



June 01, 2018

Scott McDaniel
Haile Gold Mine, Inc.
P.O. Box 128
Kershaw, S.C. 29067

RE: Approval of Modification to a Mine Operating Permit (Mod 18-1)
Permit I-000601, Haile Gold Mine, Haile Gold Mine, Inc., Lancaster County

Dear Mr. McDaniel:

The South Carolina Department of Health and Environmental Control (DHEC) has approved the application to modify the Mine Operating Permit I-000601. The modification request was to temporarily reallocate 31.35ac designated for excavation as Ledbetter Pit to a Potentially Acid Generating (PAG) cell to store low-grade ore for processing. As described in the modification application, only low-grade ore will be placed on this PAG cell, not to exceed 2.2M tons of material in 2019 or 1.6M tons of material in 2020, and must be removed by the end of calendar year 2021 or sooner.

The Ledbetter PAG cell shall disturb 31.35ac in total, and consist of a 25.35ac pad and adjoining surface water collection pond. The approved specifications of the pad and pond are outlined in the NewFields technical memorandum entitled, "Low Grade Ore Stockpile Pond Sizing" dated March 07, 2018, with one correction on page 2 that the pond be designed to evacuate the contact water to the existing 465 Pond. In addition, a minimum 12" layer of coastal plain sand will be installed over the 12" compacted clay layer to protect the integrity of the clay liner and facilitate drainage to the collection pond. Installation and construction specifications will follow pre-approved NewFields technical memoranda related to the construction of Johnny's PAG Overburden Storage Area (OSA), dated September 22, 2014, November 14, 2014, and June 30, 2015. DHEC is in receipt of the required additional financial assurance. Enclosed are the approved memoranda for your records.

Should there be any questions or if DHEC may be of further assistance, please do not hesitate to contact Jeremy Eddy at 803-898-7609 or by e-mail at eddyje@dhec.sc.gov.

Sincerely,

Joan Litton, Director
Division of Mining and Solid Waste Management

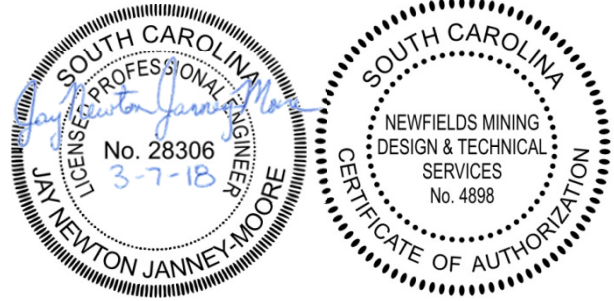
cc Joe Koon, DMSWM
Jeremy Eddy, DMSWM
Brett Caswell, BOW
Veronica Barringer, Regional Director
Steve Willis, Lancaster County (swillis@lanastercountysc.net)

TECHNICAL MEMORANDUM

To: Bruce Van Brunt
From: Jay Janney-Moore
Reviewed: Carl Burkhalter
Project: Haile Gold Mine
Project No: 475.0042.016
Subject: Low Grade Ore Stockpile Pond Sizing
Date: 7 March 2018

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1.0 INTRODUCTION

As requested by Haile Gold Mine (HGM), NewFields developed permitting level plan view and section and detail drawings for the two proposed low grade ore stockpiles utilizing the shape files provided on February 7, 2018. In support of these designs, NewFields has prepared this memorandum to summarize the pad design and storage requirements used to size the runoff collections ponds associated with Ledbetter and Parking Lot Low Grade Ore (LGO) Stockpiles.

2.0 LEDBETTER LOW GRADE ORE STOCKPILE

An area adjacent to the existing Ledbetter Reservoir was identified as a potential storage location for LGO materials. The location was selected because the existing materials can be excavated and utilized as low permeability materials. The excavation of the borrow materials will also increase the storage capacity of the facility. NewFields was provided with a proposed excavation surface that depicts the maximum excavation envisioned by Haile for the required LGO material storage of 7 million tonnes. The excavation surface can be referenced on Drawing P10.

The facility has been designed to include a 12" thick low permeability soil liner as shown in Detail A on Drawing P10. The facility is graded to drain the contact runoff water to the run-off collection pond. Initially, the runoff collection pond will be located in the southeast corner of the pad, as shown on Drawing P10. At the discretion of Haile, the finished grade elevations of the low grade ore stockpile pad and pond crest may be raised if required storage is to be reduced.

The runoff collection pond has been designed with 2.5Horizontal:1Vertical (2.5H:1V) with a 12" low-permeability soil liner overlain with 80 mil HDPE Geomembrane. The geomembrane will be



anchored along the pond crest. The runoff collection pond was sized to contain the volume resulting from the 100 Year/24 Hour event (8.59 inches) that falls on the facility. The Ledbetter Facility has an approximate contributing area of 1.13 Mft² which would result in a total event volume of 6.05 Mgal. The pond has been designed to contain the volume below 2 feet of freeboard. The design includes a 3-foot deep sump for the future design of an extraction pump to evacuate the contact water to the existing 19 Ponds. Details of the pond can be referenced on Drawing P12.

2.1 List of Drawings

- P10 – Ledbetter Low Grade Ore Stockpile Phase Grading Plan
- P12 – Ledbetter Low Grade Ore Stockpile Phase Section and Details

3.0 PARKING LOT LOW GRADE ORE STOCKPILE

The Parking Lot Low Grade Ore Stockpile facility is located at the north of the Gregory Property and east of the administration building within the current approved property boundaries. The LGO stockpile has been designed to include a 12" thick low permeability soil liner, overlain with 80 mil HDPE Geomembrane. The geomembrane liner will be covered with 2-foot protective layer as shown in Detail A on Drawing P20. The stockpile will include a network of underdrain collection pipes to convey contact water away from the base of the facility and reduce the hydraulic head on the facility lining. Details of the underdrain piping can be referenced on Drawing P22. The facility is graded to provide drainage of contact runoff water via a perimeter channel to the run-off collection pond located to the southeast of the facility.

The runoff collection pond has been designed with 2.5H:1V with a 12" low-permeability soil liner overlain with 80 mil HDPE Geomembrane. The geomembrane will be anchored along the pond crest. The runoff collection pond was sized to contain the volume resulting from the 100 Year/24 Hour event (8.59 inches) that falls on the facility. The Parking Lot Facility has an approximate contributing area of 2.39 Mft² which would result in a total event volume of 12.77 Mgal. The pond has been designed to contain required storage volume below 2 feet of freeboard. The design includes a 3-foot deep sump for the future design of an extraction pump to evacuate the contact water to the existing 19 Ponds. Details of the pond can be referenced on Drawing P27.

3.1 List of Drawings

- P20 – Parking Lot Low Grade Ore Stockpile Grading Plan
- P22 – Parking Lot Low Grade Ore Stockpile Sections and Details
- P25 – Parking Lot Low Grade Ore Runoff Collection Pond Plan
- P27 – Parking Lot Low Grade Ore Runoff Collection Pond Sections and Details



4.0 TECHNICAL SPECIFICATIONS

For the construction of the Ledbetter and Parking Lot LGO Stockpiles, NewFields recommends using the approved technical specifications developed and utilized for the construction of the Johnny's Potentially Generating Acid Overburden Storage Area.

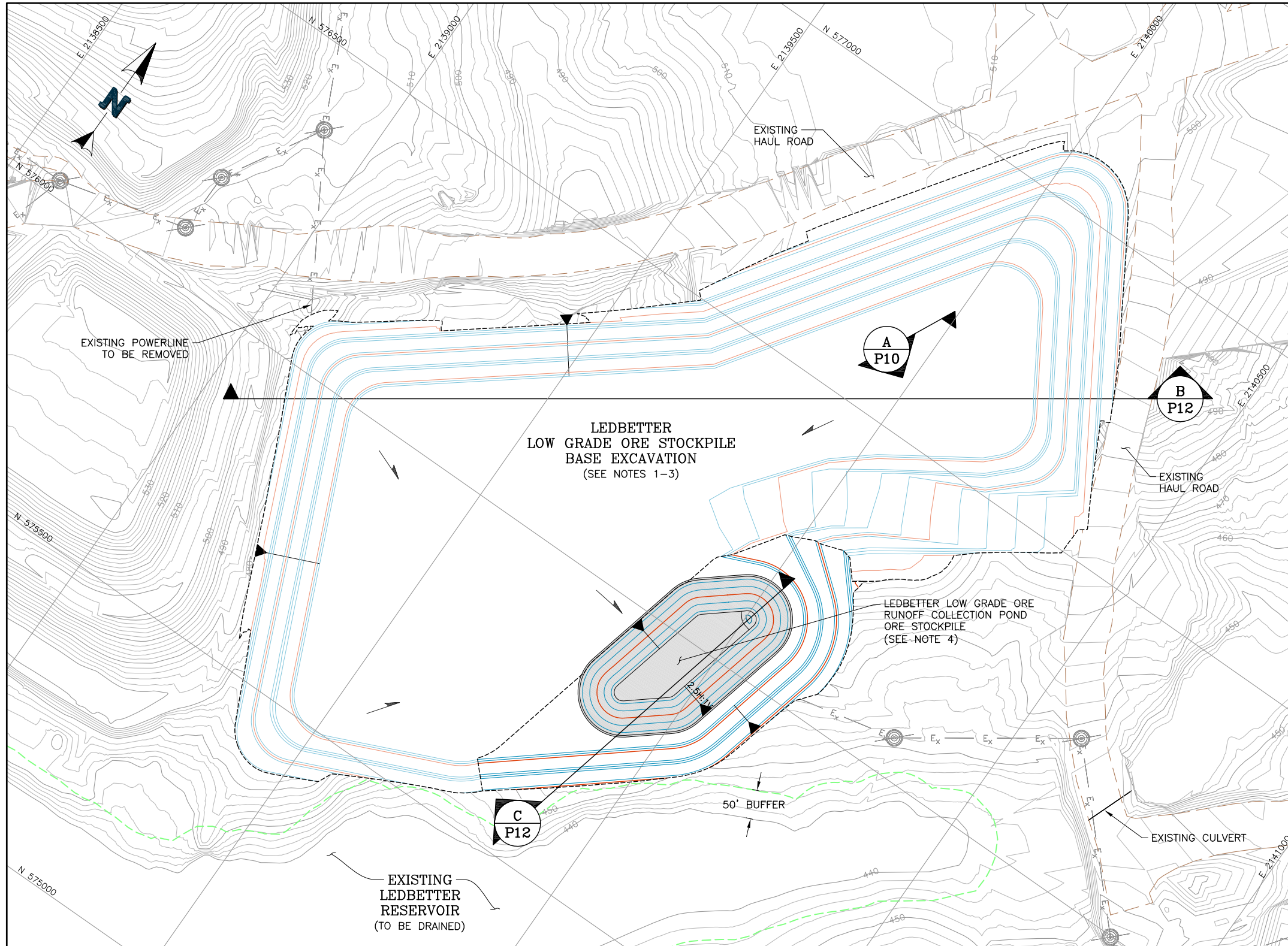
4.1 List of Approved Technical Specifications

- 0042 001-SP-CPeP Corrugated Polyethylene Pipe
- 0042 001-SP-EW-1 Earthworks
- 0042 001-SP-FN-1 Fence
- 0042 001-SP-GM-0 Geomembrane
- 0042 001-SP-GT-0 Geotextile

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Permit Drawings

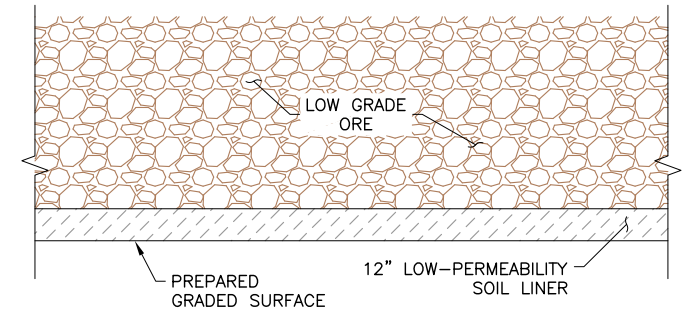


LEGEND:

- EXISTING GROUND CONTOURS
- PROPOSED GROUND CONTOURS
- PROPOSED LEDBETTER LOW GRADE ORE PAD CONTOURS
- EXISTING ROADS/TRAILS
- EXISTING CULVERT
- EXISTING POWERPOLE
- EXISTING POWER LINE
- LIMITS OF GEOMEMBRANE

NOTES:

1. THE PROPOSED PAD GRADING SHOWN DEPICTS THE MAXIMUM EXCAVATION ENVISION BY HAILE FOR THE TEMPORARY LEDBETTER LOW GRADE ORE STOCKPILE. FINAL BASE GRADING MAY VARY AND IS NOT SHOWN FOR CLARITY.
2. THE PROPOSED PAD SHOWN HAS A MAXIMUM STORAGE CAPACITY OF 7 MILLION TONNES.
3. HAILE MAY DETERMINE THAT THE REQUIRED STORAGE VOLUME FOR THE TEMPORARY LEDBETTER LOW GRADE ORE STOCKPILE IS LESS THAN 7 MILLION TONNES WHICH MAY REDUCE THE SIZE OF THE PAD.
4. THE LEDBETTER LOW GRADE ORE STOCKPILE RUNOFF COLLECTION POND WAS SIZED TO CONTAIN THE STORMWATER RUNOFF RESULTING FROM THE 100 YEAR, 24 HOUR STORM EVENT FOR THE MAXIMUM AREA.
5. PROPOSED CONTOURS REPRESENT THE TOP OF LOW-PERMEABILITY SOIL LINER WITHIN THE GEOMEMBRANE LIMITS AND FINISHED GRADE EVERYWHERE ELSE.



A A TYPICAL STOCKPILE BASE
P10 P12

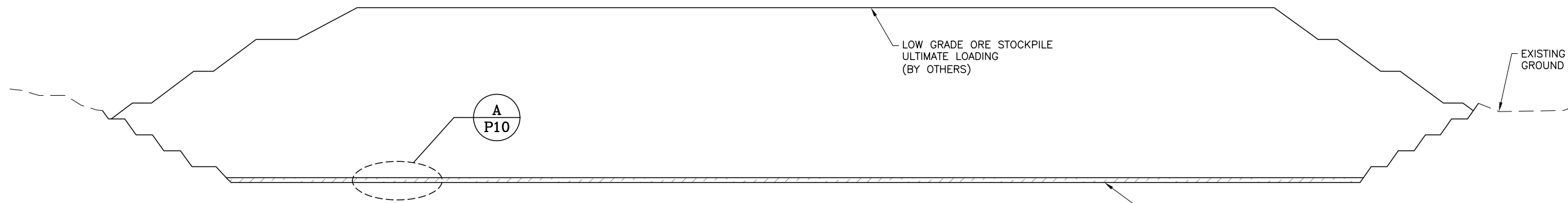


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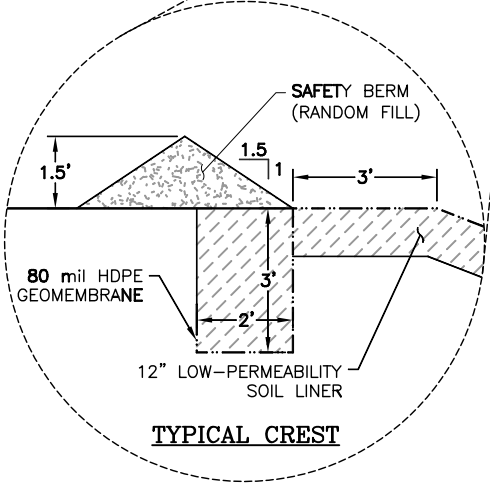
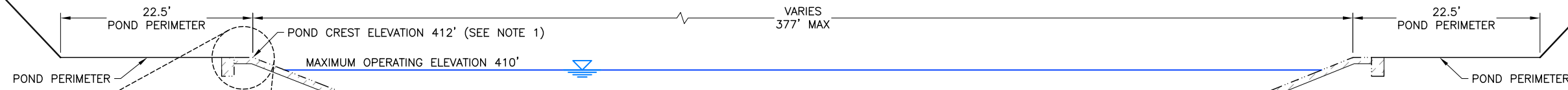
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APPROVED BY:	CJB	<p>DISCLAIMER</p> <p>NEWFIELDS PRODUCED THE INFORMATION PRESENTED ON THIS DRAWING THROUGH THE USE OF AVAILABLE TECHNICAL INFORMATION AND EXPERIENCE. RECEIVING THIS DRAWING DOES NOT GUARANTEE ANY RIGHTS TO EITHER SUCH TECHNICAL INFORMATION OR EXPERIENCE. ANY MODIFICATION OR ADAPTATION OF THE DATA OR DRAWING SHALL BE AT USER'S RISK AND WITHOUT ANY LIABILITY OR LEGAL RESPONSIBILITY TO NEWFIELDS.</p>
CHECKED BY:	JNM	
DESIGNED BY:	JNM	
DRAWN BY:	MJR	

	CLIENT	HAILE GOLD MINE INC	
	PROJECT	LOW GRADE ORE STOCKPILES	
TITLE	LEDBETTER LOW GRADE ORE STOCKPILE GRADING PLAN	FILENAME	42.016.001M
		DRAWING NO.	P10
		REVISION	0

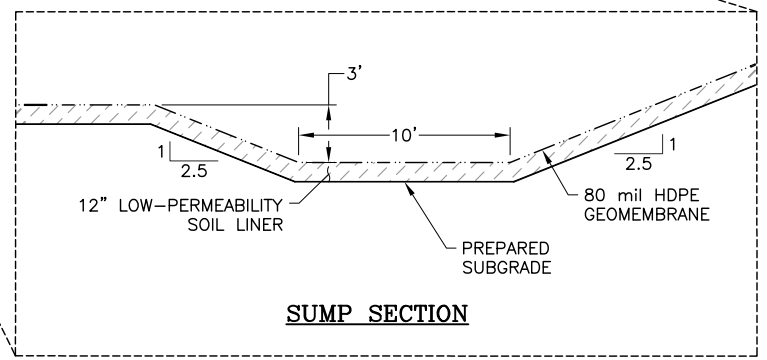
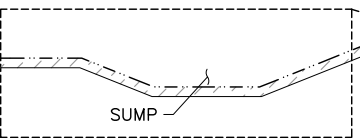
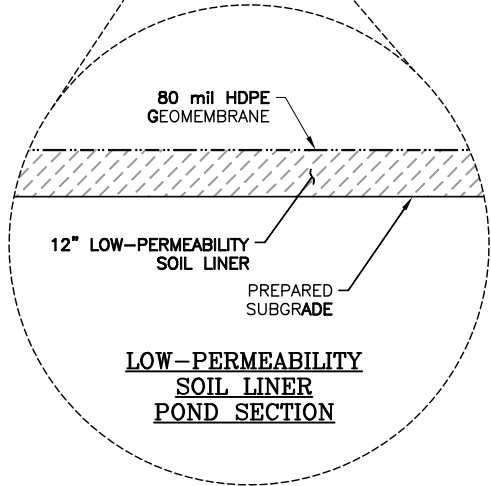


B LOW GRADE STOCKPILE OVERALL SECTION
P10



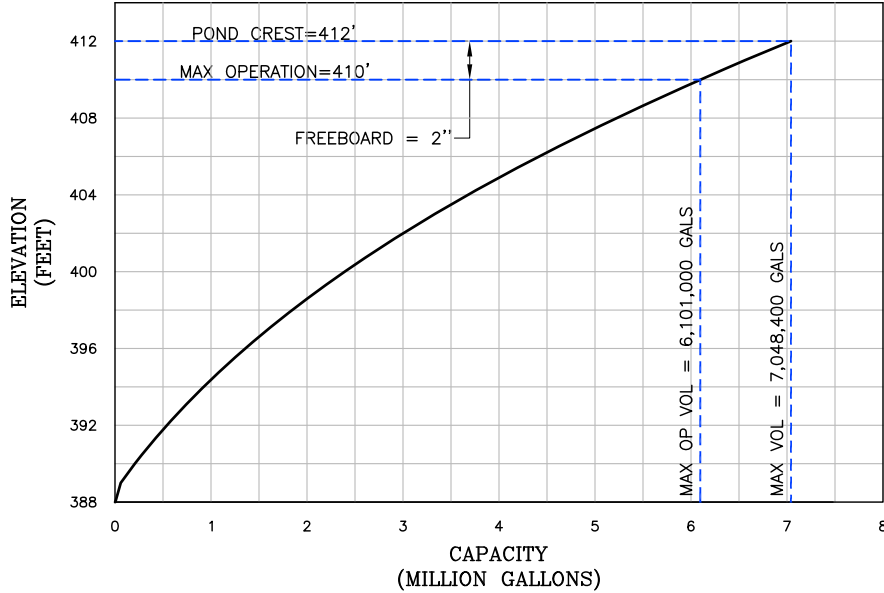
80 mil HDPE GEOMEMBRANE
PREPARED GRADED SURFACE
12" LOW-PERMEABILITY SOIL LINER

C POND SECTION
P10



NOTE:
1. FINAL POND ELEVATION IS DESIGNED FOR THE 7 MILLION TONNE FACILITY. SHOULD THE STOCKPILE BASE BE RAISED, THE POND CAN RAISE ACCORDINGLY IF DESIRED BY HAILE

LEDBETTER LOW GRADE ORE STOCKPILE RUNOFF COLLECTION POND FILLING CURVE



APPROVED BY: CJB		DISCLAIMER		CLIENT HAILE GOLD MINE INC	
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Technical Specifications



CLIENT
Haile Gold Mine Inc.

PROJECT NO
475.0042.001

PROJECT HAILE GOLD MINE PROJECT
JOHNNY'S PAG OSA AND CONTACT WATER PONDS

TITLE TECHNICAL SPECIFICATIONS FOR CORRUGATED
POLYETHYLENE PIPE MATERIALS AND CONSTRUCTION

SPECIFICATION NO.
0042 001-SP-CPEP-0

REV	DATE	PAGES	APPROVALS			REMARKS
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1.0 GENERAL

This specification defines the requirements for Corrugated Polyethylene Pipe (CPEP) materials, installation, and quality control associated with the Haile Gold Mine Inc. (Owner) Johnny's Potentially Acid Generating (JPAG) Overburden Storage Area (OSA) and Contact Water Ponds (CWP).

Any alternatives or exceptions to this specification shall be submitted in writing to the Owner or its designated representative and shall be approved by the Engineer.

1.1 Definition of Terms

- "Owner" is defined as Haile Gold Mine Inc. or any of its authorized representative(s) / agent(s).
- "Engineer" is defined as the Consultant or Engineering Company (NewFields) responsible for the detailed design or any of its authorized representative(s)/ agent(s).
- "Construction Manager" is defined as the Consultant or Engineering Company (M3 Engineering and Technology) responsible for the overall project completion.
- "Third Party Testing Contractor" is defined as the Consultant or Engineering Company (to be determined) hired by the owner to provide third party inspection and testing services for the overall project.
- "Contractor" is defined as the party(s) that has executed the contract agreement for the specified Work with the Owner or its authorized representative(s)/agent(s).
- "Specifications" are defined as this document, all supplemental addenda, and any modifications furnished by the Owner, the Engineer, or others that apply to the Work.
- "Drawings" are defined as the Construction Drawings for the JPAG OSA and CWP furnished by the Owner, Engineer, or others that apply to the Work.
- "Site" is defined as the Haile Gold Mine Project site being developed by the Owner and where the Work is to be completed as described in these Technical Specifications and detailed on the Drawings.
- "Contract" is defined as the document executed by the Owner or its authorized representative(s)/agent(s) with the Contractor to complete specified portions of the Work.
- "Work" is defined as the entire completed construction or the various separately identifiable parts thereof required to be furnished as shown on the Drawings and as described in the Specifications and Contract Documents.
- "Modifications" are defined as changes made to the Specifications or the Drawings that are approved by Owner and Engineer in writing, after the Specifications and Drawings have



been issued for construction. These also refer to changes to design elements in the field to account for unforeseen conditions.

- “Plant” is defined as all equipment, supplies, accommodations, temporary offices, etc., required to complete the Work.
- “Units” – In general, these Specifications and the Drawings will utilize English units, however metric units will be used when appropriate.

1.2 Codes and Standards

All pipe work shall be of the best quality available complying with the latest standards for the following:

- ANSI American National Standard Institute
- ASTM American Society of Testing and Materials
- AWWA American Water Works Association
- AASHTO American Association of State Highway Officials
- SPI Society of the Plastics Industry, Inc.
- PPI Plastics Pipe Institute

1.3 Material Properties

1.3.1 Corrugated Polyethylene Pipe (CPeP) with Smooth Interior

Pipe and fittings shall be made of virgin polyethylene compounds that conform with the applicable current edition of the AASHTO Material Specifications for cell classification as defined and described in ASTM D 3350. Resins that have higher cell classifications in one or more properties, with the exception of density, are acceptable provided the product requirements are met.

For slow crack growth resistance, acceptance of resins shall be determined by using the notched constant tensile load (NCTL) test in accordance with ASTM F2136 except that the applied stress for the NCTL test shall be 600 psi (Note: The notched depth of 20 percent of the nominal thickness of the specimen is critical to this procedure). The average failure time of the five test specimens must exceed 24 hours with no single test specimen's failure time less than 17 hours.



Pipe and fittings shall be manufactured and comply with the current edition of AASHTO Standard Specifications M252 and M294. All sizes shall conform to the AASHTO classification "Type S" for smooth wall interior solid pipe and "Type SP" for smooth wall interior perforated pipe.

CPeP and couplings for watertight application shall be Advanced Drainage System ADS N12 WT IB or equivalent. Prefabricated fittings for the watertight application shall have bell ends suitable for connecting to the pipe or alternatively shall have plain ends suitable for using bell-to-bell push-on gasketed couplings.

The pipe shall have a minimum pipe stiffness of 5-percent deflection when tested in accordance with ASTM D2412, as follows:

Nominal Diameter (inches)	Pipe Stiffness (psi)
4	70
6	65
8	60
10-12	50
15	42
18	40
24	34
30	28
36	22
42	20
48	18
60	14

The diameters refer to the inside pipe diameter.

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

- AASHTO M252 "Class 2" for 4-inch to 10-inch diameter CPeP
- AASHTO M294 "Class 2" for 12-inch to 36-inch diameter CPeP

Couplings (non-watertight) 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. Where pipe is joined to other materials or fittings, or joined by other methods, the manufacturer's recommendations shall be strictly enforced.

CPEP-to-HDPE pipe connections, if specified, shall be made using CPEP-to-HDPE adapters supplied by the CPEP manufacturer. The HDPE pipe end of the adapter shall match the DR (Dimensional Ratio) of the pipe being connected.

Pipe sizes and types shall be as specified on the Drawings, or as required by the **Engineer**.

1.4 Submittals

The CPEP material supplier shall submit to the **Engineer** a manufacturer's certification that all pipe and fittings they intend to supply comply with the applicable portions of the specifications.

1.5 Pipe Delivery, Handling, and Storage

Pipe, fittings, valves, and other appurtenances shall be loaded and unloaded by lifting with hoists in such a manner as to avoid damage or hazard. Under no circumstances shall pipe or pipe fittings be dropped to the ground or into trenches. Pipe handled on skid ways shall not be skidded or rolled against pipe already on the ground. The interior of all pipe and pipe fittings shall be kept free from dirt and foreign material at all times.

The **Contractor** shall be responsible for any material furnished to him by the **Owner** and shall replace or repair, in a manner approved by the **Engineer** at the **Contractor's** expense, all such material damaged in handling after delivery. This shall include the furnishing of all materials and labor required for the replacement of installed material damaged prior to the final acceptance of the Work.

1.6 Pipe Installation

CPEP shall be installed to the sizes, lines, and grades shown on the Drawings. Pipe sections shall be joined with manufacturer-supplied couplers with the open seam of the coupler turned to the side of the pipe. End caps shall be installed on the upstream ends of the pipe. Pipes shall be closely monitored during backfilling activities to ensure no damage is done to the pipe.

The pipe shall be installed to the lines and grades and generally in the manner shown on the Drawings. Where specific lines and grades are not indicated on the Drawings, the lines and



grades will be determined by the **Engineer** in the field to suit the existing ground conditions. The **Contractor** shall use equipment and methods acceptable to the **Engineer** and in accordance with the pipe manufacturer's recommendations for handling and placement of the pipe and fittings.

The **Contractor** shall provide and install all piping required to complete the piping installation in accordance with good piping practices, regardless of whether such piping is specifically detailed on the Drawings. The general layout as shown on the Drawings shall be maintained. Where interference is encountered during installation or relocation of pipelines is deemed necessary, the **Engineer** shall be consulted before any changes are made.

All pipelines shall be erected to preserve accurate alignment. Care shall be taken in the installation of pipeline runs where drainage is required to ensure that the pipeline has a continuous slope to the point of drainage.

Prior to installation, each segment of pipe and all fittings shall be inspected for defects or damage. All pipe, fittings, and other appurtenances shall be carefully lowered into position, piece by piece. Under no circumstances shall such materials be dropped into position. Extreme care shall be taken to prevent foreign material from entering the pipe while it is being installed. Temporary end caps or other approved means shall cover open ends of the pipe when installation is not in progress.

Pipe bends to form curves either in the horizontal or vertical plane shall not exceed that recommended by the manufacturer or approved by the **Engineer**. The cutting of pipe for inserting fittings or closure pieces shall be done in a neat manner and with good workmanship without damage to the pipe and leaving a smooth end at right angles to the axis of the pipe.

Wherever obstructions not shown on the Drawings are encountered during construction, and where such obstructions interfere with the work to an extent that an alteration in the lines or grades of the pipe is required, the **Engineer** shall approve any deviation or arrange for removal, relocation, or reconstruction of the obstructions.



CLIENT
Haile Gold Mine Inc.

PROJECT NO
475.0042.001

PROJECT HAILE GOLD MINE PROJECT
JOHNNY’S PAG OSA AND CONTACT WATER PONDS

TITLE TECHNICAL SPECIFICATIONS FOR EARTHWORKS
MATERIALS AND CONSTRUCTION

SPECIFICATION NO.
0042 001-SP-EW-1

REV	DATE	PAGES	APPROVALS			REMARKS
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1.0 GENERAL

This specification defines the requirements for the earthwork construction activities for the associated with the Haile Gold Mine Inc. (Owner) Johnny's Potentially Acid Generating (JPAG) Overburden Storage Area (OSA) and Contact Water Ponds (CWP). The specifications set forth in this document cover the quality of materials and workmanship for earthworks construction.

Any alternatives or exceptions to this specification shall be submitted in writing to the Owner or its designated representative(s)/agent(s) and shall be approved by the Engineer.

1.1 Definition of Terms

- "Owner" is defined as Haile Gold Mine Inc. or any of its authorized representative(s) / agent(s).
- "Engineer" is defined as the Consultant or Engineering Company (NewFields) responsible for the detailed design or any of its authorized representative(s)/ agent(s).
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- "Third Party Testing Contractor" is defined as the Consultant or Engineering Company (to be determined) hired by the Owner to provide third party inspection and testing services for the overall project.
- "Contractor" is defined as the party(s) that has executed the contract agreement for the specified Work with the Owner or its authorized representative(s)/agent(s).
- "Geomembrane Installer" is defined as the party (s) contracted by the Contractor or Owner to install, inspect and test the geomembrane portions of the project.
- "Specifications" are defined as this document, all supplemental addenda, and any modifications furnished by the Owner, the Engineer, or others that apply to the Work.
- "Drawings" are defined as the Construction Drawings for the JPAG OSA and CWP furnished by the Owner, Engineer, or others that apply to the Work.
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- “Modifications” are defined as changes made to the Specifications or the Drawings that are approved by Owner and Engineer in writing, after the Specifications and Drawings have been issued for construction. These also refer to changes to design elements in the field to account for unforeseen conditions.
- “Plant” is defined as all equipment, supplies, accommodations, temporary offices, etc., required to complete the Work.
- “Units” These Specifications and the Drawings will utilize English units, however metric units will be used when appropriate.

2.0 LANDSCAPE PRESERVATION

2.1 General

The **Contractor** shall exercise care at all times to preserve the natural landscape and shall conduct operations so as to prevent unnecessary damage, scarring or defacing of the natural surroundings in the vicinity of the work. Movement of personnel and equipment within the site disturbance, site access roads, and easements provided for access to the work shall be performed in a manner to prevent damage to the property and the environment.

2.2 Historic and Archaeological Data

There are historic and archaeological sites and artifacts known to exist within the work area. The known sites will be identified to the **Contractor** and the **Contractor** shall make its personnel and any subcontractors personnel aware of such areas and the restrictions associated with these areas. Notwithstanding, should the **Contractor** or any of its Subcontractors discover evidence of artifacts of possible scientific, historic, or archaeological significance within the work area they shall notify the **Owner** immediately.

2.3 Protection of Wetlands

There are jurisdictional wetlands within the work area. The known sites will be identified to the **Contractor**. The **Contractor** shall exercise care at all times to preserve the wetlands and shall conduct operations so as to prevent damage to the areas that will not be disturbed by the facility construction. The 100-foot buffer around all non-impacted wetlands shown on the plans will not be entered for any reason without written permission from the **Owner**.

3.0 EARTHWORKS

This section presents the technical requirements for the earthworks construction for the JPAG OSA and CWP.



All equipment used by the **Contractor** shall meet satisfactory conditions and comply with the Specifications with the approval of the **Engineer**. The **Engineer** reserves the right to request in writing a change in the required equipment or procedure of any work and the **Contractor** shall comply.

During all earthwork operations the contractor will be responsible for dust control. Care shall be taken to minimize and control the generation of dust by means approved by the **Owner** or **Construction Manager**.

3.1 Control of Surface Water and Stormwater Runoff

The **Contractor** shall review the available surface runoff and subsurface data for the project site and evaluate the surface and subsurface conditions at the project site with respect to required diversion and dewatering requirements as conceptually shown on the Drawings. During the construction period, the **Contractor** will be responsible for constructing and maintaining any temporary ditches, channels, and or sediment control ponds required to protect the works and control surface water flows as well as limit sediment transport outside the limits of the work as directed by the **Owner**.

The **Contractor** shall prepare a stormwater management plan that will allow construction of all the project elements as detailed on the design drawings and meets all requirements for the South Carolina Department of Health and Environmental Control, Stormwater Best Management Practices (BMP) Handbook. The plan shall detail the materials, equipment pumps, piping, cofferdams, channels, and other components necessary to complete the construction and erosion and sediment control.

The temporary surface water runoff control including temporary and permanent berms, canals and any other control measures, shall be built according to the line and grade indicated on the on a plan submitted by the **Contractor** and approved by the **Owner** and **Construction Manager** and maintained throughout the work.

The **Contractor** shall build berms, and embankments and other erosion control measures required to prevent significant transport of sediments from the stockpiles, fill areas, and other areas of the work that may be subject to the effects of rainwater.

The **Contractor** shall provide equipment and perform all necessary work to maintain the areas of surface and groundwater collection to remove sediments from the water before it leaves the site. The **Contractor** shall provide the temporary erosion control measures and make improvements immediately to these control measures as required by the **Owner** or **Engineer**.



The **Contractor** shall prevent all damage to the work areas due to drying, water runoff and sediment control.

The **Contractor** shall remove all temporary installations of erosion control measures when they are no longer necessary and restore the areas affected by these measures.

The **Contractor** shall be responsible for the damage that results from rainfall runoff and for failed erosion control measures.

3.2 Earthwork Specifications

3.2.1 Clearing and Grubbing

The natural ground surface is to be cleared and stripped of all organic and objectionable materials to the limits shown on the Drawings or as required by the **Engineer** to facilitate construction. The limits of stripping shall generally extend approximately 10 feet outside of the Work activity areas as shown on the Drawings. Any clearing and stripping beyond the limits shown on the Drawings, or as required by the **Engineer**, shall be subject to the approval of the **Owner**.

The area shall be cleared of all trees, shrubs, undergrowth, deadwood, rocks larger than one-foot (1') in diameter and other debris. As necessary trees shall be felled, lopped and cut to lengths suitable for removal from the site.

All stumps, the main root ball and roots systems from the cleared trees and shrubs shall be removed. Removal of root systems shall continue until all roots larger than 3 inch in diameter are removed unless approved otherwise by the **Owner** and **Engineer**.

Clearing and Grubbing will be carried out using whatever method is deemed necessary, providing it is consistent with producing an acceptable end result as determined by the **Owner** and the **Engineer**. Care is to be taken to minimize erosion and excessive sediment buildup.

Disposal of all surface debris, trees and shrubs shall be as defined in the contract documents and as designated by the **Owner**. The **Contractor** shall not burn or bury any debris or material from clearing or grubbing operations unless expressly approved in writing by the **Owner**.

The **Contractor** shall be responsible for maintaining the cleared work area in a condition free from additional vegetation growth for the duration of the project. The use of herbicides to discourage plant growth shall not be allowed unless approved by the **Owner**.

All surface water runoff shall be directed to available sediment control structures before it is released into natural drainage courses.



3.2.2 Growth Media Stripping

Once the natural ground surface has been cleared and stripped of all objectionable materials to the limits shown on the Drawings or as required by the **Engineer** the growth media (topsoil) shall be removed. All usable growth media, as determined by the **Engineer**, shall be properly placed in a storage area shown on the Drawings or as designated by the **Owner**.

Stripping shall mean the removal of growth media, which is defined as soil of any gradation or degree of plasticity that contains significant quantities of visually identifiable plant matter, sod, roots, or humus as determined by the **Engineer**. Over much of the JPAG OSA, ponds and associated construction areas, stripping will consist of removal of the small root system not removed with the clearing and grubbing operation and vegetation cover with limited removal of surface soil at a minimum of 12 inches. The stripped material shall be hauled to growth media storage areas as shown on the Drawings or as directed by the **Owner**. Stripped surface soils and vegetation suitable for use for future reclamation purposes shall be stored separately from material viewed as unsuitable for reclamation purposes.

Growth media stripping will be carried out using whatever method is deemed necessary, providing it is consistent with producing an acceptable end result as determined by the **Owner** and the **Engineer**.

After stripping of the required area, the surface shall be prepared as specified on the Drawings or in the Technical Specifications. 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 required for continuance of Work. A survey shall be taken of the area if necessary to determine quantities or for verification of lift or layer thickness after stripping is complete.

3.2.3 Grading and Prepared Surfaces

Once the work area has been cleared and stripped to the satisfaction of the **Engineer**, the surface shall be prepared and approved by the **Third Party Testing Contractor** before any overlying materials are placed. All work areas shall be graded according to the limits shown on the Drawings. Areas of both cut and fill shall be required to bring the grading of the work area to the elevations specified in the Drawings.

Areas that are to be filled and finished subgrade elevation for cut surfaces shall have the exposed surface scarified to a depth of approximately 8–inches, moisture conditioned, and compacted to 90 percent of the maximum dry density, within 3 percent of optimum moisture content as determined by the Modified Proctor Density Test, ASTM D1557. The **Engineer** may waive this requirement if the exposed surface soils without manipulating will provide a firm,



non-yielding surface for fill placement, in which case the surface shall be moistened, lightly scarified and the first layer of fill placed.

Cut surfaces on which there is no overlying construction such as a road and channel slopes, in general, do not require scarification, moisture conditioning or compaction.

All boulders and cobbles that are located at the surface or partially exposed in a finish cut or fill area that could be detrimental to the overlying construction shall be removed as directed by the **Engineer**.

Areas of unsuitable material as determined by the **Engineer** or areas of pre-existing fill not compacted to the specifications shall be excavated to the limits designated by the Engineer and replaced with compacted random fill.

Areas with material suitable for use as "Drainage Layer", "Chimney Drain", or "Low-Permeability Layer or Liner" as determined by the **Engineer** shall be excavated to the limits designated by the **Engineer**, placed into designated storage areas, and replaced with compacted fill, or the area re-contoured to tie into the adjacent designed contours as directed by the **Engineer**.

The **Contractor** is responsible for maintaining the surface in a satisfactory condition after approval of the **Engineer**. The **Contractor** shall protect the prepared surface from weather, construction equipment and other factors.

3.2.4 Prepared Diversion Surface

Diversion and runoff channels (temporary or permanent) and cut and fill areas, in general, shall be prepared as indicated above and as per the following:

All areas that require cut to achieve the rough grade within the channel flow area that is not in rock shall be scarified to a depth of approximately 8 inches, moisture conditioned, and compacted to 95 percent of the maximum dry density as determined by ASTM D1557.

Areas of the channels to receive geotextile or reinforced turf mat shall be free of angular particles and hard objects that may damage the geotextile. Smooth-drum finishing rollers shall be used to smooth the surface to embed small stones and rocks into the soil matrix. Where excessive coarse material is exposed at the surface, rock removal by appropriate methods or other surface finishing as directed by the **Engineer** will be required.



Channel areas to receive geomembrane shall be finished in accordance with Section 3.3 “Finished Surface Preparation of Areas to Receive Geomembrane Lining” unless directed otherwise by the **Engineer**.

3.2.5 Excavations and Borrow Areas

Excavation methods, techniques and procedures shall be developed with consideration to 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 as required by the **Engineer**. Excavation, shaping, etc., shall be carried out by whatever method is considered most suitable, providing it is consistent with producing an acceptable result as determined by the **Engineer**. Excavations shall be graded to provide drainage and prevent ponding. For excavations that cannot be graded to drain, the **Contractor** shall make provisions for the equipment and labor necessary to keep the excavations free of standing water.

No excavation beyond the lines and grades shown on the Drawings or as required by the **Engineer** shall be completed without the prior approval of the **Engineer** and **Owner**. If such additional excavation is done without prior approval and, in the opinion of the **Engineer**, requires backfilling to satisfactorily complete the Work, such backfilling shall be approved by the **Engineer** and shall be completed at the **Contractor's** cost. The **Contractor** shall protect and maintain all excavations until the adjacent placement or overlying placement of material has been completed.

The **Contractor** shall coordinate borrow activities with the **Engineer** and **Third Party Testing Contractor** to allow the sampling and testing of materials prior to their excavation. The **Contractor** shall allow the **Engineer** and **Third Party Testing Contractor** adequate time to evaluate potential borrow materials. Materials from excavations within the works or borrow areas that meet the specified requirements for other construction materials shall be stockpiled or placed in fill areas as directed by the **Engineer** and **Owner**. Unsuitable or excess materials shall be hauled to waste or stockpile areas.

The materials obtained from borrow pits or **Owner**-stockpiled material shall be selected to ensure that the gradation requirements for the various construction materials are achieved and that the materials are as homogeneous as possible. Care shall be taken to avoid cross-contaminating different types of materials.

On-site borrow areas shall be developed within the limits shown on the Drawings or as required by the **Owner**. Should the **Contractor** wish to develop additional borrow sources, the **Contractor** shall receive written approval from the **Owner** prior to proceeding. Approval by



the **Owner** may require that subsurface investigations be carried out to obtain samples as are required by the **Engineer** to make an appropriate assessment of the suitability of the borrow materials in the area for the intended use at the **Contractor's** cost.

Borrow pit operations shall be subject to the approval of the **Owner** and **Engineer** and shall avoid waste of any suitable construction material therein. Clearing and stripping of any borrow area is to be completed with all salvageable growth media stockpiled in areas designated on the Drawings or as directed by the **Owner**. Each borrow area shall be developed with due consideration for drainage and runoff from the excavated surfaces so as to minimize erosion and ensure sediment control prior to release of any surface water or stormwater. Each borrow area shall be excavated in near-horizontal layers and in such a manner that water will not collect and pond except as approved by the **Owner**. Before being abandoned, the sides of any borrow areas outside the Work area shall be brought to stable slopes (not steeper than 2.5H:1V) with slope intersections rounded and contoured to provide a natural, neatly graded appearance.

Growth media piles shall be leveled, trimmed and shaped to prevent the occurrence of ponding or concentrations of surface runoff and to provide a neat appearance. Finished slopes of the growth media stockpiles shall be graded to 2.5H:1V for interim reclamation. All surface water runoff shall be directed to available natural drainage courses and shall utilize proper sediment control measures approved by the **Owner**.

3.2.6 Groundwater Collection Drains

Groundwater collection drains shall be installed in the locations as shown on the Drawings or as directed by the **Engineer**. Once the work area has been dewatered, cleared, grubbed and stripped of growth media and unsuitable materials the area will be inspected by the **Engineer** to determine the need and required limits for groundwater collection drains. Generally this inspection will be a visual inspection however some excavation of test holes may be incorporated into the inspection to identify the limits of the groundwater collection system and unsuitable materials before construction of the groundwater collection drain system.

For areas within the limits of any groundwater collection drain that requires the removal of unsuitable material a determination will be made by the **Engineer** once the unsuitable material has been removed as to whether the area requires to be backfill to achieve the necessary drain profile or if the adjacent area can be re-contoured to tie into the adjacent designed contours.

Construction of the drains shall be in general accordance with the typical section(s) shown on the Drawings with such modifications as required by the **Engineer** during installation to suit the field conditions.



The lines and grades will be determined by the **Engineer** in the field to suit the existing ground conditions. The minimum slope of the trench bottom will be 0.5 percent.

The groundwater drain outlet shall be in a sump as shown on the Drawings.

3.2.7 Fill Materials

Earthfill will not be placed until the clearing and stripping, and required foundation preparations have been completed; the foundation has been inspected and approved by the **Engineer**; and any required surveys completed.

All material used for fill shall be loaded and hauled to the placement site, dumped, spread, and leveled to the specified layer thickness. Fill shall be moisture conditioned and compacted to form a dense integral fill in accordance with these technical specifications and as approved by the **Engineer**. Care shall be taken at all times to avoid segregation of the material being placed and, if required by the **Engineer**, all pockets of segregated or undesirable material shall be removed and replaced with material that matches the surrounding material. All oversized material will be removed from the fill material either prior to it being placed or after it is dumped and spread but prior to compaction. No additional payment will be made to remove oversized materials unless the Work is specifically identified as a payment item on the Schedule of Quantities.

For most construction conditions, the fill is to 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**.

Except in areas approved by the **Engineer**, where space is limited or as otherwise specified, fill shall be placed by routing the hauling and spreading units approximately parallel to the axis of fill. The hauling equipment shall be routed in such a manner that they do not follow in the same paths but spread their travel routes evenly over the surface of the fill to aid in compaction of the fill placed.

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 may be carried out by whatever method the **Contractor** deems is suitable, provided it produces the moisture content specified in these technical specifications or designated by the **Engineer**. The **Contractor** shall take the necessary measures to ensure that moisture is being distributed



uniformly throughout each layer of material being placed immediately prior to compaction. Measures shall be adopted as are necessary to ensure that the designated moisture content is preserved after compaction until the overlying layer is placed.

All particles having dimensions that interfere with compaction in the fill as determined by the **Engineer** or **Third Party Testing Contractor** shall be removed from the zone in which they were placed either prior to or during compaction.

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.

Minor deviations from the material properties and gradation limitations specified in the Sections below may be acceptable, subject to the review and approval of the **Engineer**.

3.2.7.1 Random Fill

Material Properties - The random fill will have a wide range of Unified Soil Classifications (USCS) and may contain significant variations in gradation and compaction properties. Random fill shall be placed in areas where the material is not required to be of uniform character and engineering properties. Random fill shall be free of roots, grass and other organic material and consist of inorganic soil and rock materials from required excavations, mine overburden materials or borrow material from other sources, as approved by the **Engineer**.

Materials containing rock or cobbles, gravel and clean gap graded sand (minimal fines) from required excavations may be used subject to the **Engineer's** approval and provided the rock be reasonably graded such that large void spaces do not result and the clean sand is not placed within 10 feet of a permanently exposed slope. Further, the maximum size rock shall be no larger than two-thirds (2/3) of the compacted lift thickness.

Placement Methods - Random fill shall be moisture conditioned to within 2 percent below and 3 percent above of the optimum moisture content, placed in 12-inch maximum loose lifts, and compacted to 95 percent of the maximum dry density (ASTM D1557). Slight variations from the specified moisture range may be acceptable subject to the acceptance of the **Engineer** and provided the required compacted densities are achieved. The random fill material shall be compacted with appropriate compaction equipment capable of achieving compaction through the full thickness of the lift layer. If the random fill placement and compaction utilizes 90-ton or larger haul trucks, the lift thickness can be increased subject to the approval of the **Engineer**.

Rock fill containing more than 30-percent rock (materials above ¾-inch size) shall be spread, placed and compacted using procedures based on the results of a test fill. The type of



compaction equipment, number of passes, maximum rock size and loose lift thickness 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 **Contractor** shall construct a test fill to verify the adequacy of the compaction equipment for achieving the required density. The test fill may be located so that it is incorporated into the fill area. The test fill shall be constructed and monitored in accordance with the U. S. Army Corps of Engineers' (USACE) guidelines for test fill construction (USACE, EM 1110-2-2301).

The data to be collected during construction of the test fill shall include the following:

- Lift thickness of 1, 2, and 4-feet (three test fills to determine optimum lift thickness)
- Amount of settlement after every two passes of the compactor to a maximum of 25 passes
- Gradation and moisture content of in-place material
- In-place fill density at completion of the test by nuclear gauge or other methods approved by the **Engineer**. If rockfill the water replacement method may be required to assess compaction.

A curve showing change in settlement versus number of passes shall be produced from the data. This curve will be used to determine the required minimum number of passes for acceptable compaction. In general, the minimum number of passes will be that number to achieve 80 percent of the total settlement obtained after ten complete passes of the compaction equipment. Final determination by the **Engineer** of the lift thickness and minimum required passes will be based on review of the test data.

Maximum rock size for all fills shall be two-thirds ($2/3$) of the compacted lift thickness, unless otherwise approved by the **Engineer**. Oversize materials shall be removed from the fill.

The placement of fill shall be temporarily suspended by the **Contractor** due to weather concerns if the materials and installation cannot comply with the technical specifications, with no cost to the **Owner**.

3.2.7.2 Low-Permeability Soil Liner

Material Properties – Low-permeability soil material shall consist of an inorganic fine-grained silt and clay or sandy and gravelly silt and clay material obtained from on-site excavations, near-site borrow areas or generated from the pit and stockpiled by the **Owner**.

The material gradation shall be as follows:



Sieve Size (square openings)	Percent Passing (by dry weight)
6 -inch	100
No. 4	55-100
No. 200	25-70

The low-permeability soil shall have a minimum plasticity index of 15 as determined by ASTM 4318

Laboratory testing (see Table 5) shall be completed on all low-permeability layer and liner sources prior to placement by the **Third Party Testing Contractor**. The material shall be classified and compared to the material properties used in the design and approved by the **Engineer** prior to placement.

Some oversize materials, on the order of 6 to 12-inches, will be present in the proposed low-permeability materials. Removal of the oversize materials will be necessary to meet the requirements of the material gradation and to meet the technical specifications for the requirement of the finished surface.

Placement Methods – The low-permeability material shall be placed in lifts not to exceed 12 inches compacted lift thickness. This material shall be compacted to 95 percent of the maximum dry density as determined by ASTM D1557. The moisture content of the material will be maintained at optimum to 3 percent above optimum moisture content. Slight variations from the specified material gradation, moisture range and compaction requirements may be acceptable subject to the acceptance of the **Engineer**. The low-permeability liner material shall be compacted using a sheepsfoot compactor. Smooth-drum finishing rollers shall be used to smooth the surface to remove the tracks from the sheepsfoot rollers and to embed small stones and rocks into the soil matrix for the low-permeability soil liner.

The **Contractor** shall protect the finished surface of the low-permeability soil liner from desiccation cracking and weather damage between placement activity and coverage by the **Geomembrane Installer**. Areas that exhibit desiccation cracks in excess of $\frac{3}{4}$ inch in depth or are damaged due to weather shall be reworked prior to geomembrane placement without additional costs to the **Owner**.

If moisture accumulates under the geomembrane before or after welding the panels and softens the low-permeability soil liner, the membrane shall be removed and the earthwork



Contractor shall be required to recondition and recompact the low permeability soil liner to comply with the technical specifications without additional costs to the **Owner**.

The **Contractor** shall remove all rocks larger than 4 inches and construction stakes from the low permeability soil liner and any holes shall be filled to the approval of the **Engineer**.

If any area of the low permeability soil liner does not comply with the requirements of the technical specifications and is not approved by the **Engineer** it shall be considered in nonconformance and the **Contractor** shall be required to rework the area until acceptable at no cost to the **Owner**.

3.2.7.3 Liner Protective Layer

Material Properties –Liner protective layer material shall consist of sands, silts and gravels and is placed on top of the geomembrane to provide a protective layer between the geomembrane and the overburden materials. The material shall be free from debris, large gravel particles and any other materials that have the potential to damage the underlying geomembrane. The material shall have a maximum PI of 15 as determined by ASTM 4318 and generally conform to the following gradation unless otherwise approved by the **Engineer**.

Sieve Size (square openings)	Percent Passing (by dry weight)
1 –inch (25.4 mm)	100
No. 4 (4.75 mm)	50-100
No. 40 (0.425 mm)	20-90
No. 200 (0.075 mm)	0-25

Placement Methods - Before placing the protective layer, the **Contractor** shall verify by a visual inspection that all geomembrane material installed in the area are free from perforations, wrinkles, scratches and other damage. The **Engineer** shall inspect the geomembrane material to verify that it is ready to receive the protective layer.

Protective layer material shall be placed directly on the geomembrane with extreme care to prevent damage of the geomembrane. This is generally done by hauling and placing the material on the geomembrane in a single lift with haulage units that exert less than 80 pounds per square inch (psi) of ground pressure. The material shall be spread with a low ground pressure crawler-type tractor or equivalent that exerts less than 80 psi of ground pressure. The material shall be placed at a minimum loose thickness such that the final lift thickness is



not less than the design thickness shown on the drawings (**Contractor** to determine allowance for settlement). At no time shall equipment operate directly on the surface of the geomembrane.

Special attention shall be taken when being placed over the geomembrane. All oversized material that may damage the underlying geomembrane will be removed by whatever means necessary to ensure there is no damage. Because of the thickness of the protective layer and the potential damage of the geomembrane, vehicle traffic on the protective layer shall be as minimum as possible and shall be restricted to roadways and other main access ways. Protective layer thickness within roadways shall be maintained at least 4-feet above the geomembrane surface or whatever thickness is deemed necessary by the **Engineer** based on test pad trials performed prior to starting protective layer placement.

Proposed methods and equipment to be utilized in protective layer construction, shall be submitted to the **Engineer** for review prior to commencement of the Work.

The **Contractor** shall not place fill materials at such times that, in the opinion of the **Engineer**, conditions for such operations are unsatisfactory due to precipitation, low temperatures or any other reasons. As the ambient air temperature increases, wrinkles in the geomembrane will develop due to thermal expansion of the geomembrane. Placement of the protective layer will cease if the wrinkles become large enough to fold over or it causes a crease to form when covered with protective layer material. Protective layer material shall be placed during the cooler times of the day or during the evening when the geomembrane lays relatively flat. To minimize the effect of wrinkles, the protective layer shall be placed in an uphill direction and parallel to the contours. At no time, shall conditions result in the movement or slippage of the protective layer materials that could potentially cause liner or pipe damage. Except as necessary for construction and the safety of the Works, geomembrane anchor trenches shall not be filled until several cycles of expansion and contraction have occurred.

The thickness of the protective layer shall be verified by the **Third Party Testing Contractor** and areas with deficient amounts of material shall be reworked to comply with the technical specifications. Any damage done to the geomembrane material during installation shall be exposed by the **Contractor** and repaired by the **Geomembrane Installer** at no cost to the **Owner**.

Protective layer placement shall be suspended if in the opinion of the **Engineer** the operation creates unsafe conditions due to moisture or ice build-up on the geomembrane, visibility becomes problematic or the quality of work is being compromised. The **Contractor** shall make sure material is not rutting or pumping under the haul traffic due to the excessive moisture. Materials shall not be placed on concentrations of snow or ice, nor shall concentrations of



snow or ice be incorporated into the fill material either prior to or during placement. In heavy snow, rainfall or when visual inspection is not possible either due to visibility or inability to safely stand on the geomembrane, the protective layer placement shall be suspended by the **Engineer** at no cost to the **Owner**. Snow and ice must be removed from the liner surface prior to protective layer placement. The snow or ice shall be removed a sufficient distance from the liner and drainage interface edge such that the **Third Party Testing Contractor** personnel can examine the liner conditions prior to protective layer placement. Frozen chunks in the protective layer material that may damage geomembrane or add excessive moisture to the material once thawed are not allowed.

The **Contractor** shall supply a full-time laborer to visually inspect 100% of the protective layer placement and direct the equipment. The **Third Party Testing Contractor** will also observe all protective layer placement and will have the authority to require any areas to be removed and inspected if damage to the geomembrane is suspected.

3.2.7.4 Drainage Aggregate

Material Properties - The drainage aggregate material shall consist of clean gravel. The materials shall be composed of hard, durable stone particles reasonably free from thin, flat, and elongated pieces. The material shall consist of either native non-plastic materials generated through an off-site crushing and screening operation. The material shall meet the following gradation limits:

Sieve Size (square openings)	Percent Passing (by dry weight)
1 ½ -inch	100
¾ -inch (19mm)	70-100
No. 4 (19mm)	5-50
No. 40 (mm)	0-35
No. 200 (0.075mm)	0-8

Material used for drainage aggregate may be approved by the **Engineer** by visual inspection if the rock is determined to be sound and durable. However, if in the **Engineer's** opinion, the material is questionable or unacceptable, the **Engineer** may require one or more of the following laboratory tests on representative drainage material samples in order to assess the quality of the material.

Drainage Aggregate Material Laboratory Tests



Test Description	Test Method	Specification Requirement
Los Angeles Abrasion	ASTM C 535	50% Loss Maximum (after 500 revolutions)
Sodium Sulfate or Magnesium Sulfate Soundness	AASHTO T 104 or ASTM C88	10% Maximum Loss (after 5 cycles)
Soundness by Freezing and Thawing	AASHTO T 103	10% Maximum Loss (after 12 cycles)
Slake Durability	ASTM 4644	Classification as Type 1

Placement Methods - Before placing the drainage aggregate, the earthwork **Contractor** shall verify by a visual inspection that all geomembrane materials installed in the area are free from perforations, wrinkles, scratches and other damage. The **Engineer** shall inspect the geomembrane material to verify that it is ready to receive the drainage blanket.

Drainage aggregate material shall be placed directly on the geomembrane and around piping with extreme care to prevent damage of the geomembrane. This is generally done by hauling and placing the material on the geomembrane in a single lift with haulage units that exert less than 80 psi of ground pressure. The material shall be placed at a minimum loose thickness such that the final lift thickness is not less than the design thickness shown on the drawings. **Contractor** to determine allowance for settlement. At no time shall equipment operate directly on the surface of the geomembrane.

Special attention shall be taken when drainage material is being placed over the corrugated Polyethylene (CPE) and High Density Polyethylene (HDPE) pipe. All oversized material that may damage the pipework or geomembrane will be removed by whatever means necessary to ensure there is no damage. Because of the thickness of the drainage aggregate and protective layer and the potential crushing of the collector pipes and damage of the geomembrane, vehicle traffic on the drainage materials shall be as minimal as possible and shall be restricted to roadways and other main access ways. Drainage aggregate or protective layer thickness within roadways shall be maintained at least 4-feet above the geomembrane surface. A minimum cover equal to 1-foot over the top of the 4-inch CPE pipe and a minimum of 1.5-feet over the top of 8-inch or larger CPE or HDPE pipe shall be maintained at all times.

Proposed methods and equipment to be used in drainage aggregate construction shall be submitted to the **Engineer** for review and approval prior to commencement of the Work.

The **Contractor** shall not place fill materials at such times that, in the opinion of the **Engineer**, conditions for such operations are unsatisfactory due to precipitation, low temperatures or any



other reasons. As ambient air temperature increases, wrinkles in the geomembrane will develop due to thermal expansion of the geomembrane. Placement of drainage aggregate will cease if the wrinkles become large enough to fold over or it causes a crease to form when covered with drainage blanket material. Drainage aggregate material shall be placed during the cooler times of the day or during the evening when the geomembrane lays relatively flat. To minimize the effect of wrinkles, the drainage aggregate shall be placed in an uphill direction and parallel to the contours. At no time, shall conditions result in movement or slippage of the drainage blanket materials that could potentially cause liner or pipe damage. Except as necessary for construction and the safety of the Works, geomembrane anchor trenches shall not be filled until several cycles of expansion and contraction have occurred.

The thickness of the drainage aggregate shall be verified by the **Third Party Testing Contractor** and areas with deficient amounts of material shall be reworked to comply with the technical specifications. Any damage to the geomembrane material during installation shall be exposed by the **Contractor** and repaired by the **Geomembrane Installer** at no cost to the **Owner**.

Drainage aggregate placement shall be suspended if in the opinion of the **Engineer** the operation creates unsafe conditions due to moisture or ice build-up on the geomembrane, visibility becomes problematic or the quality of work is being compromised. The **Contractor** shall make sure material is not rutting or pumping under the haul traffic due to the excessive moisture. Materials shall not be placed on concentrations of snow or ice, nor shall concentrations of snow or ice be incorporated into the fill material either prior to or during placement. In heavy snow, rainfall or when visual inspection is not possible either due to visibility or inability to safely stand on the geomembrane, the drainage aggregate placement shall be suspended. Snow and ice must be removed from the geomembrane surface prior to overliner placement. The snow or ice shall be removed a sufficient distance from the geomembrane and drainage aggregate edge such that the **Third Party Testing Contractor** personnel can examine the geomembrane conditions prior to drainage blanket placement. Frozen chunks in the drainage aggregate material that may damage geomembrane or add excessive moisture to the material once thawed are not allowed. The moisture content of the drainage aggregate shall be maintained at a minimum (<5%) to avoid excess freezing within the material.

The **Contractor** shall supply a full-time laborer to visually inspect 100% of the drainage aggregate placement and direct the equipment. The **Third Party Testing Contractor** will also observe all drainage aggregate placement and will have the authority to require any areas to be removed and inspected if damage to the geomembrane is suspected.



3.2.7.5 Pipe Bedding and Pipe Backfill

Material Properties - Pipe bedding and backfill material for foundations, culverts and pipes shall consist of materials with the following typical characteristics:

Sieve Size (square openings)	Percent Passing (by dry weight)	
	Pipe Backfill	Pipe Bedding
4 –inch (100 mm)	100	
3 –inch (75 mm)	90-100	
1-½ -inch (37.5 mm)	--	100
¾ -inch (19 mm)	--	90-100
No. 4 (4.75 mm)	--	30-70
No. 40 (0.425 mm)	--	--
No. 200 (0.075 mm)	8-20	8-20
Plasticity Index	10 max	10 max

Pipe bedding and pipe backfill shall be free of organic material.

Placement Methods - Backfilling shall be done as soon as possible after pipe or culvert installation. Suitable backfill and embankment material, free from large lumps, clods, or rocks shall be placed alongside the structure in loose layers not exceeding 8–inches thick to provide a berm of compacted earth on each side of the pipe or structure. The fill materials shall be a minimum of 5-feet wide or the width of the pipe diameter or structure but no less than required to operate the appropriate compaction equipment. Each 8-inch layer shall be moisture conditioned, as required to facilitate compaction and compacted to a minimum of 95 percent of the maximum dry density as determined by ASTM D1557 or as directed by the **Engineer**.

If it is necessary to construct a haul or other vehicle road over the pipe trench, the **Engineer** shall be consulted prior to the initiation of trench construction for specification modification to achieve structure sufficient for such traffic loading.

Backfill shall be placed symmetrically on each side of the structure. The backfill differential on either side of the pipe shall not exceed 8-inches, or one quarter of the diameter of the structure, whichever is less.



Prior to adding each new layer of loose backfill material until a minimum 12-inches of cover is obtained, an inspection shall be made by the **Third Party Testing Contractor** of the inside of the structure for local or unequal deformation caused by the backfilling operation. Only hand-operated tamping equipment shall be allowed within vertical planes 3-feet beyond the horizontal projection of the outside surfaces of the structure. Modification to this technical specification as recommended by the culvert or structure manufacturer or designer can be submitted for approval by the **Engineer**. No heavy earthmoving equipment shall be permitted over the structure until a minimum of 150 percent of the largest buried pipe diameter of compacted fill has been placed over the top of the structure, or the minimum cover recommended by the culvert manufacturer or designer. In no case shall the minimum compacted structural cover be less than 12-inches.

Backfill material shall not be placed against any concrete foundation, abutment, wing wall, or culvert until the concrete has been in place at least seven days or the compressive strength of the concrete is 75 percent of the required 28-day strength. On structures that are not permanently supported laterally and that cannot tolerate horizontal movement, internal bracing or support should be placed during backfill operations.

3.2.7.6 Riprap

Material Properties - Riprap shall be hard, durable, angular in shape, reasonably well graded and free of organic and deleterious material and foreign debris. It shall have a specific gravity greater than 2.5 and its largest dimension shall not be larger than 3 times its smallest dimension. Rounded gravel, cobble and boulders shall not be allowed unless otherwise approved by the **Engineer**. Riprap shall generally conform to the following gradation as determined by ASTM C136.

D₅₀ = 3 in. (75 mm)

Sieve Size	% Passing	Typical Stone Mass
6 in. (150 mm)	100	
3 in. (75 mm)	35-55	1.3 lbs. (0.6 kg)
1.5 in. (37.5 mm)	0-20	



D₅₀ = 6 in. (150 mm)

Sieve Size	% Passing	Typical Stone Mass
12 in. (300 mm)	100	
9 in. (225 mm)	50-70	35 lbs. (16 kg)
6 in. (150 mm)	35-55	10 lbs. (4.5 kg)
2 in. (50 mm)	2-10	0.5 lbs. (0.2 kg)

D₅₀ = 9 in. (225 mm)

Sieve Size	% Passing	Typical Stone Mass
18 in. (450 mm)	100	
15 in. (375 mm)	70-100	165 lbs. (75 kg)
9 in. (225 mm)	50-70	35 lbs. (16 kg)
6 in. (150 mm)	35-55	10 lbs. (4.5 kg)
3 in. (75 mm)	2-10	1.3 lbs. (0.6 kg)

D₅₀ = 12 in. (300 mm)

Sieve Size	% Passing	Typical Stone Mass
24 in. (600 mm)	100	
21 in. (525 mm)	70-100	440 lbs. (200 kg)
18 in. (450 mm)	50-70	275 lbs. (125 kg)
12 in. (300 mm)	35-55	88 lbs. (40 kg)
4 in. (100 mm)	2-10	3 lbs. (1.4 kg)

D₅₀ = 18 in. (450 mm)

Sieve Size	% Passing	Typical Stone Mass
36 in. (900 mm)	100	
30 in. (750 mm)	70-100	1280 lbs. (580 kg)
24 in. (600 mm)	50-70	650 lbs. (295 kg)
18 in. (450 mm)	35-55	275 lbs. (125 kg)
6 in. (150 mm)	2-10	10 lbs. (4.5 kg)

Minor deviations to the above gradations may be allowed if approved by the **Engineer**.



The stone size for grouted boulder riprap shall be as follows:

Rock Size ^a	Typical Stone Mass	Percent Passing			
		9 in. (225mm)	12in. (300mm)	15in. (375mm)	18in. (450mm)
6 in. (150mm)	10lbs. (4.5kg)	0-5	0-5		
9 in. (225mm)	35lbs. (16kg)	0-50	-		
12 in. (300mm)	88lbs. (40kg)	70-100	0-50	0-5	0-5
15 in. (375 mm)	165lbs. (75kg)	100	70-100	0-50	-
18 in. (450 mm)	275lbs. (125kg)		100	70-100	0-50
21 in. (525 mm)	440lbs. (200kg)			100	70-100
24 in. (600 mm)	650lbs. (295kg)				100
27 in. (675 mm)	925lbs. (420kg)				
30 in. (750 mm)	1280lbs. (580kg)				
Minimum Grout Thickness ^b		6 in. (150mm)	8in. (200mm)	10 in. (250 mm)	12 in. (300mm)
<p>^a The median rock size in the grouted riprap blanket should not exceed 0.67 times the blanket thickness. The largest rock used should not exceed the blanket thickness.</p> <p>^b The finished grout should not leave face stones exposed more than one-third their depth.</p>					

The concrete mortar for the grouted riprap shall consist of medium strength concrete with a strength of 2,000 psi after 28 days of curing. The maximum aggregate size should be 0.5 inches and have a slump of between 5 to 8 inches. Sand mixes may be used if sufficient cement is included in the mix to give the mortar good strength and workability. The **Engineer** shall approve all mortar mix designs before beginning work.

Weep holes should be installed through the full thickness of the grout or mortar blanket to relief any hydrostatic pressure that may build up beneath the blanket. The weep holes shall be constructed by installing 2-inch diameter PVC pipes at a spacing of 6-feet. The end of the pipe that is buried shall be covered with a wire screen or nonwoven geotextile. If there is no filter layer designed beneath the grout blanket then the bottom end of the weep hole shall be extended at least 6 inches below the grout blanket and encapsulated in a clean drain gravel material that is wrapped with geotextile. The clean gravel shall consist of 1-inch gravel.

Material used for riprap may be approved by the **Engineer** by visual inspection if the rock is determined to be sound and durable. However, if in the **Engineer's** opinion, the material is



questionable, the **Engineer** may require one or more of the following laboratory tests on representative riprap samples in order to evaluate the quality of the material.

Riprap Laboratory Tests

Test Description	Test Method	Specification Requirement
Los Angeles Abrasion	ASTM C 535	50% Loss Maximum (after 500 revolutions)
Sodium Sulfate or Magnesium Sulfate Soundness	AASHTO T 104 or ASTM C88	10% Maximum Loss (after 5 cycles)
Soundness by Freezing and Thawing	AASHTO T 103	10% Maximum Loss (after 12 cycles)
Slake Durability	ASTM 4644	Classification as Type 1

Placement Methods - Surfaces and piping to be protected by riprap shall be dressed to a smooth surface. All soft or objectionable material shall be removed as directed by the **Engineer** and replaced with an approved material. Materials underlying the riprap shall be placed in accordance with each materials specific placement specifications.

The riprap shall be placed as shown on the Drawings or as required by the **Engineer** in a manner that will produce a reasonably well graded mass of stone with the minimum practicable percentage of voids and good stone interlocking and contact. The entire mass of stone shall be placed in reasonable conformance with the lines, grades, and thicknesses shown on the Drawings. Riprap shall be placed to its full thickness during a single operation and in such a manner as to avoid damaging or displacing the underlying bedding material or geotextile.

The larger stones shall be well distributed and the materials shall be placed and distributed so that there will be no large accumulations of either the larger or the smaller size stones. Hand placing or rearranging of individual stones by mechanical equipment may be required to achieve the results specified.

For grouted riprap, stones shall be placed with due care to prevent soil, sand, or spall from filling the voids. The rock shall be wet immediately prior to commencing the grouting operation. Joints shall be filled with grout from bottom to top and the surfaces swept with a stiff broom. Full depth penetration of the concrete mortar (grout) into the riprap shall be required. To achieve this spading and rodding or a small diameter vibrator (pencil vibrator) will be required.



Grouting shall not be done in freezing weather. In hot, dry weather, the work shall be protected and kept moist for at least three days after grouting, or clear membrane curing compound may be used.

No loads will be allowed on the finished grouted riprap until 70 percent of the specified concrete mortar strength has been achieved or as approved by the **Engineer**.

3.2.7.7 Road Wearing Course

Material Properties - The road wearing course shall generally conform to the following gradation requirements as determined by ASTM C136 and C117 or as approved by the **Engineer**.

Sieve Size (square openings)	Percent Passing (by dry weight)
4 -inch (100 mm)	100
3/4 -inch (19 mm)	50-80
No. 4 (4.75 mm)	35-50
No. 16 (1.18 mm)	15-40
No. 200 (0.075mm)	2-10

The plasticity index for road wearing course materials shall be no greater than 15.

Placement Methods – Road wearing course shall be placed in a maximum 12-inch lift to 95% of the maximum dry density as determined by ASTM D1557. The moisture content shall be sufficient to obtain adequate density.

3.3 Finished Surface Preparation of Areas to Receive Geomembrane Lining

Areas to receive geomembrane lining shall be approved prepared subgrade free of angular particles over 3/4-inch diameter and hard objects that may damage the geomembrane. Where excessive coarse material is exposed at the surface, rock removal by appropriate methods or other surface finishing as directed by the **Engineer** will be required. Rough areas with depressions or loose material shall be covered with a cushion of fine-grained materials or for large depressions, with screened, prepared subgrade material (passed over ½--inch mesh screen) or equivalent.



Once the **Contractor** believes that the surface preparation is complete, an inspection will be completed by the **Geomembrane Installer, Engineer,** and **Owner** with the **Contractor** present. Any areas requiring repairs shall be fixed by the **Contractor** at no cost to the **Owner**.

3.4 Compaction Equipment

Sufficient compaction equipment of the types and sizes required to complete the work shall be provided for compaction of the various fill materials. The use of alternative equipment will 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.

Compaction equipment shall be maintained in good working condition at all times to ensure that the amount of compaction obtained is a maximum for the equipment. The **Contractor** shall provide the **Owner** and **Engineer** a list of proposed compaction equipment to be used before commencing Work.

3.4.1 Smooth Drum Vibratory Roller

Smooth 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 20,000 pounds at the drum when the roller is standing on level ground. The drum shall be not less than 60-inches in diameter and 78-inches 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 38,000 pounds.

For compaction by the vibratory roller, a single coverage shall be defined as one pass of the roller. A minimum overlap of 12-inches shall be maintained between the surfaces traversed by adjacent passes of the roller drum. During compaction, the roller shall be propelled at 2 miles per hour (mph) or lesser speed as approved by the **Engineer**. The power of the motor driving the vibrator shall be sufficient to maintain the specified frequency and centrifugal force under the most adverse conditions that may be encountered during the compaction of the fill. Propulsion equipment for the roller shall be adequate to propel the roller at speeds up to 4 mph.

3.4.2 Tamping-Foot (Sheepsfoot) Roller

The majority of the fill may be compacted with a tamping-foot or sheepsfoot roller. The tamping foot roller shall be self-propelled and fully ballasted with a standard tamping-foot design developing 5,000 pounds in force per linear foot of width at rest on level ground or equivalent as approved by the **Engineer**.



3.4.3 Special Compactors

Special compactors shall be used to compact materials that, in the opinion of the **Engineer**, cannot be compacted properly by the specified larger vibratory roller because of location or accessibility.

Special compaction measures shall be adopted such as hand-held or small walk behind 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. Such compaction shall be to the specified density for the particular material.

3.5 Quality Assurance

The **Third Party Testing Contractor** will take samples of fill materials and perform gradation, moisture content, Atterberg Limits, and field density tests on the compacted fill and any other tests that the **Engineer** considers necessary to ensure that the fill being placed meets the specified requirements. The results of the tests carried out by the **Third Party Testing Contractor** will be final and conclusive in determining compliance with the Technical Specifications. Test Methods are listed in Table 1 of Section 5.0.

Each lift of fill will be approved by the **Third Party Testing Contractor** prior to placement of additional fill materials. Sufficient time shall be allowed by the **Contractor** for the **Third Party Testing Contractor** to carry out the required test work and interpret the test results in order to determine the acceptability of each lift. Cooperation shall be given by the **Contractor**, to the **Owner** and the **Engineer and the Third Party Testing Contractor**, for taking samples or making tests, and such assistance shall be rendered as is necessary to enable sampling and testing to be carried out expeditiously.

Tests carried out by the **Third Party Testing Contractor** will be performed in accordance with the latest test methods prescribed by the American Society for Testing and Materials (ASTM) and other such recognized industry standards. The tests shall include Control and Record Tests.

3.5.1 Control Tests

Tests for gradation, moisture content, moisture density relationship and other tests where applicable will be made by the **Third Party Testing Contractor** on samples of fill materials taken from borrow areas and on the fill after spreading and prior to compaction the at frequencies listed in Section 5.0 and be sufficient to ensure that the fill material is in full compliance with the technical specifications.



3.5.2 Record Tests

The **Third Party Testing Contractor** will conduct field density, moisture content, and other tests on the compacted in-place fill and will obtain samples of the compacted fill for related laboratory testing at such frequency as the **Engineer** considers necessary to determine that the compacted fill is in full compliance with the technical specifications. Holes created from field-testing of prepared subgrade material shall be backfilled with bentonite powder.

4.0 QUALITY ASSURANCE CONSTRUCTION TOLERANCES

The **Contractor** shall construct the various aspects of the project to the lines and grades shown on the Drawings, or as required by the **Engineer**, within the following tolerances:

- Finish grades and slopes for the OSA and CWP shall be in general conformance with the Drawings. Deviations from finished grades/slopes are subject to approval by the **Engineer** and shall not result in low spots, pockets, non-uniform slopes or contours or result in slopes, which deviate by more than 4 inches from the design. The overall slope needs to be the same as shown on the Drawings.
- Finish grades and slopes for channels shall be in general conformance with the Drawings. Deviations from finished grades/slopes are subject to approval by the **Engineer** and shall not result in flat or low spots, pockets, non-uniform slopes or channel grades, which deviate by more than 2 inches from the design. The overall slope needs to be the same as shown on the Drawings.
- All drainage material locations shall be constructed such that the dimensions at any location within the zone shall not be less than is shown on the Drawings.
- The maximum permissible combined horizontal and vertical deviation of the perimeter boundaries of the OSA, CWP and channels from the lines and grades shown on the Drawings or as required by the **Engineer** shall be 12-inches.
- The finished surface of the OSA, CWP and channels shall not deviate vertically by more than 4-inches from the lines and grades shown on the Drawings.
- The elevation and width of the berm crests shall not be less than that shown on the Drawings or required by the **Engineer**.
- All pipes shall be constructed to the following tolerances: alignment and grade shall not deviate more than 5 percent of the nominal diameter of the pipe from a straight line between control points.



5.0 TESTING FREQUENCIES

The **Third Party Testing Contractor** will carry out frequent quality control and quality assurance tests as described in Section 3.5 to determine compliance of the Work with the technical specifications. The latest edition of standard procedures shall be used for all activities, and in general, these will be adopted from recognized organizations such as the American Society of Testing and Materials (ASTM). The following tables outline the test methods and the minimum testing requirements for the project:

Table 1
Test Methods

Test	Type of Test	Test Method (ASTM)
C1, R1	Atterberg Limits	D4318
C2, R2	Moisture Content	D3017
C3, R3	Particle Size Distribution	D422 ^a
C4, R4	Laboratory Compaction-Mod. Proctor	D1557
R5a	Nuclear Density	D6938
R5b	Sand Cone	D1556
R5c	Water Replacement	D5030
C6, R6a	Laboratory Permeability	D5084/ USBR 5600
R6b	Air Entry Permeameter	D5126
R7	Shear Strength	USACE EM-1110-2-1906
C8	Acid Generating Potential	EPA M600/2-78-054 3.2.3
C9	Methylene Blue Index of Clay	ASTM C837
C10	Free Swell Index	ASTM D5890
<p>Notes: C = Control Tests; R = Record Tests</p> <p>^a Hydrometer tests down to the 2-micron size will be carried out as directed by the QA Engineer but will generally not be required; all samples to be washed over a No.200 sieve.</p>		



Table 2
Test Frequency – Prepared Surfaces

Test	Type of Test	Frequency (one per)
C1, R1	Atterberg Limits	Soil Type/ 200,000 ft ²
C2, R2	Moisture Content	50,000ft ²
C3, R3	Particle Size Distribution	Soil Type/ 200,000 ft ²
C4, R4	Laboratory Compaction	Soil type
R5a	Nuclear Density	50,000ft ²
R5b/R5c	Sand Cone or Water Replacement Density	500,000ft ²
Note: Required number of tests shall be determined by whichever method of determining the frequency requires the most tests.		

Table 3
Test Frequency – Random Fill

Test	Type of Test	Frequency (one per)
C1, R1	Atterberg Limits	25,000 yd ³
C2, R2	Moisture Content	5,000yd ³
C3, R3	Particle Size Distribution	25,000 yd ³
C4, R4	Laboratory Compaction	Soil type or every 125,000 yd ³
R5a	Nuclear Density	5,000 yd ³
R5b/R5c	Sand Cone or Water Replacement Density	50,000 yd ³
Note: Required number of tests shall be determined by whichever method of determining the frequency requires the most tests. If material is too coarse for testing per ASTM then use test fill method per USACE EM 1110-2-1911.		



Table 4
Test Frequency – Low-Permeability Soil Liner

Test	Type of Test	Frequency (one per)
C1,R1	Atterberg Limits	Soil type or every 5,000 yd ³
C2, R2	Moisture Content	1,000 yd ³
C3, R3	Particle Size Distribution	Soil type or every 5,000 yd ³
C4, R4	Laboratory Compaction	Soil type or every 25,000 yd ³
R5a	Nuclear Density	1,000 yd ³
R5b	Sand Cone Density	10,000 yd ³
R6	Laboratory Permeability	100,000 yd ³
Note: Test frequencies are per lift unless indicated otherwise.		

Table 5
Test Frequency – Liner Protective Layer

Test	Type of Test	Frequency (one per)
C1, R1	Atterberg Limits	7,500 yd ³
C3, R3	Particle Size Distribution	7,500 yd ³
Note: Sample sizes to be sampled in accordance with ASTM standards.		

Table 6
Test Frequency – Drainage Aggregate

Test	Type of Test	Frequency (one per)
C3, R3	Particle Size Distribution	7,500 yd ³
C6, R6	Laboratory Permeability	37,500 yd ³
C9	Acid Generating Potential	1 per source or as requested by Engineer
Note: Sample sizes to be sampled in accordance with ASTM standards.		



Table 7
Test Frequency – Road Wearing Course

Test	Type of Test	Frequency (one per)
R1	Atterberg Limits	2,000 yd ³
R3	Particle Size Distribution	2,000 yd ³

Table 8
Test Frequency – Pipe Backfill and Pipe Bedding

Test	Type of Test	Frequency (one per)
C1, R1	Atterberg Limits	Soil type/5,000 yd ³ or 1 per structure
C2, R2	Moisture Content	per nuclear density requirements
C3, R3	Particle Size Distribution	5,000 yd ³ or 1 per structure
C4, R4	Laboratory Compaction	Soil type/25,000 yd ³
R5a	Nuclear Density	Greater of 4 per major foundation / 500 yd ³ *
R5b	Sand Cone Density	every 10 nuclear density tests
Note: *Frequency of testing for backfill for minor foundations shall be determined by the Project Field Engineer		



CLIENT
Haile Gold Mine Inc.

PROJECT NO
475.0042.001

PROJECT HAILE GOLD MINE PROJECT
JOHNNY'S PAG OSA AND CONTACT WATER PONDS

TITLE TECHNICAL SPECIFICATIONS FOR FENCE
MATERIALS AND CONSTRUCTION

SPECIFICATION NO.
0042 001-SP-FN-1.DOC

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1	06/30/15	7	JMN	CJB	CC	Issued for Construction

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1.0 GENERAL

This specification defines the requirements for the fence materials and installation associated with the Haile Gold Mine Inc. (Owner) Johnny's Potentially Acid Generating (JPAG) Overburden Storage Area (OSA) and Contact Water Ponds (CWP).

Any alternatives or exceptions to this specification shall be submitted in writing to the Owner or its designated representative and shall be approved by the Engineer.

1.1 Definition of Terms

- "Owner" is defined as Haile Gold Mine Inc. or any of its authorized representative(s) / agent(s).
- "Engineer" is defined as the Consultant or Engineering Company (NewFields) responsible for the detailed design or any of its authorized representative(s)/ agent(s).
- "Construction Manager" is defined as the Consultant or Engineering Company (M3 Engineering and Technology) responsible for the overall project completion.
- "Third Party Testing Contractor" is defined as the Consultant or Engineering Company (to be determined) hired by the owner to provide third party inspection and testing services for the overall project.
- "Contractor" is defined as the party(s) that has executed the contract agreement for the specified Work with the Owner or its authorized representative(s)/agent(s).
- "Specifications" are defined as this document, all supplemental addenda, and any modifications furnished by the Owner, the Engineer, or others that apply to the Work.
- "Drawings" are defined as the Construction Drawings for the JPAG OSA and CWP furnished by the Owner, Engineer, or others that apply to the Work.
- "Site" is defined as the Haile Gold Mine Project site being developed by the Owner and where the Work is to be completed as described in these Technical Specifications and detailed on the Drawings.
- "Contract" is defined as the document executed by the Owner or its authorized representative(s)/agent(s) with the Contractor to complete specified portions of the Work.
- "Work" is defined as the entire completed construction or the various separately identifiable parts thereof required to be furnished as shown on the Drawings and as described in the Specifications and Contract Documents.
- "Modifications" are defined as changes made to the Specifications or the Drawings that are approved by Owner and Engineer in writing, after the Specifications and Drawings have been issued for construction. These also refer to changes to design elements in the field to account for unforeseen conditions.



- “Plant” is defined as all equipment, supplies, accommodations, temporary offices, etc., required to complete the Work.
- “Units” – In general, these Specifications and the Drawings will utilize English units, however metric units will be used when appropriate.

1.2 References

The latest issue of the following publications are part of this specification, except where replaced or revised by local codes or ordinances having jurisdiction, in which case the more stringent shall govern:

- ASTM A53, A116, A120, A121 F26
- AASHTO M181 and M120
- Chain Link Fence Manufactures Institute Product Manual

2.0 CHAIN-LINK FENCE

The chain-link fence shall be as shown on the drawings and consist of chain-link fabric in accordance with the latest edition of AASHTO M181 and as per the following:

- Fabric: Type I zinc-coated steel Class C (1.2oz/ft²) or Type II aluminum coated steel (0.40 oz/ft²)
- Size of Mesh: 2-inch
- Size of Wire: 6 gauge
- Diamond Count: Standard (27½)
- Height: 96-inches
- Tension Wire: Steel coil spring wire 7 gauge (0.177-inch) conforming to ASTM 824 with Class I zinc coating
- Wire Fasteners and Tie Clips: 11 gauge galvanized steel wire

Gates shall be constructed of chain link fabric to a height equal to the fence height. The gate chain link fabric shall conform with the fence fabric. Chain link fabric shall be attached to the gate frame by use of stretcher bars and tie wires. Gates shall be fitted with hinges that allow the gate to swing 180 degrees.

Chain-link fabric is to be attached to all fence and gate structures at 12-inch intervals vertically and at 18- inches horizontally.



Posts for corner panels, gate panels and line posts shall be steel round pipe or tubing to the requirements of AASHTO M181 Grade 2.

Posts, braces and gate frames shall conform to the following:

Table 1
End, Corner and Line Brace Posts

Fabric Height (Feet)	Minimum O.D. (inches)	Minimum Weight (lbs/ft)	Concrete Base Depth/Diameter (inches)
3 thru 6	2.375	3.65	34/12
>6 thru 8	2.875	5.79	40/12
>8 thru 12	2.875	5.79	40/12

Table 2
Line Posts

Fabric Height (Feet)	Minimum O.D. (inches)	Minimum Weight (lbs/ft)	Concrete Base Depth/Diameter (inches)
3 thru 6	1.900	2.72	28/12
>6 thru 8	2.375	3.65	36/12
>8 thru 12	2.375	3.65	40/12



Table 3
Gate Materials

Fabric Height (Feet)	Gate Frame Members		Interior Bracing Members	
	Minimum O.D. (inches)	Minimum Weight (lbs)	Minimum O.D. (inches)	Minimum Weight (lbs)
6 feet or less (Leaf width of 8 feet or less)	1.66	1.83	1.66	1.83
6 feet or less (Leaf width of over 8 feet)	1.90	2.28	1.66	1.83
Over 6 feet (Leaf width of 8 feet or less)	1.90	2.28	1.66	1.83
Over 6 feet (Leaf width of over 8 feet)	1.90	2.28	1.90	2.28

Note: Gate leaf shall have vertical interior bracing at maximum intervals of 8 feet and shall have horizontal interior member if fabric height is 8 feet or more.

Table 4
Gate Strain Posts

Fabric Height (6 Feet or less)	Minimum O.D. (inches)	Minimum Weight (lbs)	Concrete Base Depth/Diameter (inches)
Gate Post (Gate leaf width up to and including 4 feet)	2.375	3.66	30/10
Gate Post (Gate leaf width over 4 to 10 feet)	2.875	5.80	36/12
Gate Post (Gate leaf width over 10 to 18 feet)	4.000	9.12	36/14
Gate Post (Gate leaf width over 18 to 24 feet)	6.625	18.99	42/16



Fabric Height (Over 6 Feet to 12 feet)	Minimum O.D. (inches)	Minimum Weight (lbs)	Concrete Base Depth/Diameter (inches)
Gate Post (Gate leaf width up to and including 4 feet)	2.875	5.80	36/12
Gate Post (Gate leaf width over 4 to 10 feet)	4.000	9.12	36/14
Gate Post (Gate leaf width over 10 to 18 feet)	6.625	18.99	42/16
Gate Post (Gate leaf width over 18 to 24 feet)	8.625	28.58	48/18

Posts shall be placed a maximum of every 10 feet on center. Posts shall be placed in a vertical position, except where, in the opinion of the **Owner**, it would be more beneficial to place posts perpendicular to the slope of the ground. Changes in the horizontal alignment of the fence where the angle of deflection is 20 degrees or more shall be considered corners and corner posts shall be installed.

End, corner, and gate posts shall be braced with horizontal braces used as compression members, and adjustable truss rods shall be used as tension members. In-line braces shall be installed at a minimum of every 500 feet.

Miscellaneous fittings and hardware shall be commercial quality steel, or better, or cast or malleable iron as appropriate to the item. The steel or iron shall have sufficient strength to provide a balanced design. Zinc coating shall be in accordance with AASHTO M232.

Tension bars shall not be less than 3/16 inch by 3/4 inch and not less than 2 inches shorter than the normal height of the fabric.

Tension bands shall be formed from flat or beveled steel and shall have a minimum thickness of 0.078 and a minimum width of 3/4 inch.

Barbed wire support arms shall be at an angle of 45 degrees and shall be fitted with clips or other means for attaching three strands of barbed wire. The top wire shall be approximately 12 inches vertically and horizontally from the top of the fence fabric and the other wires spaced uniformly between the top of the fabric and the top wire.

Tension wire shall be continuous between end or corner post and line brace post. A turnbuckle or other approved tightening device shall be used for each continuous span of tension wire.



Barbed wire shall consist of two 12.5-gauge galvanized wires twisted together with 14-gauge double point barbs installed at a minimum of 4 inches apart. Wire and barbs shall be zinc-coated steel, with a zinc coating of at least 0.3 oz/ft² of coated surface area. The minimum breaking strength of each wire shall be 950 lb-force. The barbed wire shall conform to the requirements of ASTM A121.

The bottom of the fabric shall be placed tightly to the ground to prevent animals from securing access under the fence. Additionally, a small berm a minimum of 6 inches in height shall be created outside of the fence. The contractor shall level the ground to remove mounds or minor depressions under the fence.

3.0 BARBED WIRE FENCE

Barbed wire fence shall be constructed of four strands of wires. Strands shall be installed at distances of 42 inches, 30 inches, 18 inches, and 6 inches from the ground surface. The wire shall be fastened to end, corner, and gateposts by wrapping the wire around the posts and tying each strand back to itself. Barbwire shall be fastened to steel line posts using standard galvanized clips, and fastened to wood line posts using standard 9-gauge slash cut staples.

Barbed wire shall consist of two 12.5-gauge galvanized wires twisted together with 14-gauge double point barbs installed at a minimum of 4 inches apart. Wire and barbs shall be zinc-coated steel, with a zinc coating of at least 0.3 oz/ft² of coated surface area. The minimum breaking strength of each wire shall be 950 lb-force. The barbed wire shall conform to the requirements of ASTM A121.

Gates shall be constructed with a minimum of four strands of wire and have 3-inch diameter wood stays spaced at a minimum distance of 5 feet on center. All gates are to have a minimum width of 15 feet. Gates shall be secured using mechanical "rat trap" type closers.

Posts for corner, end, gate, and line braces shall be 2-inch diameter (3.66 lb/ft) galvanized steel pipe conforming to the requirements of AASHTO M181, Grade 2. Brace posts shall be installed a minimum of 36 inches in the ground, and set in concrete.

Line posts shall be standard steel "T" drive posts, minimum 6 feet in length installed to a depth of 30 inches below the ground surface. Line posts shall be manufactured from wrought iron, rail, or new billet steel, and shall have a minimum weight of 1.33 lb/ft. The anchor plates shall weigh a minimum of 0.67 lbs and have a minimum surface area of 18 square inches. Line posts shall be studded or have other approved provisions for holding the fabric in place on the post, and must be equipped with a suitable anchor plate. Line posts shall be painted in accordance with the requirements of AASHTO M281. Line posts shall be placed a maximum of every 16.5



feet on center, with galvanized twisted wire fence stays installed equidistant between each line post. Posts shall be placed in a vertical position, except where, in the opinion of the Owner, it would be more beneficial to place posts perpendicular to the slope of the ground. Changes in the horizontal alignment of the fence where the angle of deflection is 20 degrees or more shall be considered corners and corner posts shall be installed.

End, corner, and gateposts shall be braced with double horizontal H braces. H braces shall be constructed using 8 foot long, 4-inch diameter posts used for compression members, and 9-gauge brace wire for tension members. In-line braces shall be installed a minimum distance of every 1,300 feet.



CLIENT
Haile Gold Mine Inc.

PROJECT NO
475.0042.001

PROJECT HAILE GOLD MINE PROJECT
JOHNNY'S PAG OSA AND CONTACT WATER PONDS

TITLE TECHNICAL SPECIFICATIONS FOR GEOMEMBRANE
MATERIALS AND CONSTRUCTION

SPECIFICATION NO.
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1.0 GENERAL

This specification defines the requirements for geomembrane materials, installation, and quality control associated with the Haile Gold Mine Inc. (Owner) Johnny's Potentially Acid Generating (JPAG) Overburden Storage Area (OSA) and Contact Water Ponds (CWP).

Any alternatives or exceptions to this specification shall be submitted in writing to the Owner or its designated representative with the bid.

1.1 Definition of Terms

- "Owner" is defined as Haile Gold Mine Inc. or any of its authorized representative(s) / agent(s).
- "Engineer" is defined as the Consultant or Engineering Company (NewFields) responsible for the detailed design or any of its authorized representative(s)/ agent(s).
- "Construction Manager" is defined as the Consultant or Engineering Company (M3 Engineering and Technology) responsible for the overall project completion.
- "Third Party Testing Contractor" is defined as the Consultant or Engineering Company (to be determined) hired by the owner to provide third party inspection and testing services for the overall project.
- "Contractor" is defined as the party(s) that has executed the contract agreement for the specified Work with the Owner or its authorized representative(s)/agent(s).
- "Installer" is defined as the qualified 3rd party(s) that have been hired to install the geomembrane for the specified Work.
- "Specifications" are defined as this document, all supplemental addenda, and any modifications furnished by the Owner, the Engineer, or others that apply to the Work.
- "Drawings" are defined as the Construction Drawings for the JPAG OSA and CWP furnished by the Owner, Engineer, or others that apply to the Work.
- "Site" is defined as the Haile Gold Mine Project site being developed by the Owner and where the Work is to be completed as described in these Technical Specifications and detailed on the Drawings.
- "Contract" is defined as the document executed by the Owner or its authorized representative(s)/agent(s) with the Contractor to complete specified portions of the Work.
- "Work" is defined as the entire completed construction or the various separately identifiable parts thereof required to be furnished as shown on the Drawings and as described in the Specifications and Contract Documents.
- "Modifications" are defined as changes made to the Specifications or the Drawings that are approved by Owner and Engineer in writing, after the Specifications and Drawings have



been issued for construction. These also refer to changes to design elements in the field to account for unforeseen conditions.

- “Plant” is defined as all equipment, supplies, accommodations, temporary offices, etc., required to complete the Work.
- “Units” – In general, these Specifications and the Drawings will utilize English units, however metric units will be used when appropriate.

1.2 References

1.2.1 American Society for Testing and Materials (ASTM):

- ASTM Standard D4437, 1988 (1999), “Standard Practice for Determining the Integrity of Field Seams Used in Joining Flexible Polymeric Sheet Geomembranes”, ASTM International, West Conshohocken, PA, 1999, DOI: 10.1520/D4437-99, www.astm.org.
- ASTM Standard D5199, 2001 (2006), “Standard Test Method for Measuring the Nominal Thickness of Geosynthetics”, ASTM International, West Conshohocken, PA, 1999, DOI: 10.1520/D5199-01R06, www.astm.org.
- ASTM Standard D5641, 1994 (2006), “Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber”, ASTM International, West Conshohocken, PA, 1999, DOI: 10.1520/D5641-94R06, www.astm.org.
- ASTM Standard D5820, 1995 (2006), “Standard Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembranes”, ASTM International, West Conshohocken, PA, 1995, DOI: 10.1520/D5820-95R06, www.astm.org.
- ASTM Standard D5994, 1994 (2003), “Standard Test Method for Measuring Core Thickness of Textured Geomembrane”, ASTM International, West Conshohocken, PA, 1994, DOI: 10.1520/D5994-98R03, www.astm.org.
- ASTM Standard D6365, 1999 (2006), “Standard Practice for the Nondestructive Testing of Geomembrane Seams using the Spark Test”, ASTM International, West Conshohocken, PA, 1999, DOI: 10.1520/D6365-99R06, www.astm.org.
- ASTM Standard D6392, 2010 (2012), “Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods”, ASTM International, West Conshohocken, PA, 1999, DOI: 10.1520/D6392-10R12, www.astm.org.
- ASTM Standard 7240, 2006 (2011), “Standard Practice for Leak Location using Geomembranes with an Insulating Layer in Intimate Contact with a Conductive Layer via Electrical Capacitance Technique (Conductive Geomembrane Spark Test)”, ASTM International, West Conshohocken, PA, 2006, DOI: 10.1520/D7240-06R11, www.astm.org.

1.2.2 Geosynthetic Research Institute (GRI):

- GRI GM 9, 1995, “Cold Weather Seaming of Geomembranes”, Geosynthetic Institute, Folsom, PA, www.geosynthetic-institute.org.



- GRI GM 10, 1997 (2006), “The Stress Crack Resistance of HDPE Geomembrane Sheet”, Geosynthetic Institute, Folsom, PA, www.geosynthetic-institute.org.
- GRI GM 13, 1997 (2009), “Test Properties, Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes”, Geosynthetic Institute, Folsom, PA, www.geosynthetic-institute.org.
- GRI GM 14, 1998, “Selecting Variable Intervals for Taking Geomembrane Destructive Seam Samples Using the Method of Attributes”, Geosynthetic Institute, Folsom, PA, www.geosynthetic-institute.org.
- GRI GM 17, 2000 (2009), “Test Methods, Test Properties and Testing Frequency for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes”, Geosynthetic Institute, Folsom, PA, www.geosynthetic-institute.org.
- GRI GM 19, 2002 (2010), “Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes”, Geosynthetic Institute, Folsom, PA, www.geosynthetic-institute.org.

2.0 GEOMEMBRANE

The geomembrane used for the Haile Gold Mine shall be:

- JPAG OSA –80-mil (2.0 mm) Double Textured High Density Polyethylene (HDPE)
- Double and Single Lined CWP's - 80-mil (2.0 mm) Smooth High Density Polyethylene (HDPE)

2.1 Manufacturer's Quality Control

The HDPE geomembrane shall be a high quality formulation containing approximately 97 percent polymer and 3 percent carbon black with antioxidants and heat stabilizers. It shall be resistant to ultraviolet (UV) rays. All resin shall be hexene-based, consist of all virgin material from the same manufacturer, shall not be intermixed, and no reclaimed polymer may be added to the resin. The manufacturing process shall not use more than 10 percent rework. If rework is used, it must be similar HDPE to the parent material.

The geomembrane material shall comprise HDPE material manufactured of new, first-quality products designed and manufactured specifically for the purpose of liquid containment in hydraulic structures as applied to the mining industry. The material shall be produced to be free of holes, blisters, undispersed raw materials, or any sign of contamination by foreign matter. The geomembrane shall be supplied in roll form. Each roll shall be identified with labels indicating roll number, thickness, length, width, and manufacturer's name and date of manufacture.



The geomembrane manufacturer shall be ISO 9000/2000 certified. The manufacturer's laboratory must be certified by Geosynthetic Accreditation Institute (GAI)/Laboratory Accreditation Program (LAP) for the tests being performed and shall have a third-party independent quality assurance program. The third party shall perform the required tests at the required frequency as stated in this specification or at such frequency as mutually agreed by the **Owner**, the **Engineer**, and the manufacturer at the time of award. All test results shall be provided to the **Engineer** and the rolls of material shall be clearly identified and correlate to the test results.

Extrudate rod or bead material shall be made from the same type of resin as the geomembrane and be from the same resin supplier as the resin used for manufacture of the geomembrane.

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

2.2 Submittals Post-Award

The manufacturer shall furnish the following product data, in writing, to the **Owner** and the **Engineer** prior to shipment of the geomembrane material:

- Resin data including the following:
 - Certification stating that the resin meets the specification requirements and that it is all from the same manufacturer (see Table 4).
 - Statement certifying no reclaimed polymer and no more than 10% rework of the same type of material is added to the resin (product run may be recycled).
 - Copy of quality assurance and quality control certificates issued by resin supplier.
 - All rolls shall be delivered with labels affixed to the selvage edge clearly stating the manufacturer's name, product identification, material thickness, roll number, roll type, roll dimensions and roll weight.
- Geomembrane roll, extrudate rod and bead material:
 - Copy of quality assurance and quality control certificates issued by the geomembrane manufacturer and the HDPE third-party independent quality assurance tester.



- Certification that the geomembrane material delivered to the project complies with these specifications.
- Certification that extrudate rod or bead is from one manufacturer, is the same resin type, and was obtained from the same resin supplier as used to manufacture the geomembrane rolls.

3.0 GEOMEMBRANE INSTALLATION

3.1 General

The HDPE geomembrane shall be installed on the areas shown on the Drawings or as directed by the **Engineer**. The **Installer** shall be an approved installer by the Manufacturer.

Prior to deployment of geomembrane, the **Installer** shall inspect and accept, with the **Engineer**, **Third Party Testing Contractor** and the **Owner**, all surfaces on which the geomembrane is to be placed. The surface on which the geomembrane is to be installed shall be free of sharp particles, rocks, or other debris to the satisfaction of the **Engineer**, the **Owner**, and the **Installer**. Sharp objects shall be removed by raking, sweeping, or handpicking as necessary.

The **Installer** shall supply the **Engineer** with panel layouts of the liner that must be approved by the **Engineer** prior to commencing the Work. It is the **Installer's** responsibility to submit timely proposals (allowing a minimum of two weeks for approval).

Installation of the geomembrane shall be performed under the direction of a field engineer or supervisor who has installed a minimum of 10,000,000 square feet (ft²) of the specified type of geomembrane or similar. Seaming shall be performed under the direction of a Master Seamer (who may also be the Field Installation Supervisor or Crew Foreman) with seaming experience of a minimum of 3,000,000 ft² of the geomembrane type specified or similar product, using the same type of seaming apparatus to be used in the current project. During the seaming, the Field Installation Supervisor or Master Seamer are present. Qualified technicians employed by the **Installer** complete all seaming, patching, testing, and other welding operations.

The geomembrane shall be placed over the prepared surfaces using methods and procedures that ensure a minimum of handling. Adequate temporary and permanent anchoring devices and ballasting shall be provided to prevent uplift and damage due to winds. The **Installer** is solely responsible for the safety of his operations including decisions regarding deployment in adverse weather conditions and the amount of temporary anchoring and ballasting required. The **Contractor** shall take necessary precautions to protect the geomembrane from any damage including prohibiting workers from smoking and wearing foot apparel that would damage the membrane.



To the extent possible, seams shall be oriented parallel to the fall line, slope or grade of the ground. The panels shall be secured temporarily with sandbags or other approved ballasting method to hold them in place until the field seams have been completed and the geomembrane has been permanently anchored. Ballast material shall conform to the specified requirements for drainage material.

The **Installer** shall take into account that high winds are prevalent at the project site and may result in liner damage and delays. The **Installer** shall take all necessary measures to ensure that each panel is sufficiently ballasted to prevent damage or movement by wind. Fusion of panels and repairs will only be permitted under weather conditions allowing such work, and within the warranty limits of the geomembrane manufacturer, as approved by the **Owner** and the **Engineer**.

Horizontal field seams on slopes shall be kept to a minimum and require the approval of the **Engineer**. Horizontal seams on steep slopes shall be avoided where possible by cutting the liner at a 45-degree angle. Generally, horizontal seams are to be no closer than 10-feet from the toe of the slope. Horizontal seams shall be made by lapping the uphill material over the downhill material. Panels shall be shingled in a manner that prevents water from running beneath the liner.

The geomembrane shall be installed in a relaxed condition and shall be free of tension or stress upon completion of the installation. The installed geomembrane shall contain sufficient slack material to allow for thermal expansion and contraction during the annual extreme temperatures the geomembrane is expected to endure. Individual wrinkles should take the form of undulations in the liner but should not be large enough for the material to fold over on itself.

During installation, the **Installer** shall give each field panel an "identification" code number consistent with the layout plan. The **Third Party Testing Contractor** shall agree upon the numbering system. The **Installer** shall update the layout plan as each panel is installed to show the location of each panel. A field panel is defined as the area of geomembrane that is to be seamed in the field (roll or portion of a roll cut in the field).

Individual panels of geomembrane material shall be laid out in a pattern that will produce the least number of seams. The material shall be overlapped prior to welding. Extreme care shall be taken by the **Installer** in the preparation of the areas to be welded. The joint interface shall be cleaned and prepared according to industry standard procedures, those specified by the material manufacturer and those approved by the **Engineer**. Seaming shall not take place unless the panels are dry and clean. All sheeting shall be welded together by thermal methods.



Any area showing damage due to excessive scuffing, puncture, or distress from any cause shall be replaced or repaired with an additional piece of geomembrane. The cost of replacing or repairing the geomembrane shall be borne solely by the **Installer**.

No “fish mouths” will be allowed within the seam area. Where “fish mouths” occur, the material shall be cut, overlapped, and an overlap extrusion weld applied.

Geomembrane panels must have a finished overlap of 4 to 6-inches for double-wedge welding seams and minimum 6-inches for extrusion welding seams. Notwithstanding this provision, sufficient overlap shall be provided to allow shear and peel tests to be performed on any seam.

Handling and storage of the geomembrane material shall be in accordance with the manufacturer’s printed instructions. Persons walking or working on the geomembrane shall not engage in activities or wear foot apparel that could damage the geomembrane.

An adequate amount of handling equipment, welding apparatuses, and test equipment shall be maintained on site to avoid delays due to problems with equipment failures.

3.2 Geomembrane Installation Quality Control

3.2.1 General

The **Installer** shall submit a copy of his Quality Control Manual to the **Engineer** and **Owner** prior to the start of installation of any geomembrane. If there are discrepancies between this specification and the **Installer’s** Quality Control Manual, the more stringent requirements will apply unless determined otherwise by the **Engineer**.

The **Installer** shall be fully responsible for carrying out all quality control tests on the geomembrane and shall do so to the satisfaction of the **Engineer** and in accordance with this Specification and the **Installer’s** Quality Control Manual. On-site physical nondestructive and destructive testing shall be completed on all joints to ensure that watertight uniform seams are achieved on a continuous basis as installation proceeds. The **Third Party Testing Contractor** shall be present and witness all destructive tests. At the time of bid submission, details shall be provided by the **Installer** that set forth the method proposed for both destructive and nondestructive testing of seams. The **Engineer** shall approve these methods prior to the **Installer** commencing the Work. Visual inspection alone is unacceptable.

Fusion of panels and repairs will only be permitted under weather conditions allowing work that is in conformance to the Specifications and within the warranty limits imposed by the manufacturer and to the approval of the **Engineer**.



At a minimum, the **Installer's** field installation test program shall consist of visual observations and continuity and strength tests as defined in the following subsections. The **Installer** shall not have more than 500,000 square feet of geomembrane deployed at any time without final QA/QC and acceptance by the **Third Party Testing Contractor**. At the beginning of each day's work, the **Installer** shall provide the **Third Party Testing Contractor** with copies of all the previous days' completed paperwork as well as an update of the quantity and location of geomembrane placed.

3.2.2 Trial Welds

Trial welds shall be completed to verify the performance of the welding equipment and operator prior to performing production welds. No welding equipment or operator shall perform production welds until equipment and operator have successfully completed a trial weld and approved by the **Third Party Testing Contractor**. The following procedures shall be followed for trial welds:

- Make trial welds under the same surface and environmental conditions as the production welds, i.e., in contact with subgrade and similar ambient temperature.
- Minimum of two trial welds per day per welding apparatus – one made prior to the start of work and one completed at mid-shift or for every 5 hours of seaming operations.
- Cut five 1-inch-wide-by-6-inch long test strips from the trial weld.
- Quantitatively test specimens for peel adhesion and for bonded seam strength (shear).
- Trial weld specimens shall pass when the results shown in Table 3 are achieved in both peel and shear tests and:
 - The break, when peel testing, occurs by Separation in the Plane of the sheet (SIP), not through adhesion failure separation (AD). When the seam separation is equal to or greater than 25% of the track width, it is a failed test.
 - The break is ductile.
- Repeat the trial weld, in its entirety, when the trial weld samples fail in either peel or shear as defined on Table 3.

3.2.3 Field Seaming

The **Installer** shall have at least one Master Welder who shall provide direct supervision to other welders. The Master Welder's and other welder shall submit a description of their qualifications and experience to the **Owner and Engineer** for approval prior to arrival on site.



- The welding equipment shall be capable of continuously monitoring and controlling the temperatures in the zone of contact where the machine is actually fusing the material to ensure changes in environmental conditions will not affect the integrity of the weld.
- The seam area shall be cleaned of dust, mud, moisture, and debris immediately ahead of the welding apparatus.
- The seam overlaps shall be aligned consistent with the requirements of the welding equipment being used. A 4-inch to 6-inch overlap shall be used for double-wedge welded seams and 6-inches for extrusion welded seams unless approved otherwise by the **Engineer**.
- Seaming shall not proceed when the ambient air temperature or adverse weather conditions jeopardize the integrity of the geomembrane installation. If adverse weather prevents work from being completed then the installer shall make-up the work during a scheduled day off. If enough adverse weather causes the schedule to extend beyond the agreed upon completion date then the **Owner** may compensate the **Contractor** for delays beyond their control.
- Extrusion welding apparatus' shall be purged of heat-degraded extrudate before welding.
- The double-wedge fusion welding process shall be used unless alternate methods are approved by the **Engineer**. Extrusion welding shall be permitted to weld short seams to repair small areas where double-wedge welding is not feasible, and for caps and patches.

3.2.4 Field Seam and Panel Inspection and Testing

3.2.4.1 Nondestructive Testing and Inspection

The **Installer** shall perform visual inspections of deployed and welded HDPE panels to identify defects, damage, or protrusion of sharp objects that may affect the integrity of the geomembrane. Defective or damaged areas shall be marked and repaired according to the technical specifications and the guidelines in the **Installer's** Quality Control Manual.

A quality control technician or field engineer acting for the **Installer** and **Third Party Testing Contractor** shall inspect each seam, marking his initials and date inspected at the end of each panel. Any area showing a defect shall be marked and repaired in accordance with the applicable repair procedures.

3.2.4.2 Continuity Testing

A maximum effort shall be made by the **Installer** to install a perfect geomembrane liner. This implies that all seams completed in the field, patches, and extrusions shall be tested and recorded. All failures shall be isolated and repaired as directed by the **Engineer and Third Party Testing Contractor**. A general testing procedure for the **Installer** is included as follows:



- Test all field seams and patches with interseam pressure, vacuum box, spark tester, or other approved methods. Non-destructive testing methods are discussed in following subsections.
- Isolate and repair all areas indicating any leakage. Retest the repair.

Interseam Pressure Testing. Test procedure in accordance with ASTM D 5820 for interseam pressure for seams (for double-wedge welding only):

- Seal both ends of the seam to be tested by applying heat to the end of the seam via a heat gun until flow temperature is achieved. Clamp off the ends and let cool.
- Insert a pressure gauge with needle assembly into the end of the seam and seal.
- Pressurize the air channel between the two seams to between 30 psi and 35 psi. Following pressure stabilization, take the initial pressure reading, hold the pressure a minimum of 5 minutes and take a second reading.
- The allowable leak-down for the seam is 3 psi maximum.
- If the pressure does not drop below the maximum allowable 3 psi, open the air channel at the end away from the pressure gauge. Air should rush out and the pressure gauge should register an immediate drop in pressure, indicating that the entire length of seam has been tested. If this does not happen, either the air channel is blocked or the equipment is faulty, and the test is not valid.
- Enter the results of the leak test on the appropriate documentation, indicating either a passed or a failed seam. If the seam fails, the repair work and subsequent testing should be recorded on the same document.
- Repair the area where the pressure gauge/needle assembly was installed and where the air was released.

Vacuum Box Testing: Where possible, the **Installer** shall test all extrusion seams as follows:

- Mix a solution of liquid detergent and water and apply an ample amount to the area to be tested. If a seam contains excess overlap or loose edges, it must be trimmed before testing.
- Place a rigid transparent vacuum box over the area and apply a slight amount of downward pressure to the box to seat the seal strip to the liner.
- Apply a vacuum of 3 psi to 5 psi for a minimum of 15 seconds to the area. The **Installer** shall examine the geomembrane through the viewing window for the presence of soap bubbles indicating a leak. If no bubbles appear after 15 seconds, consider the area leak free. Once the area is leak free, depressurize the box and move it over the next adjoining area with an appropriate overlap and repeat the process.



- Enter the results of the leak test on the appropriate documentation, indicating either a passed or a failed seam. If the seam fails, the repair work and subsequent testing should be recorded on the same document.

Spark Testing: Extrusion welded patches, caps, pipe boots, etc., in lieu of being vacuum-box testing, shall be spark tested in accordance with ASTM D 6365 and the following procedures:

- The seam shall be prepared for extrusion welding in accordance with the **Installer's** procedures.
- Just prior to applying the extrusion bead, a small-gauge copper wire (18-gauge bare copper wire or equivalent) shall be placed into the seam. The wire should be grounded at one end and placed at the edge of the top sheet of the overlap seam. Tucking the wire under the edge of the top sheet will help hold the wire in place during welding, but this should be done prior to grinding to avoid the risk of contamination of the weld area. Electrically conductive tape placed along the edge of the overlying patch can also be used instead of copper wire.
- Apply the extrudate bead as normal and allow the weld to cool.
- Complete a calibration test on a trial seam containing a non-welded segment ensuring the identification of such a defect (non-welded segment) under the planned spark tester settings and procedures.
- Energize the spark tester and move the electrode wand near the trial seam to determine the maximum length of spark that can be generated. Adjust the output voltage setting until the spark length exceeds the greatest potential leak path distance. This is typically the diagonal distance from the embedded wire to the edge of the weld bead at a "T" joint.
- Once the output voltage has been set testing may be started. Testing is performed by passing the electrode over the seams with the electrode in contact with the membrane or the extruded weld bead. The audible and visual indication of a spark provides the determination of a potential leak path.
- If a potential leak is detected the area can be repaired with a patch. Applying additional weld beads adjacent to the leaking weld is not an acceptable repair technique. This will only lengthen the leak path to the extent that the spark tester may not be capable of generating a spark of sufficient length to breach the lengthened gap.
- After patching, the seam must be retested until no defects are indicated.
- Enter the results of the spark test on the appropriate documentation, indicating either a passed or a failed seam. If the seam fails, the repair work and subsequent testing should be recorded on the same document.
- When flammable gasses are present, use special care and precautions in the area to be tested.



3.2.4.3 Destructive Testing

Peel and shear seam strength testing shall be carried out on samples of seams removed from the installed panels. For these tests, the following procedures shall be followed:

- Coupon sampling of all field seams, including patches and repair areas, shall be taken by cutting perpendicular to the seams a sample approximately 36-inch by 12-inch. This sample shall be cut into three 12-inch by 12-inch samples and labeled with the sample number, date, time, location and seam number, and individually marked “**Owner** (Archive) Sample,” “**QA (Third Party Testing Contractor)** Sample,” and “**Installer** QC Sample.” The frequency and location shall be determined by the **Third Party Testing Contractor** but shall not be less than one sample per 500-feet of field seams. These coupons shall be tested by the Installer on-site for peel and shear seam strength and thickness in accordance with ASTM D6392.
- Heat-welded seams shall be allowed to cool or warm to about 70°F prior to testing. Solvent seams, when used, shall be allowed to cure according to the manufacturer’s recommendations. Additionally, at the **Engineer’s** option, approximately 10 percent of the coupons (size 1-inch by 6-inches) shall be sent to an independent laboratory for confirmation testing. Should the lab and field tests conflict, installation shall halt until the conflict is resolved to the satisfaction of the **Engineer**.

The **Third Party Testing Contractor** shall continuously inspect the installation of the HDPE liner to ensure that the procedures specified in this section are adhered to fully.

Weld specimens shall pass the requirements for shear and peel presented in Table 3 and as follows:

- During testing, the break shall occur by Separation in the Plane of the sheet (SIP) not through adhesion failure separation (AD). When the seam separation is equal to or greater than 25% of the track width, it is a failed test.
- The break is ductile.

In the event of a failing test result, the following procedures shall be used:

- The Installer shall follow one of two options:
 - Reconstruct the seam between any two passed test locations, or
 - Trace the weld to an intermediate location at least 10-feet or to where the seam ends in both directions from the location of the failed test. Once the failing limits of the seam are isolated, that portion of the seam shall be reconstructed or capped.

Seams welded prior to and after the failed seam using the same welding device and/or operator shall also be tested.



- Enter the results of the destructive testing on the appropriate documentation, indicating either a passed or a failed seam. If the seam fails, the repair work and subsequent testing should be recorded on the same document.

3.2.5 Repair Procedures

Damaged or defective geomembrane or seam areas failing a destructive or non-destructive test shall be repaired. Each repair requires a non-destructive test using either a vacuum box or spark testing methods. The **Installer** shall be responsible for repair of damaged or defective areas. The repair method shall be decided by the **Installer** but must be agreed upon by the **Third Party Testing Contractor**. Procedures available include the following:

- Replacement: Remove damaged geomembrane or unacceptable seam and replace with acceptable geomembrane materials if the damage cannot be satisfactorily repaired.
- Patching: Used to repair large holes, tears, undispersed raw materials, and contamination by foreign matter.
- Capping: Used to repair large lengths of failed seams.

Abrading and rewelding of small seam areas and welding the flap on fusion-welded seams are not acceptable repair procedures and shall not be accepted.

In addition, the following procedures shall be observed:

- Surfaces of the polyethylene that are to be repaired by extrusion welds shall be lightly abraded to ensure cleanliness.
- All geomembrane shall be clean and dry at the time of repair.
- Extend patches or caps at least 6-inches for extrusion welds and 4-inches for wedge welds beyond the edge of the defect, and round the corners of the patch material. The edges of all patches are to be beveled.

Furthermore, repair verification shall be performed as follows:

- Number, date, location, technician and test outcome of each patch.
- Non-destructively test each repair using methods specified in this technical specification.
- Enter the results of the repair procedures on the appropriate documentation, indicating the repair verification. If the repair fails, the repair work and subsequent testing should be recorded on the same document.



3.2.6 Hydrostatic Test Procedures

The Contact Water Ponds shall be subject to hydrostatic testing to be performed as described herein. If leaks are defined, the cost of all testing activities to find and repair the leaks will be borne by the **Installer** or **Contractor**. Hydrostatic testing and full-time QA observations shall be employed before, during and after construction.

- Evacuate all leak detection systems of any residual fluids in the pond that may have accumulated during construction.
- Begin filling the pond with cool (not warm or hot) fresh water.
- Monitor the leak detection system and water level at regular time intervals. The time interval will depend upon how fast the water is rising in the test area.
- Record all pertinent levels as monitoring continues.
- If, at any time during the test, leakage is discovered, immediately stop filling the pond.
- Quantify the leak rate by pumping the leak detection port.
- Lower the water level and continue to monitor and quantify the leak rate.
- When the leakage stops, the leak(s) will be bounded by the two-recorded water levels.
- Visually inspect, identify suspect areas, repair and retest in accordance with the same procedures outlined above.
- Continue the test until the maximum fluid level is attained with zero leakage.
- Enter the results of the hydrostatic test on the appropriate documentation, indicating either a passed or a failed test. If the test fails, the repair work and subsequent testing should be recorded on the same document.

4.0 CERTIFICATION

At the completion of the geomembrane installation, the **Installer** shall provide the **Engineer** and **Owner** with a certification stating that the geomembrane was installed and tested in accordance with the technical specifications together with a report of the test results. The certification shall be provided to the **Owner** prior to the demobilization of the installation personnel from the site unless agreed otherwise by the **Owner**. The report of the test results shall be provided in hard copy and digital format to the **Owner** and the **Engineer** no later than 30 days after the installation work has been completed.

5.0 COMPLETION

At the completion of the installation, the **Installer** shall provide a set of as-built drawings showing the actual geomembrane panel layout, seams, location of destructive test samples,



and the location of major repairs including repaired seams and capped areas. The as-built panel layout must be submitted in hard copy and digital format to the **Owner** and the **Engineer** no later than 30 days after the installation work has been completed.



Table 1
HDPE Geomembrane - Smooth
(per GRI Test Method GM13 revision 11 dated 12/14/2012)

Properties	Test Method	Test Value		Testing Frequency (minimum)
		1.5 mm (60 mil)	2 mm (80 mil)	
Thickness (min. avg.) ▪ Lowest individual of 10 values	ASTM D5199	Nominal -10%	Nominal -10%	Each roll
Density mg/L (min.)	ASTM D1505/D792	0.940 g/cc	0.940 g/cc	200,000 lbs
Tensile Properties ¹ (min. avg.) ▪ Yield strength ▪ Break strength ▪ Yield elongation ▪ Break elongation	ASTM D6693 Type IV	126 lbs/in 228 lbs/in 12% 700%	168 lbs/in 304 lbs/in 12% 700%	20,000 lbs
Tear Resistance (min. avg.)	ASTM D1004	42 lbs	56 lbs	45,000 lbs
Puncture Resistance (min. avg.)	ASTM D4833	108 lbs	144 lbs	45,000 lbs
Stress Crack Resistance ²	ASTM D5397 (Appendix)	300 hrs	300 hrs	Per GRI-GM10
Carbon Black Content (range)	ASTM D4218 ³	2.0-3.0%	2.0-3.0%	20,000 lbs
Carbon Black Dispersion	ASTM D5596	Note 4	Note 4	45,000 lbs
Oxidative Induction Time (OIT) (min. avg.) ⁵ a) Standard OIT --OR--	ASTM D3895	100 min.	100 min.	200,000 lbs
b) High Pressure OIT	ASTM D5885	400 min.	400 min.	
Oven Aging at 85°C ^{5,6} a) Standard OIT (min. avg.) – % retained after 90 days --OR--	ASTM D5721 ASTM D3895	55%	55%	Each formulation
b) High Pressure OIT (min. avg.) – % retained after 90 days	ASTM D5885	80%	80%	
UV Resistance ⁷ a) Standard OIT (min. avg.) --OR--	GRI GM11 ASTM D3895	N.R. ⁸	N.R. ⁸	Each formulation
b) High Pressure OIT (min. avg.) – % retained after 1,600 hrs ⁹	ASTM D5885	50%	50%	

¹ Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction. Yield elongation is calculated using a gage length of 1.3 inches. Break elongation is calculated using a gage length of 2.0 inches.

² The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value via MQC testing.

³ Other methods such as D1603 (Tube furnace) or D6370 (TGA) are acceptable if an appropriate correlation to D4218 (muffle furnace) can be established.

⁴ Carbon black dispersion (only near spherical agglomerates) for 10 different views: 9 in Categories 1 or 2 and 1 in Category 3.

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

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

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

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

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



Table 2
HDPE Geomembrane - Textured
(per GRI Test Method GM13 revision 11 dated 12/14/2012)

Properties	Test Method	Test Value		Testing Frequency (minimum)
		60 mils	80 mils	
Thickness (min. avg.)	ASTM D5994	Nominal (-5%)	Nominal (-5%)	Per roll
▪ Lowest individual for 8 out of 10 values		-10%	-10%	
▪ Lowest individual for any of the 10 values		-15%	-15%	
Asperity Height mils (min. avg.) ¹	D 7466	10 mil	10 mil	Every 2 nd roll ²
Density mg/L (min.)	ASTM D1505/D792	0.940 g/cc	0.940 g/cc	200,000 lbs
Tensile Properties ³ (min. avg.)	ASTM D6693 Type IV			20,000 lbs
▪ Yield strength		126 lbs/in	168 lbs/in	
▪ Break strength		90 lbs/in	120 lbs/in	
▪ Yield elongation		12%	12%	
▪ Break elongation	100%	100%		
Tear Resistance (min. avg.)	ASTM D1004	42 lbs	56 lbs	45,000 lbs
Puncture Resistance (min. avg.)	ASTM D4833	90 lbs	120 lbs	45,000 lbs
Stress Crack Resistance ⁴	ASTM D5397 (App.)	300 hrs	300 hrs	Per GRI-GM10
Carbon Black Content (range)	ASTM D4218 ⁵	2.0-3.0%	2.0-3.0%	20,000 lbs
Carbon Black Dispersion	ASTM D5596	Note 6	Note 6	45,000 lbs
Oxidative Induction Time (OIT) (min. avg.) ⁷				200,000 lbs
a) Standard OIT	ASTM D3895	100 min.	100 min.	
--OR--				
b) High Pressure OIT	ASTM D5885	400 min.	400 min.	
Oven Aging at 85°C ^{7, 8}	ASTM D5721			Per each formulation
a) Standard OIT (min. avg.) - % retained after 90 days	ASTM D3895	55%	55%	
--OR--				
b) High Pressure OIT (min. avg.) - % retained after 90 days	ASTM D5885	80%	80%	
UV Resistance ⁹	D7238			Per each formulation
a) Standard OIT (min. avg.)	ASTM D3895	N.R. ¹⁰	N.R. ¹⁰	
--OR--				
b) High Pressure OIT (min. avg.) - % retained after 1,600 hrs ¹¹	ASTM D5885	50%	50%	



Properties	Test Method	Test Value		Testing Frequency (minimum)
		60 mils	80 mils	
<p>1 Of 10 readings; 8 out of 10 readings must be ≥ 7 mils, and the lowest individual reading must be ≥ 5 mils. Also see note 6.</p> <p>2 Alternate the measurement side for double-sided textured sheet.</p> <p>3 Machine direction (MD) and cross-machine direction (XMD) average values should be on the basis of five (5) test specimens each direction.</p> <p>Yield elongation is calculated using a gauge length of 1.3 inches.</p> <p>Break elongation is calculated using a gauge length of 2.0 inches.</p> <p>4 P-NCTL test is not appropriate for testing geomembranes with textured or irregular rough surfaces. Test should be conducted on smooth edges of textured rolls or on smooth sheets made from the same formulation as being used for the textured sheet materials.</p> <p>The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value via MQC testing.</p> <p>5 Other methods, such as D1603 (tube furnace) or D6370 (TGA) are acceptable if an appropriate correlation to D4218 (muffle furnace) can be established.</p> <p>6 Carbon black dispersion (only near spherical agglomerates) for ten (10) different views: Nine (9) in Categories 1 or 2 and one (1) in Category 3.</p> <p>7 The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.</p> <p>8 It is also recommended to evaluate samples at 30 and 60 days to compare with the 90-day response.</p> <p>9 The condition of the test should be 20-hour UV cycle at 75°C followed by 4-hour condensation at 60°C.</p> <p>10 Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV-exposed samples.</p> <p>11 UV resistance is based on percent-retained value regardless of the original HP-OIT value.</p>				



Table 3
Seam Strength and Related Properties of Thermally Bonded
Smooth and Textured HDPE Geomembranes as per GRI Test Method GM19 Revision 7
updated 11/4/2013

Geomembrane Nominal Thickness	1.5 mm (60 mil)	2.0 mm (80 mil)
Hot Wedge Seams¹		
Shear strength ² (lbs/in.)	120	160
Shear elongation at break ³ (%)	50	50
Peel strength ² (lbs/in.)	91	121
Peel separation (%)	25	25
Extrusion Fillet Seams		
Shear strength ² (lbs/in.)	120	160
Shear elongation at break ³ (%)	50	50
Peel strength ² (lbs/in.)	78	104
Peel separation (%)	25	25
¹ Also for hot air and ultrasonic seaming methods ² Value listed for shear and peel strengths are for 4 out of 5 test specimens; the 5 th specimen can be as low as 80% of the listed values ³ Elongation measurements should be omitted for field testing		

Table 4: Raw Material Properties

Property	Test Method	HDPE
Density (g/cm ³)	ASTM D1505	≥0.932
Melt Flow Index (g/10 min)	ASTM D1238 (190/2.16)	≤1.0
OIT (minutes)	ASTM D3895 (1atm/200°C)	≥100



CLIENT
Haile Gold Mine Inc.

PROJECT NO
475.0042.001

PROJECT HAILE GOLD MINE PROJECT
JOHNNY'S PAG OSA AND CONTACT WATER PONDS

TITLE TECHNICAL SPECIFICATIONS FOR GEOTEXTILE
MATERIALS AND CONSTRUCTION

SPECIFICATION NO.
0042.001-SP-GT-0

REV	DATE	PAGES	APPROVALS			REMARKS
			ORIGINATOR	PM/PIC	CLIENT	
0	09/22/14	8	JNM	CJB	CC	Issued for Construction

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1.0 GENERAL

1.1 SCOPE

This specification defines the requirements for geotextile materials, installation, and quality control for use as a protection (cushioning) material and as a separation material associated with the Haile Gold Mine Inc. (Owner) Johnny's Potentially Acid Generating (JPAG) Overburden Storage Area (OSA) and Contact Water Ponds (CWP).

Any alternatives or exceptions to this specification shall be submitted in writing to the Owner or its designated representative with the bid.

1.2 Definition of Terms

- "Owner" is defined as Haile Gold Mine Inc. or any of its authorized representative(s) / agent(s).
- "Engineer" is defined as the Consultant or Engineering Company (NewFields) responsible for the detailed design or any of its authorized representative(s)/ agent(s).
- "Construction Manager" is defined as the Consultant or Engineering Company (M3 Engineering and Technology) responsible for the overall project completion.
- "Third Party Testing Contractor" is defined as the Consultant or Engineering Company (to be determined) hired by the owner to provide third party inspection and testing services for the overall project.
- "Contractor" is defined as the party(s) that has executed the contract agreement for the specified Work with the Owner or its authorized representative(s)/agent(s).
- "Specifications" are defined as this document, all supplemental addenda, and any modifications furnished by the Owner, the Engineer, or others that apply to the Work.
- "Drawings" are defined as the Construction Drawings for the JPAG OSA and CWP furnished by the Owner, Engineer, or others that apply to the Work.
- "Site" is defined as the Haile Gold Mine Project site being developed by the Owner and where the Work is to be completed as described in these Technical Specifications and detailed on the Drawings.
- "Contract" is defined as the document executed by the Owner or its authorized representative(s)/agent(s) with the Contractor to complete specified portions of the Work.
- "Work" is defined as the entire completed construction or the various separately identifiable parts thereof required to be furnished as shown on the Drawings and as described in the Specifications and Contract Documents.
- "Modifications" are defined as changes made to the Specifications or the Drawings that are approved by Owner and Engineer in writing, after the Specifications and Drawings have



been issued for construction. These also refer to changes to design elements in the field to account for unforeseen conditions.

- “Plant” is defined as all equipment, supplies, accommodations, temporary offices, etc., required to complete the Work.
- “Units” – In general, these Specifications and the Drawings will utilize English units, however metric units will be used when appropriate.

1.3 References

1.3.1 American Society for Testing and Materials (ASTM):

- D1883 – Test Method for CBR (California Bearing Ratio) of Laboratory Compacted Soils.
- D4354 – Practice for Sampling of Geosynthetics for Testing
- D4491 – Standard Test Method for Water Permeability of Geotextiles by Permittivity
- D4533 – Test Method for Trapezoidal Tearing Strength of Geotextiles
- D4632 – Test Method for Grab Breaking Load and Elongation of Geotextiles
- D4751 – Standard Test Method for Determining Apparent Opening Size of a Geotextile
- D4759 – Practice for Determining the Specification Conformance of Geosynthetics
- D4833 – Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products
- D4873 – Guide for Identification, Storage and Handling of Geotextiles
- D5261 – Test Method for Measuring Mass per Unit Area of Geotextiles
- D5494 – Test Method for the Determination of Pyramid Puncture Resistance of Unprotected and Protected Geomembranes
- D6241 – Test Method for Static Puncture Strength of Geotextiles and Geotextile Related Product Using a 50-mm Probe
- D7238 – Test Method for Effect of Exposure of Unreinforced Polyolefin Geomembrane Using Fluorescent Condensation Apparatus

1.3.2 American Association of State Highway and Transportation Officials (AASHTO):

- M288-05 – Geotextile Specification for Highway Applications

1.3.3 Geosynthetic Research Institute (GRI):

- GT12(a) – Test Methods and Properties for Nonwoven Geotextiles Used as Protection (or Cushioning) Materials, Revision 1, December 18, 2012, www.geosynthetic-institute.org.
- GT13(a) – Test Methods and Properties for Geotextiles Used as Separation Between Subgrade Soil and Aggregate, Revision 3: December 19, 2012 www.geosynthetic-institute.org.



1.4 Submittals Post-Award

- Prior to material delivery to the project site, the **Contractor** shall provide the **Engineer** with a written certification or manufacturers quality control data which displays that the geotextile meets or exceeds the values specified herein.
- The **Contractor** shall submit, if required by the **Engineer**, manufacturer's quality control manual for the geotextile to be delivered to the site.

1.5 Submittals during Manufacturing

- Manufacturer quality control certificates stating the name of the manufacturer, product name, style number, chemical composition of the filaments or yarns, and other pertinent information to fully describe the geotextile.
- The manufacturer is responsible for establishing and maintaining a quality control program to assure compliance with the requirements of the specification. Documentation describing the quality control program shall be made available upon request.
- The manufacturer's certificate shall state that the finished geotextile meets the Minimum Average Roll Value (MARV) requirements of the specification as evaluated under the manufacturer's quality control program. A person having legal authority to bind the manufacturer shall attest to the certificate.
- Mislabelling or misrepresentation of materials shall be reason to reject those geotextile products.

1.6 Shipment, Storage and Handling

- Geotextile labelling, shipment and storage shall follow ASTM D4873. Product labels shall clearly show the manufacturer or supplier name, style, and roll number. Each shipping document shall include a notation certifying that the material is in accordance with the manufacturer's certificate.
- Each geotextile roll shall be wrapped with a material that will protect the geotextile, including the ends of the roll, from damage due to shipment, water, sunlight and contaminants. The protective wrapping shall be maintained during periods of shipment and storage.
- During storage, geotextile rolls shall be elevated off the ground and adequately covered to protect them from the following: site construction damage, precipitation, extended ultraviolet radiation including sunlight, chemicals that are strong acids or strong bases, flames including welding sparks, temperatures in excess of 160°F (71°C), and any other environmental condition that may damage the property values of the geotextile.



2.0 PRODUCT

2.1 Geotextile

- The nonwoven needle punched geotextile specified herein shall be made from staple fiber.
- The geotextile shall be of new prime quality virgin polymer of 100-percent polyethylene (97-percent polypropylene and 3-percent carbon black with antioxidants and heat stabilizers), or polyester/polypropylene blend designed and manufactured specifically for the purpose of separation, tensile reinforcement, planar flow, filtration and protection and shall be used as designated on the Drawings.
- The geotextile shall be able to withstand direct exposure to ultraviolet radiation from the Sun for up to 30 days without any noticeable effect on index or performance properties.
- Rolls shall be free of holes, contamination and foreign debris.
- Geotextile shall meet or exceed all material properties listed herein based on the specific purpose and expected conditions.

Table 1 – Required Properties, Test Methods and Values for Geotextiles Used as Geomembrane Protection (or Cushioning) Materials

Property ¹	Test Method ASTM	Unit	Mass/Unit Area (oz/yd ²)					
			10	12	16	24	32	60
Mass per unit area	D5261	oz/yd ²	10	12	16	24	32	60
Grab Tensile strength	D4632	lb	230	300	370	450	500	630
Grab tensile elongation	D4632	%	50	50	50	50	50	50
Trap. Tear strength	D4533	lb	95	115	145	200	215	290
Puncture (pin) strength	D4833	lb	120	140	170	250	300	390
UV resistance ²	D7238	%	70	70	70	70	70	70

Table 2 – Alternative Puncture Test Methods to be Considered in Place of Pin Puncture, ASTM D4833, in Table 1

Property ¹	Test Method ASTM	Unit	Mass/Unit Area (oz/yd ²)					
			10	12	16	24	32	60
Mass per unit area	D5261	oz/yd ²	10	12	16	24	32	60
Puncture (pyramid) strength	D5494	lb	300	320	410	440	510	760
Puncture (CBR) strength	D6241	lb	700	800	900	1100	1700	2400
Puncture (CBR) elongation	D6241	in	1.5	1.5	1.5	1.5	1.5	1.5

Notes:

1. All values are MARV except UV resistance which is a minimum value. For geosynthetics, MARV is a manufacturing quality control tool used to establish published values such that the purchaser will



have a 97.7% confidence that the property in question will meet published values. For normally distributed data, "MARV" is calculated as the typical value minus two (2) standard deviations from documented quality control test results for a defined population from one specific test method associated with one specific property.

2. Evaluation to be on 2.0 inch strip tensile specimens after 500 lt. hours exposure.

- For the purposes of separation the geotextile shall meet the minimum required values as defined in the Tables 3, 4 and 5 below with the exception of AOS which is maximum average roll value (MaxARV) and UV stability which is a minimum average value:

Table 3– Geotextile Properties Class 1 (High Survivability)

Property ¹	ASTM Test	Unit	Elongation < 50%	Elongation ≥ 50%
Grab Tensile Strength	D4632	lb	315	203
Trapezoid Tear Strength	D4533	lb	112	79
CBR Puncture Strength	D6241	lb	630	440
Permittivity	D4491	sec ⁻¹	0.02	0.02
Apparent Opening Size	D4751	in	0.024	0.024
UV Stability ²	D7238	% Str. Ret. @ 500 lt. hours	50	50

Table 4 – Geotextile Properties Class 2 (Moderate Survivability)

Property ¹	ASTM Test	Unit	Elongation < 50%	Elongation ≥ 50%
Grab Tensile Strength	D4632	lb	248	158
Trapezoid Tear Strength	D4533	lb	90	56
CBR Puncture Strength	D6241	lb	500	320
Permittivity	D4491	sec ⁻¹	0.02	0.02
Apparent Opening Size	D4751	in	0.024	0.024
UV Stability ²	D7238	% Str. Ret. @ 500 lt. hours	50	50

Table 5– Geotextile Properties Class 3 (Low Survivability)

Property ¹	ASTM Test	Unit	Elongation < 50%	Elongation ≥ 50%
Grab Tensile Strength	D4632	lb	180	113
Trapezoid Tear Strength	D4533	lb	68	41
CBR Puncture Strength	D6241	lb	380	230
Permittivity	D4491	sec ⁻¹	0.02	0.02
Apparent Opening Size	D4751	in	0.024	0.024
UV Stability ²	D7238	% Str. Ret. @ 500 lt. hours	50	50



Table 6 – Required Degree of Survivability as a Function of Subgrade Conditions, Construction Equipment and Lift Thickness (Class 1, 2 and 3 Properties are Given in Table 3, 4 and 5; Class 1+ Properties are Higher than Class 1 but Not Defined at this Time)

	Low ground-pressure equipment ≤ 25 kPa (3.6 psi)	Medium ground-pressure equipment > 25 to ≤ 50 kPa (> 3.6 to ≤ 7.3 psi)	High ground-pressure equipment > 50 kPa (> 7.3 psi)
Subgrade has been cleared of all obstacles except grass, weeds, leaves and fine wood debris. Surface is smooth and level so that any shallow depressions and humps do not exceed 450 mm (18 in.) in depth or height. All larger depressions are filled. Alternatively, a smooth working table may be placed.	Low (Class 3)	Moderate (Class 2)	High (Class 1)
Subgrade has been cleared of obstacles larger than small to moderate-sized tree limbs and rocks. Tree trunks and stumps should be removed or covered with a partial working table. Depressions and humps should not exceed 450mm (18 in.) in depth or height. Larger depressions should be filled.	Moderate (Class 2)	High (Class 1)	Very High (Class 1+)
Minimal site preparation is required. Trees may be felled, delimbed, and left in place. Stumps should be cut to project not more than ± 150 mm (6 in.) above subgrade. Fabric may be draped directly over the tree trunks, stumps, large depressions and humps, holes, stream channels, and large boulders. Items should be removed only if placing the fabric and cover material over them will distort the finished road surface.	High (Class 1)	Very High (Class 1+)	Not Recommended

*Recommendations are for 150 to 300 mm (6 to 12 in.) initial lift thickness. For other initial lift thicknesses:

- 300 to 450mm (12 to 18 in.): reduce survivability requirement one level;
- 450 to 600mm (18 to 24 in.): reduce survivability requirement two levels;
- >600mm (24 in.): reduce survivability requirement three levels;

Note 1: While separation occurs in every geotextile application, this pavement-related specification focuses on subgrade soils being “firm” as indicated by CBR values higher than 3.0 (soaked) or 8.0 (unsoaked).

Source: Modified after Christopher, Holtz and DiMaggio



3.0 EXECUTION

3.1 Quality Assurance

- A. The **Engineer** or **Third Party Testing Contractor** shall examine the geotextile rolls upon delivery to the site and report any deviations from project specifications to the contractor.
- B. The **Engineer** may decide to arrange conformance testing of the rolls delivered to the job site. For this purpose, the **Engineer** shall take a sample three feet (along roll length) by roll width according to ASTM Practice D 4354. The sample shall be properly marked, wrapped and sent to an independent laboratory for conformance testing.
- C. The pass or fail of the conformance test results shall be determined according to ASTM Practice D 4759.

3.2 Installation

- A. The geotextile shall be handled in such a manner as to ensure that it is not damaged in any way. Should the **Contractor** damage the geotextile to the extent that it is no longer usable as determined by these specifications or by the **Engineer** or **Third Party Testing Contractor**, the **Contractor** shall replace the geotextile at his own cost.
- B. The geotextile shall be installed to the lines and grades as shown on the contract drawings and as described herein.
- C. The geotextile shall be rolled down the slope in such a manner as to continuously keep the geotextile in tension by self weight. The geotextile shall be securely anchored in an anchor trench where applicable, or by other approved or specified methods.
- D. In the presence of wind, all geotextiles shall be weighted by sandbags or approved equivalent. Such anchors shall be installed during placement and shall remain in place until replaced with cover material.
- E. The **Contractor** shall take necessary precautions to prevent damage to adjacent or underlying materials during placement of the geotextile. Should damage to such material occur due to the fault of the **Contractor**, the latter shall repair the damaged materials at his own cost and to the satisfaction of the **Engineer**.
- F. During placement of the geotextile, care shall be taken not to entrap soil, stones or excessive moisture that could hamper subsequent seaming of the geotextile as judged by the **Engineer** or **Third Party Testing Contractor**.
- G. The geotextile shall not be exposed to precipitation prior to being installed and shall not be exposed to direct Sun light for more than 15 days after installation.
- H. The geotextile shall be seamed using heat seaming or stitching methods as recommended by the manufacturer and approved by the **Engineer**. Sewn seams shall be made using polymeric thread with chemical resistance equal to or exceeding that of the geotextile. All sewn seams shall be continuous. Seams shall be oriented down slopes perpendicular to grading contours unless otherwise specified. For heat seaming, fusion welding techniques recommended by the manufacturer shall be used.



- I. The contractor shall not use heavy equipment to traffic above the geotextile without approved protection.
- J. The geotextile shall be covered as soon as possible after installation and approval. Installed geotextile shall not be left exposed for more than 15 days.
- K. Material overlying the geotextile shall be carefully placed to avoid wrinkling or damage to the geotextile.
- L. Holes in the geotextile material shall be repaired using a patch of identical material extending a minimum 6 inches on all sides of the hole and heat bonded. If heat bonding is not possible, the patch shall extend a minimum of 18 inches on all sides of the hole.
- M. In areas where the non-woven geotextile is used as separation or filtration, care shall be taken to install the layer without producing holes or gaps where the migration of fines into the drainage system could occur. This is accomplished by ensuring sufficient overlap of seams of 18-inches minimum overlap and properly wrapping the edges of the geotextile under the gravel areas being protected or by over running the edges of the geotextile beyond the area requiring separation or filtration.

4.0 CERTIFICATION

At the completion of the geotextile installation, the **Contractor** shall provide the **Owner** with a certification stating that the geotextile was installed and tested in accordance with the Specifications together with a report of the test results. The certification shall be provided to the **Owner** prior to the demobilization of the installation personnel from the site unless agreed otherwise by the **Owner**. The report of the test results shall be provided in hard copy and digital format to the **Owner** and the **Engineer** no later than 30 days after the installation work has been completed.