. Test fills shall also be conducted if circumstances arise where they are deemed necessary by the Engineer such as in order to determine if greater or lesser lift thicknesses are appropriate for certain soils and to still meet the design intent for site grading fill. The type of compaction equipment, number of passes, and maximum particle size and loose lift thickness to be used in the Work will be approved by the Engineer in writing based on the acceptable test fill performance. The Contractor shall outline his proposed procedures for moisture conditioning and fill placement and submit them to the Engineer for review and approval.

The test fill shall be constructed within the limits of the Work to determine the compactive effort required to be applied to a particular material or increased lift thickness. The test fill shall be sufficiently wide to support the compaction equipment. The proposed compaction equipment to be used in actual site grading fill placement shall be routed over the test fill.

In the soil test fill, the number of compaction equipment passes shall be counted, and, at certain numbers of passes, in-place density tests shall be performed by the nuclear gauge method (ASTM D-2922) or sand cone method (ASTM D-1556). This process shall be repeated until a curve representing number of passes versus density is generated. This information will allow the Engineer to evaluate the optimum density of the soil and the corresponding number of passes. This will establish a guideline for the compaction procedure required during construction.

For rockfills, the data to be collected from the test fill shall include the following:

- Lift thickness of 0.3, 0.6, and 0.9 m (three test fills to establish optimum lift thickness);
- Amount of settlement after every two passes of compactor to a maximum of 25 passes;
- Gradation and moisture content of in-place material; and
- In-place fill density at completion of the test fill by nuclear gauge method (ASTM D-2922) or sand cone method (ASTM D-1556), as approved by the Engineer.

A curve showing change in rockfill lift settlement versus number of passes shall be produced from the data. The minimum number of passes to achieve acceptable compaction will be the number required to achieve 80 percent of the total settlement obtained after no fewer than ten complete passes of the compaction equipment. The lift thickness and minimum number of passes with compaction equipment shall be approved by the Engineer after review of test fill data.

Upon completion of each test fill, a test fill report shall be generated that must include all appropriate documentation pertinent to the test fill, including but not limited to, field and laboratory test results, graphics displaying the aforementioned curves, photographs, and a written narrative of the test fill and results.

3.6 Seal Zone Fill

The intent of the design is to construct a 0.3-m minimum compacted thickness of low-permeability clay soil liner beneath the geomembranes of the leach pad and collection ponds. Low-permeability clay soil fill will also be used to construct the cell divider berms and the pad phase berms within the leach pad as shown on the Drawings. Prior to placement of the low-permeability clay soil liner, the Contractor (under the Engineer's supervision) shall survey the liner area using a survey grid pre-approved by the Engineer to determine the base elevation of the low-permeability clay soil liner. This will establish a means to verify the clay soil liner thickness post placement.

If the in-place material is not suitable for seal zone fill, then suitable material shall be imported from required excavations within the HLP limits and/or from borrow sources. Imported seal zone fill material shall be placed in two 0.15 m thick lifts (after compaction) and be moisture conditioned if necessary and compacted according to the requirements stated above. Prior to placing the second lift, and if necessary, the surface of the first lift shall be scarified to a depth of 50 mm or otherwise roughened to ensure complete bonding between the lifts, as directed by the Engineer.

Moisture conditioning of seal zone fill material to adjust the measured moisture content shall occur when the material is in a loose condition such as after scarifying or during placement of imported materials and never after compaction. The seal zone fill material shall be scarified, mixed, and moisture conditioned, if necessary, by sprinkling and disk harrowing until a uniform distribution of moisture is obtained. Material that is too wet may be spread on the fill area and permitted to dry, assisted by disking and harrowing if necessary, until the moisture content is reduced to within the specified limits.

The seal zone fill layer, following conditioning and compaction, shall be in aggregate not less than 0.3 m in thickness. The Contractor shall adopt removal of oversized or protruding particles, and in general all holes greater than 19 mm shall be filled with compacted clay soil liner material.

The Contractor shall be responsible for keeping the seal zone fill surface from desiccating by lightly sprinkling it with water or otherwise protecting it. The Contractor shall be responsible for repairing any desiccation cracks in excess of 50 mm deep by scarifying the soil to a depth below the cracks, moisture conditioning, and recompacting the material to the specified moisture/ density requirements for the clay soil liner. Desiccation that is less than 50 mm deep shall be repaired in a manner mutually agreed upon by the Contractor and Engineer. The Contractor shall also be responsible for protecting the seal zone fill from erosion or other damage. All repairs shall be the responsibility of the Contractor. Areas that are repaired by the Contractor shall be retested for conformance with the Specifications.

After the seal zone fill has been sealed, the Contractor shall survey the top of the clay soil liner surface. In areas where fill materials have been placed for clay soil liner construction, the Engineer shall verify the clay soil liner thickness. At no location shall the thickness of the clay soil liner be less than 0.3 m. The Contractor shall submit a survey grid for approval by the Engineer at a spacing that demonstrates compliance with the Specifications.

3.6.2 Material Requirement

In-place or imported low-permeability clay soil liner material meeting the requirements stated herein shall be acceptable. If suitable in-place clay soil liner material cannot be found as

specified by the Engineer, additional material, which meets the material requirements, shall be imported from excavations within the HLP limits or designated borrow areas. Suitability of soils in this category is dependent on the properties of gradation, plasticity, strength and permeability to provide a suitable foundation for the geomembranes of the pad and collection ponds.

The seal zone fill material shall have a minimum Plasticity Index (PI) of 15 as determined by ASTM D-4318, and its coefficient of permeability shall be no greater than 1×10-7 m/sec as determined by ASTM D-5084 when compacted to the requirements stated below. The Engineer will have the authority to approve variations to the compaction and moisture content requirements as long as the minimum permeability requirement is achieved. The Engineer will determine the suitability of the material for use as seal zone fill material. The seal zone fill material shall conform to the following gradation.

ASTM Sieve Size	Percent Passing
75 mm	100
No. 4	60-100
No. 200	35-100

Seal zone fill material shall be free of organic matter in quantities that would adversely affect the performance of the HLP, as specified by the Engineer.

3.6.3 Placement

Where suitable material exists in-place, the top 0.15 m of the material shall be removed and windrowed to allow access to the lower half of the seal zone fill layer. The lower 0.15 m of the clay soil liner shall be scarified by disking or other approved means, moisture conditioned if necessary, and compacted to minimum of 95 percent of the maximum dry density at a moisture content between -2 and +1 percent of the optimum, as determined by the Standard Proctor test (ASTM D-698). Once the compaction of the lower layer has been confirmed, the upper 0.15 m of material shall be spread across the surface; moisture conditioned if necessary, and compacted according to the requirements stated above.

3.7 Granular Fill

3.7.1 Fine Filter Zone

Fine filter zone material shall be used to construct the leach pad liner cover fill and the process pond leak detection sump, as shown on the Drawings. The drain fill material shall be produced from crushing and/or screening operations of ore and/or mine waste, and/or from screening of sand and gravel aggregate from borrow sources. Crushed low grade ore will be used predominantly as the pad liner drain cover fill material, and crushed mine waste rock will be used for the process pond leak detection sump. The Owner shall provide the drain fill material in stockpiles near the crusher site and/or shall designate a borrow source for the drain fill. The material shall be free of organic matter and soft, friable particles in quantities objectionable to the Engineer.

3.7.1.1 Material Requirement

The fine filter zone material for the leach pad liner cover fill shall consist of free-draining granular material with 25-mm maximum particle size and a maximum of 5 percent fines passing the No. 200 ASTM sieve size (0.075-mm).

Fine filter zone material shall be used in constructing the process pond leak detection sump. The select drain fill shall consist of hard and durable free-draining fine gravels with 12.5-mm maximum particle size and a maximum of 3 percent passing the No. 200 ASTM sieve size (0.075-mm).

The drain fill shall have an operational permeability of $1x10^{-4}$ m/sec or greater when tested in accordance with the constant-head method described in ASTM D 5856, using a hydraulic gradient of 1.

3.7.1.2 Placement

Fine filter zone material material shall be placed in such a manner as to reduce segregation and construct the zones in accordance with the details and to the lines and grades shown on the Drawings, or as specified by the Engineer. Methods shall be developed on site for placing the material in a manner that will protect the drain pipework from damage and keep compaction of the material to a minimum. Any drain fill material that has received too much compaction shall be scarified to a loose condition without damage to the underlying geomembrane and pipework.

The pad liner cover fill above the geomembrane shall be placed in 0.3 m maximum loose lifts by suitable dozer and truck equipment, as approved by the Engineer. A thicker layer, a minimum of twice the pipe diameter, shall be placed above the larger diameter primary collection drain pipes as detailed on the Drawings. No moisture conditioning or compaction is required. Haul truck speeds, braking, and turning during drain cover fill placement shall be strictly controlled by the Contractor to prevent damage to the underlying geomembrane and pipework. The cover fill thickness shall also be increased in concentrated traffic areas or across collection pipes, as required, to prevent damage to the geomembrane and pipework. Haul traffic on the cover fill surface shall be spread out as much as practical to prevent over-compaction of the cover fill in localized areas.

Fine filter zone material to construct the process pond leak detection sump shall be placed in a single lift thickness with no moisture conditioning or compaction. The top surface of the select drain fill shall be hand leveled in preparation for geocomposite placement. Any loose particles spilled outside of the backfilled sump area shall be removed from the pond's bottom geomembrane surface to prevent geomembrane puncture.

3.7.2 Coarse Filter Zone

3.7.2.1 Material Requirement

Generally, the granular fill material shall be produced from crushing and/or screening alluvial or competent rock sources or borrow sources and shall consist of well-graded sandy gravel. The coarse filter zone material shall conform to the following gradation.

ASTM Sieve Size	Percent Passing
450 mm	100
150 mm	30
No. 200	5

Coarse filter zone material shall have a coefficient of uniformity (Cu) shall be less than 6 when tested in accordance with ASTM D 422 or ASTM C 136.

3.7.3 Placement

The coarse filter zone material for subgrade preparation shall be placed and spread in the fill to form lifts which shall not exceed 200 mm in loose thickness unless otherwise specified by the Engineer and proven to achieve the specified compaction. The layer shall be graded to form a relatively smooth surface, free of rock pockets or protrusions of rock fragments.

The coarse filter zone material shall contain enough moisture to produce a homogeneous, smooth, and compacted layer. To achieve this, the Contractor may be required to moisture condition the material in the processing operation before placement, or after spreading but before compaction.

3.7.4 Compacted Rock Fill

The intent of the compacted rock fill is to form the Embankment to hold the waste rock for heap leach operations.

3.7.4.1 Material Requirement

Compacted rock fill shall consist of rock excavated from mine pre-stripping operations that generate relatively high strength, durable and relatively clean marbleized limestone resistant to weathering and to water action, and free of potentially acid-generating rock, shale, soil, organic, deleterious, or other objectionable material. Rounded rock, in general, is not desirable. The quality of the material must be approved by the Engineer prior to removal from the processed stockpile.

The maximum particle size for the compacted rock fill shall be no greater than 2/3 the fill loose lift thickness as determined in test fills and all rock fill material shall contain more than 30 percent particles larger than 19mm.

Rock fill shall be competent material with a minimum strength rating determined by ISRM methods of R3, moderately strong rock.

3.7.4.2 Placement

The Contractor shall place the rock fill in maximum loose lifts and compact in accordance with specifications derived from results of test fills.

3.7.5 Overliner Drain Fill

Overliner drain fill shall be used to construct the leach pad liner cover fill and the process pond leak detection sump, as shown on the Drawings. The drain fill material shall be produced from crushing and/or screening operations of sand and gravel aggregate from borrow sources. Crushed cobbles and boulders screened from placer fill deposits in Dublin Gulch and/or crushed competent rock from site excavations are anticipated as the primary source. The material shall be free of organic matter and soft, friable particles in quantities objectionable to the Engineer.

3.7.5.1 Material Requirement

The overliner drain fill shall consist of free-draining granular material with 38-mm maximum particle size and a maximum of 5 percent fines passing the No. 200 ASTM sieve size (0.075-mm).

The drain fill shall have an in situ hydraulic conductivity of $2x10^{-4}$ m/sec or higher when tested in accordance with the constant-head method described in ASTM D 5856, using a hydraulic gradient of 1.

3.7.5.2 Placement

The overliner drain fill material shall be placed in such a manner as to reduce segregation and construct the zones in accordance with the details and to the lines and grades shown on the Drawings, or as specified by the Engineer. Methods shall be developed on site for placing the material in a manner that will protect the drain pipework from damage and keep compaction of the material to a minimum. Any drain fill material that has received too much compaction shall be scarified to a loose condition without damage to the underlying geomembrane and pipework.

The pad liner cover fill above the geomembrane shall be placed in a single 1-m minimum lift thickness by suitable dozer and truck equipment, as approved by the Engineer. A thicker layer, a minimum of twice the pipe diameter, shall be placed above the larger diameter primary collection drain pipes as detailed on the Drawings. No moisture conditioning or compaction is required. Haul truck speeds, braking, and turning during drain cover fill placement shall be strictly controlled by the Contractor to prevent damage to the underlying geomembrane and pipework. The cover fill thickness shall also be increased in concentrated traffic areas or across collection pipes, as required, to prevent damage to the geomembrane and pipework. Haul traffic on the cover fill surface shall be spread out as much as practical to prevent over-compaction of the cover fill in localized areas.

Select drain fill to construct the process pond leak detection sump shall be placed in a single lift thickness with no moisture conditioning or compaction. The top surface of the select drain fill shall be hand leveled in preparation for geocomposite placement. Any loose particles spilled outside of the backfilled sump area shall be removed from the pond's bottom geomembrane surface to prevent geomembrane puncture.

3.7.6 Anchor Trench Backfill

3.7.6.1 Material Requirement

Geomembrane anchor trenches shall be backfilled with inorganic material meeting the site grading fill material requirement.

3.7.6.2 Placement

The anchor trenches shall be excavated to the lines and grades shown on the Drawings. Particles greater than 138mmin size and any other protrusions shall be removed from the trench bottom and sides to protect the geomembrane from puncture. The backfill material shall be placed in nominal150 mm thick lifts and compacted to a minimum of 85 percent of the maximum dry density as determined by the Standard Proctor test (ASTM D-698). Moisture conditioning will not be critical, as determined by the Engineer. Compaction shall be accomplished by the use of hand-operated compactors. Care shall be exercised to avoid damage to the geomembrane. The final backfill surface shall be rolled by a rubber-tired front-end loader with loaded bucket, or equivalent equipment approved by the Engineer. The final backfill surface shall be graded to drain.

3.8 QA/QC Testing

3.8.1 General

The Engineer and his quality assurance team will be responsible for testing construction materials to assess whether materials and methods comply with these Technical Specifications. All testing performed by the Engineer will be performed in accordance with procedures outlined in the Specifications. The results of the tests carried out by the Engineer will be final and conclusive in determining compliance with the Specifications. The QA/QC test results shall be used to document and verify the quality of work and the extent to which the earthwork and related installations have been completed as set forth in the Drawings, Specifications, and permits for the construction and operation of the facilities.

To the extent possible, QA/QC testing shall be conducted so as not to interfere with normal construction operations. However, if required for any reason, the Contractor shall stop work in the area being tested, until the QA/QC testing is complete or approval to proceed has been given by the Engineer or his appointed representative. Each lift of fill will require approval by the Engineer prior to placement of the next lift. Sufficient time shall be allowed by the Contractor for the Engineer to carry out the required test work and interpretation of the test results in order to decide upon the acceptability of each lift. Cooperation shall be given by the Contractor to the Owner and the Engineer for taking samples and making tests, and such assistance shall be rendered as is necessary to enable sampling and testing to be carried out expeditiously.

The QA/QC guidelines do not relieve the Contractor of any of his responsibilities to conduct his own daily quality control testing or to complete in a timely manner the Work agreed to under the Contract Documents in accordance with the Specifications.

3.8.2 Tests

Laboratory tests including moisture content (ASTM D-2216), Atterberg limits (ASTM D-4318), gradation (ASTM D-422), moisture/density relationship (ASTM D-1557), permeability (ASTM D-5084) and other tests, where applicable, will be conducted by the Engineer on samples of fill materials taken from cuts within the HLP limits and from borrow areas at frequencies sufficient to assess whether the materials are in compliance with these Technical Specifications. The Engineer will also conduct field density tests (ASTM D-2922/nuclear gauge method and/or ASTM D-1556/sand cone method), and will obtain samples of the compacted fill for related laboratory testing at such frequency as the Engineer considers necessary to assess whether the compacted fill is in full compliance with the Specifications. In-place field density testing on soil fills may also be conducted in accordance with ASTM D-2167 and D-3017, as specified by the Engineer. Rockfill materials exceeding the standard range of soil testing methods shall be tested for acceptable compactive effort as specified in the Site Grading Fill Section of these Specifications.

3.8.3 QA/QC Plan

If the above tests indicate the Work does not meet the specified requirements, the following remedial action shall be performed.

Compaction below specified minimum: apply additional effort, or scarify, moisture condition, recompact, and retest.

- Moisture content outside of specified limits during compaction:
- Moisture content below specified minimum: scarify the depth of the lift, moisture condition, mix to achieve uniform moisture content, compact, and retest.

- Moisture content above specified maximum: scarify the depth of the lift, allow to air dry, mix to achieve uniform moisture content, compact, and retest; or remove the wet material. Mixing of dry material to lower the moisture content shall not be allowed without the prior approval of the Engineer and on a case by case basis.

Moisture content outside of specified limits after compaction and approval but prior to covering: determine depth of material outside of specified limits and correct as specified above.

Material not in accordance with the Specification requirements: remove material in its entirety, as directed by the Engineer.

3.8.4 Testing Frequency

The testing frequencies in the following tables are the minimum number of record QC tests to be completed on the various fill materials during the Work. The Engineer may specify additional tests to be carried out, if in the opinion of the Engineer, such additional tests are required due to variability in the soil materials or soil properties that may affect the Work. Control tests shall be performed on the material, as necessary, to determine the suitability of borrow areas. The number of control tests shall satisfy the minimum record test frequency for the volume anticipated to be removed. This may entail performing enough testing to develop "families" of borrow area soils, classified by both gradation and moisture/density relationship. The control test results shall be submitted to the Engineer for approval prior to removing material from borrow areas for fill placement. The results must demonstrate that the borrow materials conform to the Specifications. The control tests conducted for borrow areas are considered essential to understanding how borrow area materials will be placed in the Work. Upon review of the control test data, the Engineer may specify that additional tests be performed prior to approval of a borrow area.

Site Grading Fill	
Laboratory/Field Test	**Test Frequency**
Moisture Content	Minimum 1 per 5,000 m3
Atterberg Limits	Minimum 1 per soil type or 1 per 5,000 m3, whichever is more frequent
Gradation	Minimum 1 per soil type or 1 per 5,000 m3, whichever is more frequent
Moisture/Density Relationship	Minimum 1 per soil type or 1 per 5,000 m3, whichever is more frequent
In-Place Density and Moisture	Minimum 1 per 1,500 m3 placed

Seal Zone Fill	
Laboratory/Field Test	**Test Frequency**
Moisture Content	Minimum 1 per 3,000 m^3
Atterberg Limits	Minimum 1 per soil type or 1 per 3,000 m^3, whichever is more frequent
Gradation	Minimum 1 per soil type or 1 per 3,000 m^3, whichever is more frequent
Moisture/Density Relationship	Minimum 1 per soil type or 1 per 3,000 m^3, whichever is more frequent
In-Place Density and Moisture	Minimum 1 per lift per 1,500 m^2
Laboratory Permeability	Minimum 1 per lift per 75,000 m^2

Fine Filter Zone	
Laboratory/Field Test	**Test Frequency**
Moisture Content	Minimum 1 per 5,000 m^3
Gradation	Minimum 1 per 5,000 m^3
Moisture/Density Relationship	Minimum 1 per 5,000 m^3
In-Place Density and Moisture	Minimum 1 per lift per 1,500 m^2

Coarse Filter Zone	
Laboratory/Field Test	**Test Frequency**
Gradation	Minimum 1 per 2,000 m3

Overliner Drain Fill	
Laboratory/Field Test	**Test Frequency**
Moisture Content	Minimum 1 per 5,000 m^3
Gradation	Minimum 1 per 5,000 m^3
Moisture/Density Relationship	Minimum 1 per 5,000 m^3
In-Place Density and Moisture	Minimum 1 per lift per 1,500 m^2

Anchor Trench Backfill	
Laboratory/Field Test	**Test Frequency**
Moisture Content	Minimum 1 per 5,000 m^3
Atterberg Limits	Minimum 1 per soil type or 1 per 5,000 m^3, whichever is more frequent
Gradation	Minimum 1 per soil type or 1 per 5,000 m^3, whichever is more frequent
Moisture/Density Relationship	Minimum 1 per soil type or 1 per 5,000 m^3, whichever is more frequent
In-Place Density and Moisture	Minimum 1 per 150 linear m of trench length

Gradation testing of the rock fill shall not be required. The Engineer will visually inspect the rock fill in conjunction with measurement of the size of select stones to determine its compliance with the gradation requirements.

Tests may be conducted more frequently at the direction of the Engineer. More frequent testing shall be performed, where indicated by the following guidelines:

- Areas where special compaction equipment or methods are used;
- Areas where the height of fill rises quickly versus the quantity of fill placed, specifically in areas of slope reduction fill;
- Areas where compaction control is particularly important such as around appurtenant structures;
- Areas where doubtful construction procedures are being used;
- Areas where the required compaction may not have been achieved based upon visual observations; and
- Areas where unacceptable material may have been placed.

4.0 GEOSYNTHETICS

4.1 Geomembrane

4.1.1 General

The intent of the design is to provide linear low density polyethylene (LLDPE) geomembrane for the leach pad,. The geomembrane shall be manufactured in the largest widths and lengths possible to minimize the number of field seams. The Geomembrane Installer shall install geomembrane materials and miscellaneous materials incident thereto in accordance with the Manufacturer's recommendations. Alignments, lengths and areas are shown on the Drawings. Exact locations and lengths may vary to suit field conditions, as approved by the Engineer.

Direct vehicular contact with the geomembrane shall not be allowed to prevent geomembrane damage. Ultra-violet (UV) sensitive geomembrane shall be protected from exposure to sunlight until placement. After placement, the geomembrane shall be covered within three months of placement, unless otherwise approved by the Owner and warranted by the Manufacturer.

The Installer shall notify the Engineer for written acceptance of the completed geomembrane installation prior to covering the leach pad's geomembrane with drain fill and prior to covering the process pond's bottom geomembrane with geocomposite.

The geomembrane materials, installation and testing shall be in accordance with the following sections, and shall generally conform to the Geosynthetic Research Institute (GRI) standards GM-13, GM-17 and GM-19, or Engineer approved equivalent.

4.1.2 Manufacturer's Experience

The Manufacturer of the geomembrane shall have previously demonstrated the ability to produce the specified geomembrane by having successfully manufactured a minimum of 500 acres of similar geomembrane for hydraulic lining installations. A list of similar containment projects completed in which the manufactured material has been successfully used shall be submitted and is subject to approval by the Engineer.

4.1.3 Submittal of Engineering Data

The Installer is responsible for supplying engineering data and results of QC testing of the geomembrane materials. The Manufacturer shall allow sufficient time in his production schedule to perform the specified QC testing for the project. The results of all required testing shall be supplied at least seven days prior to shipment of the materials to the site. The Installer shall furnish the following engineering data prior to construction:

1. Shop drawings with panel layouts and appropriate details along with a time schedule for the installation of the geomembrane;
2. An instruction manual which includes the proper storage, handling, deployment, and seaming of the geomembrane. This manual shall be in compliance with these Specifications and any conditions of warranty;
3. QC certificates on the resin used to manufacture the geomembrane. The data submitted on the resin shall include production dates and the results of conformance tests. The submittals for the resin shall also include a statement that no reclaimed polymer was used. The edges of geomembrane that are trimmed during the manufacturing process are not considered reclaimed polymer. All resin shall be of the same type and quality;

4. QC certificates on each geomembrane roll. Each certificate shall be customized for the project and shall include but not be limited to: the roll and resin batch numbers, production date of the roll, a listing of the QC tests, test method numbers, values specified for the project, and the QC test results. All tests shall be performed prior to submittal of the QC certificates to the Engineer. Test results for each property specified shall be provided on the QC certificate.
5. Certification that the geomembrane and extrudate rod or beads are made from the same resin type and have the same properties.

4.1.4 Delivery, Storage and Handling of the Geomembrane

The Installer shall be responsible for transporting, unloading, and storing the geomembrane. At the discretion of the Owner, conformance testing and a plant audit may be performed by the Engineer and/or Owner prior to shipment. In the event that conformance testing is to be performed, the Manufacturer shall not arrange for transport of the geomembrane until such testing is complete. The Installer or Manufacturer shall provide the Engineer and Owner a schedule for manufacturing the materials for the project at least 14 days prior to manufacturing so that testing and travel arrangements can be properly arranged. This schedule shall remain firm throughout the duration of the project. Any proposed changes to the production schedule shall be approved by the Owner. The Engineer shall notify the Manufacturer at least seven days prior to performing the testing or plant audit of his intentions to perform these tasks.

The geomembrane shall be shipped such that it is not damaged in transport and shall be offloaded in the presence of the Owner. Any damage to the geomembrane during the offloading process will be documented by the Owner. All damaged rolls shall be separated from undamaged material. The final disposition of the damaged rolls shall be determined by the Owner with input from the Engineer. The Installer shall be responsible for replacing any geomembrane determined to be unacceptable at no additional cost to the Owner.

Once the geomembrane rolls have been offloaded, they shall be stacked on a prepared surface no more than three rolls high. The surface shall be prepared such that the geomembrane is not subjected to rocks or sharp objects, water, oil, or other deleterious conditions. The geomembrane rolls shall not be placed on pallets.

The Installer shall use appropriate equipment to transport the geomembrane from the storage area and deploy it. This equipment may include a spreader and roll bars and shall not damage the geomembrane or subgrade. Any damage shall be repaired by the Installer to the satisfaction of the Engineer.

4.1.5 Material Requirement

The geomembrane shall be composed of new, first quality material designed and manufactured specifically for the purpose of liquid containment. The geomembrane shall be produced in rolls and shall be free of holes, blisters, undispersed raw material, cuts, folds, or any sign of foreign matter. Each roll of geomembrane shall be identified with a label that provides the thickness, length, width, roll number, and plant location.

The total combined percentage of all additives including carbon black, antioxidants, and processing aids shall be less than 3.5 percent by weight of the geomembrane. Of the 3.5 percent, no more than 1 percent shall be additives other than carbon black. All additives shall be evenly dispersed throughout the geomembrane.

The material shall be warranted against Manufacturer's defects as well as degradation due to UV light for exposed geomembrane for a minimum of 20 years from the date of installation or as mutually agreed upon in writing prior to award of the contract between the Owner and the Manufacturer. This warranty shall cover the cost of material, shipping and handling, labor, and equipment to replace the defective or failed material.

The materials provided for the leach pad, collection ditch, collection ponds, and any other process component liners as 60-mil smooth and double-side textured LLDPE geomembranes, and 80-mil single-side textured HDPE geomembrane shall conform to the following standards:

Geomembrane Property	**ASTM Test Method**	**Value[1]**		
		~~**60-mil Smooth LLDPE**~~	**60-mil Double-Side Textured LLDPE**	~~**80-mil Single-Side Textured HDPE**~~
Thickness2, mil	D-5994	54	54	72
Density, g/cm3	D-1505	0.92	0.92	0.94
Tensile Strength at Break, of width (lb/in)	D-6693	243	243	324
Tensile Strength at Yield, of width (lb/in)	D-6693	N/A	N/A	173
Tensile Elongation at Break, %	D-6693	800	600	560
Tensile Elongation at Yield, %	D-6693	N/A	N/A	13
Tear Resistance, (lb)	D-1004	36	36	60
Puncture Resistance, (lb)	D-4833	80	80	105
Carbon Black Content, %	D-1603	2	2	2
Carbon Black Dispersion	D-5596	See Note 3		

Notes:

[1] Geosynthetic Research Institute (GRI) guidelines for minimum geomembrane values shall be acceptable, as approved by the Engineer, except geomembrane thickness shall not vary by more than 5 percent from design thickness.

[2] Texture in textured LLDPE eomembranes shall not be considered as contributing to the geomembrane thickness.

[3] Carbon Black Dispersion for 10 different views (only applies to near spherical agglomerates):

Minimum 9 of 10 in Categories 1 or 2

No more than 1 view in Category 3

The above properties shall be evaluated by the Manufacturer at a minimum frequency of one test every 0.5 hectares of geomembrane. In the event that the Manufacturer performs any given test at a frequency greater than specified herein, the results of such testing shall be reported to the Engineer and Owner. The testing shall be performed and the results submitted to the Owner and Engineer prior to arranging shipment of the materials to the project site.

4.1.6 Conformance Testing

Prior to or upon delivery to the site, samples of the geomembrane shall be removed by the Owner or Engineer and sent to a laboratory selected by the Owner for testing to ensure conformance to the requirements of these Technical Specifications. Conformance sampling may be performed at the Manufacturer's plant or in the field at the site. Unless testing is performed prior to shipment, the Installer shall deliver the geomembrane to the site an adequate period of time prior to installation to allow for sufficient time for sampling and testing, as specified by the Owner or Engineer.

Samples shall be taken at the rate of one sample per batch or one sample per 6 acres, whichever is less. Samples shall be taken from across the entire width of the geomembrane roll and shall be at least 1m long unless otherwise approved by the Engineer. The samples shall not include the first 1m of the roll. The Engineer may increase the frequency of sampling in the event that test results do not comply with these Specifications. Any material that is not certified in accordance with the Specifications shall be rejected and replaced with new material.

4.1.7 Installation

Installation of the geomembrane shall be performed by the geomembrane Manufacturer or an Installer trained and certified by the Manufacturer. The purpose of these Specifications is to achieve a lined system as free of defects as current installation and inspection techniques will allow.

Surfaces to receive geomembrane shall be prepared as specified in the Subgrade Preparation Section of these Technical Specifications. The surfaces shall be smooth and free of all rocks, stones, sticks, roots, sharp objects, or debris of any kind. The surface shall provide a firm, unyielding foundation for the geomembrane with no sudden, sharp or abrupt changes in grade. No standing water or excessive moisture shall be allowed. The Installer shall certify in writing that the surface on which the geomembrane is to be installed is acceptable before commencing work.

Once the subgrade is acceptable, it shall be maintained until the geomembrane has been installed and accepted. Any rough areas or damage caused by the installation shall be repaired by the Installer. The leading edge of the anchor trench shall be rounded to avoid a sharp bend in the geomembrane.

4.1.7.1 Placement

To the maximum extent possible, the geomembrane panels shall be oriented such that they are perpendicular to the natural contours (parallel to the maximum slope). Unless otherwise approved in writing by the Engineer, no horizontal seams will be allowed on slopes steeper than 3H:1V. All seams shall be oriented such that they are shingled in a down-slope direction. If cross seams are required on a steep slope, the end of each panel shall be cut at a diagonal of 45 degrees and seamed to prevent installation of a horizontal seam. The geomembrane shall

be placed according to the panel layout drawing submitted by the Installer and approved by the Engineer.

Each geomembrane panel shall be labeled with a unique identification number or code which is agreed to by all parties. The geomembrane shall be placed using methods and equipment that do not damage it or the subgrade. Installation personnel working on the geomembrane shall not smoke, wear shoes that could damage the geomembrane, or engage in potentially damaging activities.

The Installer shall use appropriate means to protect the geomembrane from uplift from the wind. Edges of panels shall have continuous ballast to lessen the chance of wind flow under the panels. The material used to hold down the geomembrane shall not cause damage to it. No vehicles shall be allowed to drive over exposed geomembrane.

As the geomembrane material is deployed, it shall be visually inspected and any defects marked for repair. If a significant amount of defects are identified as determined by the Engineer, the material shall be removed and replaced at no expense to the Owner. No geomembrane deployment shall be allowed during periods of wet or extremely windy weather or in the presence of ponded water.

The Installer shall provide sufficient slack in the geomembrane to allow for contraction due to cold temperatures. Prior to the start of construction, the Installer shall submit calculations and a resultant table showing the amount of extra material required per 30m of geomembrane in place, for a given temperature.

4.1.7.2 Seaming

Prior to installation, the Installer shall submit the resumes of seaming personnel who will be used on the project. At least one seaming supervisor shall be present who has the experience of a minimum of 0.5 hectares of geomembrane installation using the seaming device proposed for use at the project site.

The Installer shall weld the geomembrane, where possible, using the double-wedge fusion welding method. No seaming shall begin until each welding technician and apparatus used in the field has passed a test weld. Scrap pieces of geomembrane material at least 1m long and 0.3m wide shall be seamed together under the same conditions as those in the area to be lined. A minimum of four 25mm wide coupons shall be cut from the test weld and quantitatively tested for shear and peel with a field tensiometer in accordance with ASTM D-6392. A test weld passes when:

1. The break is ductile and a film tearing bond (FTB);
2. The minimum fusion and extrusion peel strength for 60-mil LLDPE geomembrane (smooth and textured) is 75 lb/in;
3. The minimum shear strength for 60-mil LLDPE geomembrane (smooth and textured) is 90 lb/in;

A test weld is considered passing when all coupons pass the above requirements. If repeated test welds fail, the welding technician or apparatus may not be used until the reason for the failing values is identified. Once the test welds have passed and are approved by the Engineer, seaming of the geomembrane may begin.

The geomembrane panels shall overlap a minimum of 3 in for extrusion welding and 4 in for fusion welding. Any fishmouths or wrinkles at seam overlaps shall be cut out and removed. If the overlap after cutting is less than 3 in, the area shall be patched. As seaming progresses, the

Installer shall log the temperature measured at 6 in above the geomembrane, the operating temperature, pressure, and speed of the wedge welder, and the extrudate temperatures in the barrel and at the nozzle of the extrusion welder.

If a hot wedge welding device is used by the Installer, it shall be self-propelled and equipped with gauges that monitor the temperature and speed of the apparatus. The wedge welder shall not be placed directly on the geomembrane when not in use. The Installer shall make sure that there is no dirt or moisture build-up between the geomembrane sheets.

When using an extrusion welder, the Installer shall tack bond the geomembrane sheets together in a manner that does not damage the geomembrane. The Installer shall thoroughly clean and dry the seam area immediately before tack bonding (lystering) and wedge welding. Prior to welding and after any work stoppages of more than three minutes, the welding apparatus shall be purged of heat-degraded extrudate. The top edges of the geomembrane shall be beveled prior to welding and the oxidation on the geomembrane surface shall be removed by a disc grinder no more than a half hour before welding. On seams that are more than five minutes old, the end of the seam shall be ground prior to continuing the weld. All grind marks shall not extend more than 6 mm beyond the weld head. The grinder shall be held parallel to the geomembrane edge and any area where grinding removes more than 4 mils shall be patched.

No seaming shall be conducted if the temperature measured at 15cm above the geomembrane is lower than 5°Cor above 38°C, without written acceptance by the Engineer. When the temperature is below 10°C, the Installer shall preheat the weld zone by a hot air device.

4.1.7.3 Seaming Equipment

The approved processes for field seaming are extrusion welding and fusion (hot wedge) welding. The preferred method of seaming is the double-fusion welding. Proposed alternative processes shall be documented and submitted to the Owner or Engineer for approval.

The extrusion welding apparatus shall be equipped with gauges giving the temperature of the apparatus at the nozzle. The fusion-welding apparatus shall be an automated vehicular-mounted device which produces a double seam with an enclosed space. The fusion welding apparatus shall be equipped with gauges giving the applicable temperatures. The Engineer shall verify that:

1. Equipment used for seaming is not likely to damage the geomembrane;
2. The extrusion welder is purged prior to beginning a seam until all heat-degraded extrudate has been removed from the barrel; and
3. The electric generator is placed on a smooth base such that no damage occurs to the geomembrane.

The Installer shall carry on-site spare welders and the necessary spare parts for their repair, such that construction delays do not occur.

4.1.8 Field Quality Control

The Installer shall designate a technician that is responsible for supervising and/or conducting the Installer's field quality control program. Testing of the geomembrane seams shall consist of both destructive and non-destructive testing. All seams shall be 100 percent inspected using non-destructive test methods. Non-destructive and destructive testing procedures are outlined below.

In addition to the field seam testing specified herein, the Installer shall water test the top geomembrane installed in the process pond with ponded fresh water to a level of 1m below the pond crest. No leaks shall be detected by the pond's leak detection system over a 48-hour period prior to acceptance by the Owner. If leaks occur in the installed geomembrane, the Installer shall find and repair the leaks and retest as before. The Owner shall provide the source of water for testing.

4.1.8.1 Non-Destructive Testing

Vacuum boxes shall be used to non-destructively test extrusion or single wedge fusion welds over their entire length. Prior to using the vacuum box, the weld to be tested shall be wetted with a soapy solution. The vacuum box shall then be placed over the weld and a vacuum of 35 to 56 kN/m2 (5 to 8 psi)shall be drawn. The entire length of the box shall be observed through the viewing window for the creation of bubbles for a period of at least 15 seconds and shall be tested with a minimum of 75 mm of overlap with the previous section. Any areas that bubbles appear on, shall be identified, repaired, and retested.

In areas that cannot be tested with a vacuum box, the seam should be cap-stripped if possible. If the seam can be tested prior to installation, then the Installer shall do so. Seaming and testing in these areas shall be observed by the Engineer.

If the double hot wedge welding system is used, air pressure testing may be conducted instead of vacuum testing. Each continuous length of seam shall be pressurized to 210 kN/m2 (30 psi) and monitored for a period of 5 minutes. In order to pass, the seam shall stabilize and not lose more than 14 kN/m2 (2 psi)of pressure. The test method shall include a method to verify that the entire length of the air channel is pressurized. If the wedge weld cannot be air tested because of a blockage in the air channel, the welded seam shall be considered a failure. Any failed seams shall be repaired and retested. The repair may include running an extrusion weld along the wedge weld.

4.1.8.2 Destructive Testing

The location of all destructive tests shall be determined by the Engineer. A minimum of one sample per 500 mof seam shall be obtained. The frequency of testing may be increased by the Engineer to suit the field conditions. The Installer shall repair any suspicious looking welds before release of a seam for destructive sampling. Destructive samples shall be cut as the installation progresses and not at the completion of the project. All destructive samples shall be marked with consecutive numbers along with the seam number. A log shall be kept with the date, time, location, seaming technician, apparatus, temperature, and pass or fail criteria. All destructive sample holes shall be repaired immediately. The destructive samples shall be a minimum of 1 ft wide by 3 ft long with the seam centered lengthwise.

The destructive samples shall be cut into three total samples, two which are 0.3 m by 0.3 m (one each for the Installer and Owner) and one which is 0.3 m by 1.0.4 m(for the Engineer). Prior to removing a destructive sample, two 25 mm coupons shall be cut off of each end of the designated destructive sample location and tested in the field using a field tensiometer. These coupons shall pass the specified requirements for shear and peel. If a coupon sample fails, the Installer shall go a minimum of 3 m in each direction and obtain additional samples for retesting. These samples shall also be given to the Engineer for testing using a field tensiometer. This procedure shall continue until the coupons on each side of a destructive sample location pass the shear and peel criteria.

Once the sample coupons pass the seam strength requirements, a destructive sample shall be obtained and divided as specified above. No destructive sample need be obtained between failing coupon tests. The destructive samples shall be tested in the field by the Engineer or the testing may be conducted offsite with the consent of the Owner.

For each destructive test, a minimum of five samples in shear and five samples in peel shall be tested according to ASTM D-6392. In order to have passing results, a minimum of four out of five samples shall meet the specified test values. In order for one failed test out of five to be acceptable, the failure shall be ductile, a film tearing bond, and shall be within 80 percent of the required specifications. The specified criteria are as follows:

1. The break is ductile and a film tearing bond (FTB);
2. The minimum fusion and extrusion peel strength for 60-mil LLDPE geomembrane (smooth and textured) is 75 lb/in;
3. The minimum shear strength for 60-mil LLDPE geomembrane (smooth and textured) is 90 lb/in;

The Engineer will notify the Installer and Owner of any failing results. Should a destructive sample fail, the Installer shall move 3 m in either direction from the failure and take additional destructive samples. This procedure shall continue until passing results are obtained. The Installer shall repair or cap-strip seams that have failing destructive tests. The Installer shall not cover any seams which have not been tested unless he agrees in writing to uncover any failing seams and make the required repairs.

4.1.9 Repairs

The Installer may repair holes smaller than 6 mm by using an extrusion weld. The surface oxidation surrounding the hole shall be removed a minimum of 125 mm around the hole and then immediately welded. After the hole has been welded, it shall be vacuum tested for leaks. The result of the test, the name of the tester, and the date shall be recorded on the geomembrane near the repair.

All destructive sample holes, tears, large holes, or areas with blisters or undispersed raw materials shall be patched. Patches shall be round or oval in shape, extend at least 150 mm beyond the defect, and made of the same material as the geomembrane. The edge of the patch shall be beveled and welded to the geomembrane according the procedures outlined for extrusion welding. All patches shall be vacuum tested and the results recorded on the geomembrane.

For areas that have very large defects, the material shall be removed and replaced. All folds or large wrinkles shall also be removed. The Engineer shall determine the areas that require removal. Seams that fail destructive testing or cannot be vacuum tested shall be cap-stripped. Bridging or trampolining of the geomembrane shall also be repaired prior to covering. At no time shall the Installer discard excess geomembrane, packaging materials, or other items beneath the geomembrane.

4.1.10 Quality Assurance and Acceptance

Quality Assurance testing will be performed by the Engineer in accordance with these Specifications. The Installer shall be responsible for notifying the Engineer when areas of Work are completed and ready for QA testing. Additionally, the Installer shall allow time for the testing to be performed. Every reasonable effort will be made to expedite the necessary testing;

nevertheless, delays occasioned by testing will not be considered grounds for extension of time to complete the contract Work.

The Installer shall be responsible for maintaining the geomembrane until final acceptance by the Engineer. The Engineer will recommend final acceptance when all seams have passed destructive testing, the Installer has supplied all documentation, and all field and laboratory testing is complete and satisfactory. As part of the final acceptance, the Installer shall furnish reproducible as-built drawings showing the location of the geomembrane panels, seams, repairs, patches and destructive samples. The drawings shall be prepared on 24 by 32-inch size sheets to a scale approved by the Engineer. They shall be submitted in final form to the Owner within two weeks after completion of each phase of construction.

4.2 Geocomposite

A geocomposite will be installed between the geomembranes of the process pond to serve as a leak detection layer connected to the pond's leak detection sump. The geocomposite will consist of 200-mil geonet heat-laminated on both sides with 270 gr/sq m (8 oz/sq yd) nonwoven geotextile.

4.2.1 Material Requirement

The geonet shall be a high flow capacity polyethylene grid manufactured by extruding two crossing strands to form a bi-planar drainage net structure. The geonet shall conform to the following standards:

Geonet Property	ASTM Test Method	Value
Transmissivity, m2/sec	D-4716	1 × 10-3
Thickness, mm (mil)	D-5199	5 (200)
Density, g/cm3	D-1505	0.94
Tensile Strength, N/mm (lb/in)	D-5034/5035	7.9 (45)
Carbon Black Content, %	D-1603	2

The material requirement for the nonwoven geotextile component of the geocomposite is covered in the following section.

The Contractor shall provide a written material guarantee covering the geocomposite material for a minimum warranty period of one year. The material warranty shall cover the cost of any material required to replace failed material. A minimum one-year installation warranty shall also be provided and shall cover the cost of labor and equipment to replace the failed material.

4.2.2 Installation

In constructing the process pond liner, each geocomposite roll shall be placed over the pond's bottom geomembrane taking precautions to prevent damage to the geomembrane. The geocomposite shall not be welded or bonded to either the bottom or top geomembrane. Each

roll sheet shall be connected to the adjacent sheet with bands, as recommended by the Manufacturer to prevent damage to the geomembranes. The Installer shall notify the Engineer of the completed geocomposite installation for written acceptance prior to covering with the pond's top geomembrane.

4.3 Nonwoven Geotextile

A 270 gr/sq m (8 oz/sq yd) nonwoven geotextile will be used in manufacturing the process pond geocomposite. A 405 gr/sq m (12 oz/sq yd) nonwoven geotextile will be used for lining the steeper portions of the diversion channels as specified on the Drawings.

4.3.1 Material Requirement

The nonwoven geotextile shall be of new, first-quality (needle-punched) material having polymer of 100 percent polyethylene, 100 percent polypropylene, or polyester/polypropylene blend designed and manufactured specifically for the purpose of separation, tensile reinforcement, planar flow, and filtration. The geotextile material shall be produced such that it is free of holes, undispersed raw materials, broken needles, or any sign of contamination by foreign matter. The geotextile shall be uniform in color, thickness, size, and texture, and all rolls shall be properly tagged and identified by the Manufacturer.

The non-woven geotextile shall conform to the following minimum average roll values (MARV) unless otherwise specified.

Nonwoven Geotextile Property	ASTM Test Method	Value[1]	
		270 gr/sq m (8 oz/sq yd)	405 gr/sq m (12 oz/sq yd)
Grab Tensile Strength, N (lb)	D-4632	930 (210)	1,420 (320)
Grab Elongation, %	D-4632	50	50
Puncture Strength, N (lb)	D-4833	600 (135)	930 (210)
Mullen Burst, kPa (psi)	D-3786	2,895 (420)	4,270 (620)
Trapezoidal Tear Strength, N (lb)	D-4533	420 (95)	555 (125)
Apparent Opening Size, US Sieve No. (mm)	D-4751	80 (0.180)	100 (0.150)
Permeability, cm/sec	D-4491	0.38	0.29
Water Flow Rate, lpm/m2 (gpm/ft2)	D-4491	4,480 (110)	2,440 (60)
UV Resistance (retained after 500 hours), %	D-4355	70	70

Notes:

[1] All values are MARV except apparent opening size; it is the maximum average value per roll, and the UV resistance is the minimum value.

4.3.2 Installation

The nonwoven geotextile fabric sheets shall be placed as shown on the Drawings or as directed by the Engineer. All joints shall have a 0.15-m minimum overlap and shall be heat fused or sewn. The integrity of each seam is important. As a means of regulating the fusion machines, frequent samples of seams will be tested for grab strength. Minimum grab strength of 80 percent of the fabric strength, as defined above, will be required. Any machine that produces failing samples shall be repaired or removed from the Work.

On slopes steeper than 10H:1V, all seams shall be oriented parallel to the slope direction. Seams constructed perpendicular or transverse to the direction of the slope will not be accepted, unless approved by the Engineer.

Seams shall be sewn using a Type 401 stitch. One or two rows of stitching may be used. Each row of stitching shall consist of four to seven stitches per 25 mm. The minimum seam allowance (minimum distance from the geotextile edge to the stitch line nearest that edge) shall be 38 mm if a Type SSa (prayer or flat) seam is used. The minimum seam allowance for all other seam types shall be 25 mm. The Engineer shall have final approval of all seams. The Installer shall ensure that no soil materials are present within seams or overlaps.

All seams will be inspected for continuity, and the Installer shall repair any gaps or seams that are flawed. Costs for repairing the geotextile shall be borne by the Installer.

Sandbags shall be provided as ballast to hold the various layers of geotextile in place prior to the next operation. If permanently left in place to ensure that wind damage does not occur during the expected exposure life, sufficient ultraviolet-resistant sandbags shall be used.

4.4 Geosynthetic Clay Liner

A geosynthetic clay liner (GCL) will be used in the leach pad liner system instead of the low-permeability clay soil liner for the HLP and ponds, as shown on the Drawings.

4.5 Material Requirement

The GCL shall be reinforced consisting of a layer of sodium bentonite between two nonwoven geotextiles, which are needle-punched together (similar to Cetco Bentomat DN, or equivalent). The geotextile shall conform to the standards in the previous section of these Specifications. The GCL material shall be warranted against Manufacturer's defects for a period mutually agreed upon in writing prior to award of the contract between the Owner and the Manufacturer. This warranty shall cover the cost of material, shipping and handling, labor, and equipment to replace the defective or failed material.

The GCL material shall conform to the following standards and shall be free of tears, holes, or other defects that may affect its serviceability.

GCL Property	ASTM Test Method	Required Value
Bentonite Swell Index	D-5890	24 mL/2g min.
Bentonite Fluid Loss	D-5891	18 mL max.
Bentonite Mass/Area[1]	D-5993	3.6 kg/m^2 (0.75 lb/ft^2) min.
GCL Grab Strength[2]	D-4632 D-6768	660 N (150 lbs) MARV 66 N/cm (37.5 lbs/in) MARV
GCL Peel Strength[2]	D-4632 D-6496	65 N (15 lbs) min. 4.4 N/cm (2.5 lbs/in) min.
GCL Hydraulic Conductivity	D-5887	5 x 10^{-10} m/sec min.
GCL Hydrated Internal Shear Strength[3]	D-5321 D-6243	24 kPa (500 psf) typ.

Notes:

1 At 0 percent moisture content.

2 Testing is performed in the machine direction using 100-mm grips. Results are reported as minimum average roll values (MARV) unless otherwise indicated.

3 Peak values measured at 10 kPa (200 psf) normal stress for a specimen hydrated for 48 hours.

The GCL material shall be sampled and tested in accordance with the Manufacturer's approved QC Manual.

4.5.1 Installation

In general, the GCL material shall be installed in accordance with the procedures provided in the Manufacturer's QC Manual and approved by the Engineer. In particular, the following procedures shall be followed.

The GCL rolls shall be protected from damage during shipping and exposure to the elements until time of deployment. Rolls damaged during shipping, storing and deploying, or from climate exposure, in ways that affect the quality of the GCL as an effective seepage barrier, shall be rejected as determined by the Engineer, and replaced with acceptable rolls.

The subgrade shall be prepared in accordance with the Subgrade Preparation Section of these Technical Specifications prior to GCL installation. The GCL shall be installed in advance of the geomembrane installation, provided the GCL panels can be covered with seamed geomembrane within each day of deployment. Only those GCL panels that can be covered in the same day shall be unpackaged and installed. If exposed GCL cannot be permanently covered before the end of the work day, it shall be temporarily covered with plastic or other waterproof material to prevent hydration.

The GCL panels shall be placed with seams oriented parallel to the line of maximum slope and shall be free of tension or stress upon completion of the installation. Panels shall be positioned with the seam overlap not less than 6 in after shrinkage for longitudinal seams and 2 ft after shrinkage for end-of-panel seams. Dirt or other foreign matter shall be removed from the overlap area immediately prior to seaming. Granular sodium bentonite of the same type as the bentonite used in the GCL shall be placed along the entire seam overlap at minimum widths of 3 in and 1 ft from the edge of the underlying panel for longitudinal and end-of-panel seams, respectively. The minimum application rate of the granular sodium bentonite shall be 0.27 lb/ft. End-of-panel overlapped seams shall be constructed such that they are shingled in the direction of the grade to prevent runoff from entering the overlap zone.

Holes or tears in the GCL shall be repaired by placing a patch of GCL extending a minimum of 1 ft beyond the edges of the hole or tear on all sides. Granular sodium bentonite or bentonite mastic shall be applied in the overlap area. Patches shall be secured with construction adhesive or other approved methods.

GCL shall not be covered prior to inspection and approval by the Engineer.

4.6 Corrugated PE Pipe

This section refers to all corrugated polyethylene (PE) pipework to be used in the project including solution collection and drainage pipes and diversion culvert pipes. Pipe and fittings shall be made of virgin polyethylene compounds, which shall have a minimum cell classification of 324420C for 3 in through 10 in diameters or 335420C for 1 ft through 5 ft diameters as defined in ATSM D-3350. Pipe and fittings shall be manufactured and comply with AASHTO Standard Specifications M-252, M-294 and MP-7. All sizes shall conform to the AASHTO classification "Type S" for dual wall smooth interior solid pipe, "Type SP" for dual wall smooth interior perforated pipe, and "type CP" for single wall perforated pipe, or "Type D" for diameters greater than 3.5 ft. Sealed couplers shall conform to ASTM D-3212.

Dual wall pipe shall have minimum pipe stiffness at 5 percent deflection when tested in accordance with ASTM D-2412 as follows:

Internal Diameter mm (in)	Pipe Stiffness kPa (psi)
100 – 300 (4 – 12)	345 (50)
375 (15)	289 (42)
450 (18)	276 (40)
600 (24)	234 (34)
750 (30)	193 (28)
900 (36)	152 (22)
1,050 (42)	138 (20)
1,200 (48)	124 (18)
1,500 (60)	96 (14)

Where perforations are specified, they shall conform to the requirements as follows:

- ASTM F-667 for 3 in diameter pipe
- AASHTO M-252 “Class 2” for 4 in to 10 in diameter pipe
- AASHTO M-294 “Class 2” for 1 ft to 4 ft diameter pipe
- AASHTO MP-7 “Class 2” for 5 ft diameter pipe

Slots shall be cut circumferentially unless specified otherwise.

Couplings shall be corrugated to match the pipe corrugations and shall provide sufficient longitudinal strength to preserve pipe alignment and prevent separation at the joints. Couplings, unless watertight connections are specified, shall be split collar and shall engage at least two full corrugations on each pipe section.