FINAL

Design Basis Memo

Wastewater Treatment Ponds
Mary River Mine, Nunavut, Canada

Prepared for:

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June 25, 2026

Pinchin File: 369884

Issued to: Baffinland Iron Mines Corporation
Issued on: June 25, 2026
Pinchin File: 369884
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APPENDICES

1.0 INTRODUCTION

Pinchin Ltd. (Pinchin) was retained by Baffinland Iron Mines Corporation (Client, Baffinland) to prepare the design basis for wastewater retention ponds at the Mary River Mine, Nunavut, Canada (Site).

Historically, industrial wastewater collected from sump pits across the Site was stored in totes and shipped off-site by sealift for treatment and disposal. Based on pilot testing and trials completed by the Client, a preliminary on-site wastewater treatment approach was developed.

The preliminary treatment approach consists of two stages. Year 1 focuses on retention ponds for chemical treatment and physio-chemical separation. Year 2 focuses on additional filtration before discharge of treated water.

Year One consists of the following steps:

- pH adjustment at the tote (to pH 11.5);
- Contaminated water from the totes is pumped through a Geotube for coarse solids removal. Filtrate from the Geotube flows by gravity to a settling pond where sedimentation and oil floatation occurs.
- From the settling pond, water can be pumped to a mixing tank where hydrated lime is added to increase the pH to approximately 11.5 or to Storage Pond No. 1 if the pH has already been adjusted. The treated water is subsequently discharged to Storage Pond No. 1 which provides the following treatment functions:
    - Promote additional sediment settling;
    - Enhance oil and grease flotation;
    - Inhibit algae growth due to elevated pH; and
    - Ammonia reduction through volatilization at elevated pH.
- The water within Storage Pond No. 1 will be recirculated as required, and the pH will be continuously monitored to ensure optimal pH 11.5 is maintained.
- During freezing conditions (typically beginning at the end of September), water will remain in the Storage Pond No. 1 to allow continued sediment settling and oil floatation. Stored water will be treated during Year 2 Operations.

The Client provided a preliminary footprint and supporting information for the Year 1 storage pond. Pinchin reviewed and revised the concept to address site-specific geotechnical and civil requirements. This design basis memo summarizes the design assumptions and requirements for the proposed storage ponds.

2.0 BACKGROUND INFORMATION

The Site is developed as the Mary River Mine; an open pit mine with crushing and screening facilities, and ancillary support buildings.

Currently, wastewater generated from the Site from various mine operations is collected and stored in totes on Site. Without an on-site wastewater treatment system capable of treating this water, these totes are transported south for treatment. Baffinland wishes to implement an on-site wastewater treatment system to treat this water.

It is Pinchin's understanding that in support of the long-term goal of treating and discharging this stored wastewater to the environment, the Client requires several lined ponds to be designed and installed at the site, including a system of two (2) water storage ponds for the storage of contaminated and treated water.

The Client has indicated that they will provide a conceptual design for each pond. The conceptual design will include the following:

- Preferred location of the Ponds (Georeferenced coordinates);
- Physical feature requirements of the Ponds, including:
    - Access for equipment within the pond;
    - Berm width for equipment traffic.

3.0 OBJECTIVE

Develop a design basis for wastewater retention ponds to be utilized for wastewater treatment at the Mary River Mine, Nunavut, Canada.

4.0 DESIGN BASIS

The design basis will be divided into the following sections:

- Preliminary Design;
- Geotechnical;
- Permafrost Considerations;
- Civil Construction;
- Liner;
- Ancillary Equipment; and
- Quality Assurance and Quality Control Measures

4.1 Preliminary Design

4.1.1 Flowrate and Loading Estimates

The conceptual treatment plan targets processing contaminated water at a rate of 10 totes per hour assuming each tote contains 1 cubic metre (m^3).

Influent loading will vary with tote contents. Based on analytical results from 10 totes, the average characteristics presented below are anticipated for preliminary design.

PARAMETERS	AVG CONC.	Units
Physical Tests (Matrix: Water)		
Solids, total dissolved [TDS]	1567.30	mg/L
Solids, total suspended [TSS]	26.60	mg/L
Turbidity	139.36	NTU
pH	7.02	pH units
Anions and Nutrients (Matrix: Water)		
Ammonia, total (as N)	1024.09	mg/L
Phosphorus, total	7.0263	mg/L
Total Metals (Matrix: Water)		
Arsenic, total	<0.001	mg/L
Copper, total	<0.005	mg/L
Lead, total	<0.0005	mg/L
Nickel, total	0.017	mg/L
Zinc, total	1.80	mg/L
Dissolved Metals (Matrix: Water)		
Aluminum, dissolved	0.177	mg/L
Antimony, dissolved	<0.001	mg/L
Arsenic, dissolved	<0.001	mg/L
Barium, dissolved	0.040	mg/L
Beryllium, dissolved	<0.0002	mg/L
Bismuth, dissolved	<0.0005	mg/L
Boron, dissolved	0.612	mg/L

PARAMETERS	AVG CONC.	Units
Cadmium, dissolved	0.009	mg/L
Calcium, dissolved	70.99	mg/L
Cesium, dissolved	<0.0001	mg/L
Chromium, dissolved	<0.00	mg/L
Cobalt, dissolved	<0.00	mg/L
Copper, dissolved	<0.00	mg/L
Iron, dissolved	0.858	mg/L
Lead, dissolved	<0.0005	mg/L
Lithium, dissolved	0.376	mg/L
Magnesium, dissolved	58.367	mg/L
Manganese, dissolved	1.853	mg/L
Molybdenum, dissolved	0.616	mg/L
Nickel, dissolved	<0.005	mg/L
Phosphorus, dissolved	8.24	mg/L
Potassium, dissolved	63.53	mg/L
Rubidium, dissolved	0.0370	mg/L
Selenium, dissolved	0.00085	mg/L
Silicon, dissolved	3.438	mg/L
Silver, dissolved	<0.0001	mg/L
Sodium, dissolved	73.57	mg/L
Strontium, dissolved	0.344	mg/L
Sulfur, dissolved	69.65	mg/L
Tellurium, dissolved	<0.002	mg/L
Thallium, dissolved	<0.0001	mg/L
Thorium, dissolved	<0.001	mg/L
Tin, dissolved	<0.001	mg/L
Titanium, dissolved	<0.003	mg/L
Tungsten, dissolved	<0.001	mg/L
Uranium, dissolved	0.0069	mg/L
Vanadium, dissolved	<0.005	mg/L
Zinc, dissolved	1.418	mg/L
Zirconium, dissolved	<0.003	mg/L

PARAMETERS	AVG CONC.	Units
Aggregate Organics (Matrix: Water)		
Oil & grease (gravimetric)	97.6	mg/L
Volatile Organic Compounds (Matrix: Water)		
Benzene	11.71	µg/L
Ethylbenzene	10.90	µg/L
Toluene	35.09	µg/L
Xylene, m+p-	49.80	µg/L
Xylene, o-	39.94	µg/L
Xylenes, total	89.74	µg/L
BTEX, total	138.79	µg/L
Hydrocarbons (Matrix: Water)		
F1 (C6-C10)	737.5	µg/L
F2 (C10-C16)	27651	µg/L
F3 (C16-C34)	16290	µg/L
F4 (C34-C50)	7510	µg/L
F1-BTEX	599.75	µg/L
Hydrocarbons, total (C6-C50)	47519	µg/L
Hydrocarbons Surrogates (Matrix: Water)		
Bromobenzotrifluoride, 2- (F2-F4 surrogate)	88.08	%
Dichlorotoluene, 3,4-	84.08	%
Volatile Organic Compounds Surrogates (Matrix: Water)		
Bromofluorobenzene, 4-	91.66	%
Difluorobenzene, 1,4-	98.25	%

4.1.2 Design Constraints

The following design constraints and objectives were considered in the pond design:

- Constraints:
  - Potential permafrost degradation of subgrade soils;

- Client-provided footprint, preliminary pond layout, and dimensions;
- Equipment access requirements;
- Availability of materials; and
- Length of the construction season.

- Objectives:
  - Review and revise the Client's preliminary design, as required, to address site constraints and meet geotechnical and civil requirements.

4.1.3 Available Footprint

The Client-provided footprint is 87 metres (m) by 75 m and is located near the airstrip, southeast of the hazardous waste facility and southwest of the Site Services Facility.

The design, which incorporates geotechnical and civil requirements, provides a capacity of approximately **2330.8** m^3 per pond.

It is assumed that the overall footprint will be maintained, and that pond capacity will be adjusted as required to address geotechnical and civil design requirements.

4.1.4 Treatment Objectives

The treatment objective is to retain preliminarily treated water for approximately one year. During the retention period, the following parameters are to be monitored:

- pH;
- Total Ammonia as Nitrogen (TAN); and
- Oil and Grease.

4.1.5 Availability of Power at Site

Based on the industrial nature of the facility, 600 volt (V), three-phase, 60 hertz (Hz) power is assumed to be available at the installation area. To provide operational flexibility, mobile equipment is recommended to operate using generators when required.

4.2 Geotechnical

4.2.1 Summary of Soil and Groundwater Data

- In 2021, Knight Piésold Consulting completed a geotechnical site investigation, including one (1) borehole (Borehole DH21-16) approximately 140 m to the south/southwest of the planned ponds (location coordinates: 558,194 E, 7,914,309 N; ground surface elevation 176.0 m). The soils contacted at Borehole BH21-16 consisted of the following:

  - 0.0 to 1.8 m (Elevation 176.0 to 174.2 m) - Sand and Gravel, some organics, loose.
  - 1.8 to 7.6 m (Elevation 174.2 to 168.8 m) - Sand with trace gravel, some individual ice inclusions (approximately 30% ice).
  - 7.6 to 8.8 m (Elevation 168.8 to 167.2 m) - Ice and Sand (approximately 70% ice).
  - 8.8 to 12.2 m (Elevation 167.2 to 163.8 m) - Gravelly Sand (approximately 30 to 35% ice).
  - 12.2 to 28.9 m (Elevation 163.8 to 147.1 m) – Ice.
  - 28.9 to 33.1 m (Elevation 147.1 to 142.9 m) - Ice and Sand.
  - The borehole was terminated within overburden materials at 33.1 m.
- In 2024, WSP completed groundwater monitoring, hydraulic conductivity testing, and sampling across the mine Site. The WSP report notes that monitoring wells in the general area of the proposed ponds were installed by Knight Piésold Consulting in 2022 and 2023 using test pits. Installation logs were not included in the WSP report; however, the data presented indicate that the test pits were shallow; approximately 0.9 to 1.6 m deep. The screened intervals of four monitoring wells (HWB-KP22-01, HWB-KP22-04, HWB-KP23-01, and HWB-KP23-03) used for hydraulic conductivity testing were described as penetrating sand and gravel, coarse sand with some gravel and cobbles, coarse sand with large pebbles and cobbles, and coarse to medium sand with medium to large pebbles. Groundwater monitoring completed on September 5, 2024, in the general area of the planned ponds, indicated water levels between 0.14 and 0.59 m below ground surface (elevation 173.1 to 174.0 m).
- The WSP report describes the active zone to be 3 m thick at DH21-12 located approximately 3.1 km southeast of the planned ponds.
- In April 2026, the Client completed two (2) boreholes to 3.5 m depth near the center of the proposed footprint of the central berm dividing the two planned ponds. The borehole drilling was completed with an air-rotary drill rig. The drill method does not allow collection of intact samples, but rather pulverizes the cuttings allowing only a general indication of what subsurface soils may be present. The soils recovered from the two boreholes were described as primarily sand. Ice was not observed to be present.

4.2.2 Summary of Planned Pond Structure

Based on the provided Mary River Water Storage Ponds Conceptual Design, the proposed ponds will have the following layout:

- Overall footprint of the two (2) ponds with containment berms will be 87 m by 75 m.
- Each pond to be designed with a capacity of **2,330.8** m^3 per pond.
- Except for the eastern berm used for maintenance access into the ponds, the interior slopes of the berms are proposed at 2H to 1V (horizontal to vertical), and the exterior slopes are proposed at 2H to 1V.
- At the eastern berm, Pinchin recommends the implementation of 5H to 1V side slopes for both the interior and exterior slopes for equipment access.
- The berm crest width is proposed at 3 m.
- The overall height of the berms will be 3.3 m.
- The target maximum water depth will be 2.1 m.
- The ponds will be lined (Enviroliner).

It is understood that no inlet or outlet structures are proposed for the ponds.

To minimize the degradation of the existing permafrost, the proposed pond is designed at ground surface and not as initially considered partially excavated with the pond base below existing grades.

4.2.3 Material Specifications and Base Support Specifications

Limited subsurface soil data are available below the planned pond system footprint. Borehole DH21-16 indicated the presence of ice inclusions within the upper deposits and ice below 12.2 m. The active zone at the Site is around 3 m. There is potential that freeze-thaw cycles within the active layer may lead to seasonal soil movement and settlement potentially resulting in failure of the lined pond system. As such, Pinchin will build on grade.

- Grade area of pond to 174 m (any minor site grading activities involving fill placement should follow the specifications provided for Type 2 aggregate in the table below);
- Install a non-woven geotextile (GT160 Skaps or equivalent);
- Install a minimum of 0.15 m of fine sand (see specifications in the table below), compacted to 100% standard Proctor maximum dry density (SPMDD);
- Install non-woven geotextile – geomembrane liner – non-woven geotextile layer (follow installation instructions provided by the vendor; liner to be Layfield 6060 or equivalent);

- Install a minimum of 0.25 m of fine sand (see specifications in the table below), compacted to 100% standard Proctor maximum dry density (SPMDD);
- Install a non-woven geotextile (GT160 Skaps or equivalent);
- Install a minimum of 0.2 m of rip rap (see specifications in the table below);

A 150 mm thick sand fill transition layer and 250 mm thick sand fill transition layer has been provided both below and above the liner, respectively, to minimize the risk of liner puncture or stress concentration where larger size gravel is exposed at subgrade level as suggested by the liner manufacturer (Layfield).

To ensure berm stability under the proposed interior slopes (2H:1V and 5H:1V) and exterior slopes (2H:1V and 5H:1V), berm fill should consist of type 2 aggregate meeting the specifications provided in the table below. The berm fill material is to be placed in maximum 300 mm thick lifts and compacted to 100% SPMDD.

To prevent damage to the liner from machinery during maintenance activities, a 200 mm thick layer of rip-rap has been included to be placed above the finished liner grade within the pond bottoms, as well as along designated access routes on the interior slopes for allowing equipment to access the ponds. A 200 mm thick layer of rip-rap has been included to be used along designated access routes within the exterior slopes to ensure stability of the berm slopes. Rip-rap should be graded at 18 cm-minus. A non-woven geotextile is to be installed for material separation between the sand and rip-rap.

Additional details pertaining to the materials are summarized in the table below:

Table 1 Description of Material Properties

Material Description	Construction Material	Typical Placement and Compaction Requirements
Type 2 Aggregate	Angular rock fragments or sand and gravel graded at 100 mm-minus with less than 5% fines passing 0.075 mm. Material to be durable. Material to be free of ice, frozen materials, organics, and deleterious materials.	Install in maximum 300 mm thick layers, compacted to 100 % SPMDD using a smooth-steel drum non-vibratory roller
Sand Fill	Sand or sand with some fine gravel with less than 8% fines passing 0.075 mm. Fines should not be plastic. Particles to be subangular or subrounded. Material to be free of ice, frozen materials, organics, and deleterious materials. Wet materials not permitted. Requirements of sand fill for liner protection should be confirmed with liner supplier.	Install in maximum 300 mm thick layers, compacted to 100 % SPMDD using a smooth-steel drum non-vibratory roller
Rip Rap	Graded at 18 cm – minus.	

Acceptance of materials for use onsite to be confirmed through appropriate property testing, including gradation analysis, percent crushed particles, petrographic testing, and/or Micro-Deval testing as applicable (please refer to Section 5.1).

Anticipated qualities of materials required for the pond construction are as follows:

Table 2 Quantity of Materials Required for Pond Construction

	Quantity	Units
Type 2 Aggregate	7,800	m^3
Fine Sand	2,170	m^3
Rip Rap	280.0	m^3
Geotextile	12,780	m^2
Liner (HDPE Geomembrane)	5,330	m^2

Construction dewatering will be required for any excavations extending below the seasonal groundwater level within the active zone. As the ponds are to be constructed above grade, this recommendation should be reviewed at the time of construction. Moderate to heavy groundwater inflow should be expected from the sandy soils; however, the dewatering requirements will depend on the water levels within the active zone at time of construction, depth to frozen ground, and soils exposed in the walls / bottom of the excavation. The design of the dewatering system should be left to the contractor's discretion, and the system should meet a performance specification to maintain and control the groundwater at least 0.5 m below the excavation base.

4.3 Permafrost Considerations

Due to permafrost conditions, Pinchin has adopted a conservative design approach in which the ponds are constructed at grade.

4.4 Civil Construction

4.4.1 Location, Footprint, and Capacity

The ponds are proposed to be located on the western side of the existing settling pond.

Initial review of the topographic survey provided by the Client indicated that the proposed location was not level. During follow-up review with the Client, the apparent grade change was attributed to containers captured in the survey. For preliminary design, a relatively flat area within the 87 m by 75 m footprint is assumed to exist at elevation 174 m. This elevation is assumed to define the pond base and the toe of the berm slopes.

Refer to Appendix A and Appendix B for Detailed Design Drawings, and Pond Volume and Material Calculations, respectively, detailing how the 87 m by 75 m footprint with a capacity of **2330.8** m^3 per pond is achieved.

This capacity reduction allows the two-pond configuration to provide the following operational benefits:

- The ability to take one pond offline for maintenance;
- Overflow capacity as one pond can discharge to the other if required; and
- Reduced potential for continuous thermal loading on the underlying permafrost by alternating annual operation between ponds which may help limit long-term subgrade degradation.

4.5 Liner

Baffinland provided the liner specification available on site. Refer to Appendix C for liner specifications, chemical resistance information, and installation guidance. Reviewing the liner specifications for the Layfield 6060 Geomembrane Liner, the liner specifications are deemed adequate for the application.

Given the high pH, wastewater chemistry, and variable site temperatures, additional monitoring around the ponds is strongly recommended.

To protect liners, a suggested 150 mm layer of sand is to be placed under and on top of the liners on interior slopes of the pond in addition to the 0.45m layer of sand on the top of the berm crests. At the pond bottoms, 250 mm of fine sand, a non-woven geotextile, and 200 mm of rip-rap are to be installed on top of the liner at the bottom of the pond to provide a sufficient base allowing for a bobcat to navigate the bottom of the pond without restriction when performing maintenance activities.

To provide access to the ponds under the proposed maintenance roads, 250 mm of fine sand, a non-woven geotextile, and 200 mm of rip-rap are to be installed to provide a sufficient base to allow for a bobcat to travel into and out of the pond.

During installation, the maintenance access road can be constructed with a deeper layer of fine sand to allow for heavier equipment to enter the pond during construction and modified after construction to reflect maintenance demands. The increased fine sand thickness would not need to extend across the full pond base, but may be required along the access road, and if necessary, within a limited portion of the pond bottom to accommodate access by heavier equipment.

During installation, the Client is advised to follow the liner manufacturer’s recommended installation and testing procedures. Refer to Appendix C. Given the importance of liner integrity to pond performance, installation by a qualified specialty contractor is recommended.

4.5.1 Liner Anchorage

To ensure that the liner is secured at the top to withstand dragging forces of the sloped liner and prevent slippage, a liner anchor consisting of 0.45 m coverage of fine sand above the liner at the high water level + 0.15 m with a 0.3 m length into the berm, 0.3 m depth into the berm, and 0.3 m covered section of the berm. This provides sufficient friction with the anticipated sand characteristics to meet requirements. When establishing the trench at the berm, it is recommended that if a square trench cannot be dug, that a trapezoidal trench be dug with 2:1 (H:V) slope. Please note that when establishing the liner anchorage, the buffer layer of sand (0.15 m below the liner) is to be maintained. Please refer to Appendix D for anchor calculations for reference.

4.5.2 Liner Installation

4.5.2.1 Subgrade Preparation

- The subgrade shall be prepared in accordance with the project specifications. The geomembrane subgrade shall be uniform and free of sharp or angular objects that may damage the geomembrane prior to installation of the geomembrane.
- The Geomembrane Installer and Owner’s Representative shall inspect the surface to be covered with the geomembrane on each day's operations prior to placement of geomembrane to verify suitability.
- The Geomembrane Installer and Owner’s Representative shall provide daily written acceptance for the surface to be covered by the geomembrane in that day's operations. The surface shall be maintained in a manner to ensure subgrade suitability.
- All subgrade damaged by construction equipment and deemed unsuitable for geomembrane deployment shall be repaired prior to placement of the geomembrane. All repairs shall be approved by the Owner's Representative and the Geomembrane Installer.

4.5.2.2 Geomembrane Placement

- The geomembrane shall be installed to the limits shown on the project drawings and essentially as shown on approved panel layout drawings.
- No geomembrane material shall be unrolled or deployed if the material temperatures are lower than 0 degrees C unless otherwise approved by the Owner’s Representative in writing. The specified minimum temperature for material deployment may be adjusted by the Owner’s Representative. Temperature limitations should be defined in the preconstruction meeting. Typically, only the quantity of geomembrane that will be anchored and seamed together in one day should be deployed.

- No vehicular traffic shall travel on the geomembrane other than an approved ground pressure vehicle or equivalent.
- Sand bags or equivalent ballast shall be used as necessary to temporarily hold the geomembrane material in position under the foreseeable and reasonably expected wind conditions. Sand bag material shall be sufficiently close-knit to prevent soil fines from working through the bags and discharging on the geomembrane.
- Geomembrane placement shall not be done if moisture prevents proper subgrade preparation, panel placement, or panel seaming. Moisture limitations should be defined in the preconstruction meeting.
- Damaged panels or portions of the damaged panels which have been rejected shall be marked and their removal from the work area recorded.
- The geomembrane shall not be allowed to "bridge over" voids or low areas in the subgrade. The geomembrane shall rest in intimate contact with the subgrade.
- Wrinkles caused by panel placement or thermal expansion should be minimized.
- Build in adequate slackness to allow for thermal contraction without significant applied stress at temperatures between ambient temperature at installation and -50 degrees C.
- Considerations on Site Geometry: In general, seams shall be oriented parallel to the line of the maximum slope. In corners and odd shaped geometric locations, the total length of field seams shall be minimized. Seams shall not be located at low points in the subgrade unless geometry requires seaming at such locations and if approved by the Owner's Representative. Welds on slopes must be constructed with the upper panel overtop of the lower panel.
- Overlapping: The panels shall be overlapped prior to seaming to whatever extent is necessary to affect a good weld and allow for proper testing. In no case shall this overlap be less than 75 mm.

4.5.2.3 Seaming Procedures

- The Geomembrane Installer shall maintain at least one spare operable seaming unit on site at all times.
- The welding technique shall produce a joined interface of uniform properties across the full width of the weld.
- Welding may only be performed within the "window" of parameters supplied by the Contractor in the written Welding Procedures.

- Portable structures may be used to facilitate attainment of these parameters in the area to be seamed, but must be approved by the Owner's representative.
- Welding shall not proceed when the prepared surfaces cannot be maintained free of moisture
- All surfaces to be joined shall be cleaned free of grease, oils, dirt, and foreign material.
- Prepared surfaces shall not remain exposed for more than 30 minutes before welding.
- Cold weather installations should follow guidelines as outlined in GRI GM9.
- No geomembrane material shall be seamed when liner temperatures are less than 0 degrees C unless the following conditions are complied with:
  - Seaming of the geomembrane at material temperatures below 0 degrees C (measured 150 mm above the geomembrane surface) is allowed if the Geomembrane Installer can demonstrate to the Owner's Representative, using pre-qualification test seams, that field seams comply with the project specifications, the safety of the crew is ensured, and geomembrane material can be fabricated (i.e. pipe boots, penetrations, repairs. etc.) at sub-freezing temperatures.
  - The Geomembrane Installer shall submit to the Owner's Representative for approval detailed procedures for seaming at low temperatures, possibly, including the following:
    - Preheating of the geomembrane
    - The provision of a tent or other device if necessary to prevent heat losses during seaming and rapid heat losses subsequent to seaming
    - Number of test welds to determine appropriate seaming parameters.
- No geomembrane material shall be seamed when the sheet temperature is above 75 degrees C as measured by an infrared thermometer or surface thermocouple unless otherwise approved by the Owner's Representative. This approval will be based on recommendations by the manufacturer and on a field demonstration by the Geomembrane Installer using prequalification test seams to demonstrate that seams comply with the specification.
- Seaming shall primarily be performed using automatic fusion welding equipment and techniques. Extrusion welding shall be used where fusion welding is not possible such as at pipe penetrations, patches, repairs, and short (less than a roll width) runs of seams.

- Fish mouths or excessive wrinkles at the seam overlaps shall be minimized and when necessary, cut along the ridge of the wrinkles back into the panel, so as to effect a flat overlap. The cut shall be terminated with a keyhole cut (nominal 10 mm diameter hole), so as to minimize crack/tear propagation. The overlay shall subsequently be seamed. The key hole cut shall be patched with an oval or round patch of the same base geomembrane material extending a minimum of 150 mm beyond the cut in all directions.

4.6 Geotextile

Geotextiles are to be placed on the bottom and top of all geomembranes, on the bottom of all rip rap layers, and between fine sand and native grade.

4.6.1 Geotextile Installation

Installation:

- Where applicable, place geotextile directly on top of and below geomembrane as shown on drawings. The surface must be smooth and free of sharp objects.
- Where located below a geomembrane, below rip rap, or at native grade, maintain contact between geotextile and soil, so that no void spaces occur. Avoid laps and folds in the geotextile.
- Employ sufficient anchorage to hold the geotextile in place during deployment and backfilling.
- Do not cover geotextile prior to inspection and approval by the Owner's Representative.
- Place fill material or geomembrane immediately after inspection is complete.
- Placement of soil cover soil:
  - Place in a manner that prevents soil from entering the geotextile overlap zone, prevents tensile stress from being mobilized in the geotextile, and prevents wrinkles from folding over onto themselves.
  - Maximum drop height for fill directly onto geotextile is 1 m.
  - Minimum lift thickness prior to starting compaction is 300 mm.
- On side slopes, soil backfill shall be placed from the bottom of the slope upward.
- Seams and Joints: Seams shall be overlapped; minimum overlap 600 mm.
- Heat tack or sew seams.
- Anchor the geotextile at the perimeter of the pond berm as shown on the Drawings.
- Do not permit passage of any vehicle directly on the geotextile.

5.0 QUALITY ASSURANCE AND QUALITY CONTROL MEASURES

The construction quality assurance program must be structured to ensure that construction of sensitive features of the design are achieved. The elements of the program will include:

- Careful surveying to establish material quantities and allow preparation of as-build construction drawings;
- Specific engineering approvals at critical times such as berm construction, liner trench excavation, and cleaning;
- Monitoring field and laboratory testing of fill materials;
- Specific approval of construction procedures for moisture condition and placement of berm materials, and liner installation;
- Observation and approval of contractor's proposed material placement sequences and preparation of each surface prior to placement of the next lift; and
- Defined procedures for reporting with identified responsibilities for decision making during construction.

Specific testing requirements and frequencies for granular fill and liner installation are outlined below

5.1 Granular Fill Material Testing;

5.1.1 Granular Fill Materials Testing References

Where materials are specified, the following standards are applicable:

Materials International

1. ASTM D698 [07e1], Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft lbf/ft) (600kN m/m3).
2. ASTM D422 Test Method for Particle-Size Analysis of Soils.
3. ASTM D1140 Test Method for Amount of Material in Soils Finer than the No. 200 (75 µm) Sieve.
4. ASTM C136 Test Method for Sieve Analysis of Fine and Coarse Aggregates.
5. ASTM D2216 Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock.
6. ASTM D1556 Test Method for Density of Soil in Place by the Sand-Cone Method
7. ASTM D2922 Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (shallow depths).

Canadian General Standards Board (CGSB)

1. CAN/CGSB-8.1-88, Sieves, Testing, Woven Wire, Inch Series.
2. CAN/CGSB-8.1-88, Sieves, Testing, Woven Wire, Inch Series.

5.1.2 Quality Assurance

The subgrade soil is to be inspected prior to construction of the pond system. Soft or organic soils, as well as ice lenses exposed within the subgrade must be removed and replaced with Type 2 Aggregate as described in Section 4.2.3.

Testing to be carried out by the Owner's representative or an independent testing firm engaged by the Owner. Samples of Type 2 and Fine Sand materials shall be tested as follows to verify that they meet the specified requirements. Additional testing shall be carried out as requested by the Owner's representative.

Test	ASTM Standard	Minimum Test Frequency of Placed Material
Moisture-Density Relationship	D698	One per 50 m^3
In-Situ Density	D5195	One per 300 m^3
Grain Size Distribution	D422	One per 500 m^3

During construction, maximum lift thicknesses and compaction verification per Section 4.2.3 are to be followed. In the absence of compaction verification testing, materials shall be installed in not exceeding their prescribed maximum lift thicknesses and compacted with a minimum 10-tonne steel drum roller. Prior to placement, the material should be confirmed to be at an appropriate moisture content (not saturated or dry) to achieve the specified compaction level. A minimum of four to six passes per lift are to be completed. During compaction, monitoring of soil deflection of each lift is to be observed. Sections of lifts having deflections of 50 mm or greater are to be removed, moisture conditioned (dried or wetted), and reinstalled.

5.2 Liner Installation Testing;

5.2.1 Liner Installation Testing References

Where material properties are specified, the following standards are applicable:

American Society for Testing and Materials (ASTM):

1. D 413, Standard Test Methods for Rubber Property—Adhesion to Flexible Substrate
2. D 638, Standard Test Method for Tensile Properties of Plastics.
3. D 751, Standard Test Methods for Coated Fabrics.

4. D 792, Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
5. D 1004, Standard Test Method for Initial Tear Resistance of Plastic Film and Sheeting.
6. D 1204, Standard Test Method for Linear Dimensional Changes of Non Rigid Thermoplastic Sheeting or Film at Elevated Temperature.
7. D 1238, Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer.
8. D 1505, Standard Test Method for Density of Plastics by Density-Gradient Technique.
9. D 1603, Standard Test Method for Carbon Black in Olefin Plastics.
10. D 3895, Test Method for Oxidative Induction Time of Polyolefins by Thermal Analysis.
11. D 4218, Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique.
12. D 4437, Standard Practice for Determining the Integrity of Field Seams Used in Joining Flexible Polymeric Sheet Geomembranes.
13. D 4833, Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products.
14. D 5199, Standard Test Method for Measuring Nominal Thickness of Smooth Geomembranes.
15. D 5397, Standard Test Method for Evaluation of Stress Crack Resistance of Polyolefins using Notched Constant Tensile Load Test.
16. D 5596, Standard Practice for Microscopical Examination of Pigment Dispersion in Plastic Compounds.
17. D 5641, Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber.
18. D 5820, Test Method for Air Testing.
19. D 5994, Standard Test Method for Measuring Nominal Thickness of Textured Geomembranes.
20. D 6365, Standard Practice for the Non-destructive Testing of Geomembrane Seams using The Spark Test.
21. D 6392 Determining the Integrity of Non-reinforced Geomembrane Seams Produced Using Thermo-Fusion Methods.
22. D 5820-95, Pressurized Air Channel Test for Dual Seamed Geomembranes

Geosynthetic Research Institute (GRI)

1. GRI GM 9, Cold Weather Seaming of Geomembranes
2. GRI GM 10, The Stress Crack Resistance of HDPE Geomembrane Sheet
3. GRI GM 12, Measurement of the Asperity Height of Textured Geomembranes Using a Depth Gage
4. GRI GM 13, Test Properties, Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes
5. GRI GM 14, Selecting Variable Intervals for Taking Geomembrane Destructive Seam Samples Using the Method of Attributes
6. GRI GM 19, Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes

5.2.2 Quality Assurance

5.2.2.1 Installer's Qualifications

- The geomembrane installer shall be the Manufacturer, approved Manufacturer's Installer, or a contractor approved by the Owner's Representative to install the geomembrane.
- The Geomembrane installer shall have at least 3 years of experience in installation of the specified geomembrane or similar. The Geomembrane installer shall have installed at least 10 projects involving a total of 500,000 m^2 of the specified type of geomembrane or similar during the last three years.
- Installation shall be performed under the direction of a field Installation Supervisor who shall be responsible throughout the geomembrane installation for geomembrane panel layout, seaming, patching, testing, repairs, and all other activities of the Geomembrane Installer. The Field Installation Supervisor shall have installed or supervised the installation and seaming of a minimum of 10 projects involving a total of 500,000 m^2 of geomembrane of the type specified or similar product.
- Seaming shall be performed under the direction of a Master Seamer (who may also be the Field Installation Supervisor or Crew Foreman) who has seamed a minimum of 300,000 m^2 of geomembrane of the type specified or similar product using the same type of seaming apparatus to be used in the current project. The Field Installation Supervisor and/or Master Seamer shall be present whenever seaming is performed.
- All seaming, patching, other welding operations, and testing shall be performed by qualified technicians employed by the Geomembrane Installer.

5.2.2.2 Project Conditions

- Geomembrane should not be installed in the presence of standing water while precipitation is occurring, during excessive winds, or when material temperature are outside of limits specified (0 degrees Celsius).

5.2.2.3 Field Quality Control

The Owner's Representative shall be notified prior to all pre-qualification and production welding and testing, or as agreed upon in the preconstruction meeting.

5.2.2.3.1 Prequalification Test Seams

- Test seams shall be prepared and tested by the Geomembrane Installer to verify that seaming parameters (speed, temperature, and pressure of welding equipment) are adequate.
- Test seams shall be made by each welding technician and tested in accordance with ASTM D 4437 at the beginning of each seaming period. Test seaming shall be performed under the same conditions and with the same equipment and operator combination as production seaming. The test seam shall be approximately 3.3 m long for fusion welding and 1 m long for extrusion welding with the seam centered lengthwise. At a minimum, test seams should be made by each technician one time every four to six hours; additional tests may be required with changes in environmental conditions.
- Two 25 mm wide specimens shall be die-cut by the Geomembrane Installer from each end of the test seam. These specimens shall be tested by the Geomembrane Installer using a field tensiometer testing both tracks for peel strength and also for shear strength. Each specimen should fail in the parent material and not in the weld, "Film Tear Bond"(F.T.D. failure). Seam separation equal to or greater than 25% of the track width shall be considered a failing test.
- The minimum acceptable seam strength values to be obtained for all specimens tested are listed in table below. Four specimens shall pass for the test seam to be a passing seam.

Geomembrane Seam Properties	
Geomembrane Nominal Thickness	1.5 mm
Hot Wedge Seams(1)	
Sheer Strength(2), N/25 mm	525

Geomembrane Seam Properties	
Shear Elongation at break[(3)]	50
Peel Strength[(2)], N/25 mm	340
Peel Separation, %	25

(1) Also for hot air and ultrasonic seaming methods

(2) Value listed for shear and peel strength are for 4 out of 5 test specimens; the 5th specimen can be low as 80% of the listed values.

(3) Elongation measurements should be omitted for field testing

- If a test seam fails, an additional test seam shall be immediately conducted. If the additional test seam fails, the seaming apparatus shall be rejected and not used for production seaming until the deficiencies are corrected and a successful test seam can be produced.
- A sample from each test seam shall be labelled. The label shall indicate the date, geomembrane temperature, number of the seaming unit, technician performing the test seam, and pass or fail description. The sample shall then be given to the Owner's Representative for archiving.

5.2.2.3.2 Field Seam Non-Destructive Testing

- All field seams shall be non-destructively tested by the Geomembrane Installer over the full seam length before the seams are covered. Each seam shall be numbered or otherwise designated. The location, date, test unit, name of tester, and outcome of all non-destructive testing shall be recorded and submitted to the Owner's Representative.
- Testing should be done as the seaming work progresses, not at the completion of all field seaming, unless agreed to in advance by the Owner's Representative. All defects found during testing shall be numbered and marked immediately after detection. All defects found should be repaired, retested, and remarked to indicate acceptable completion of the repair.
- Non-destructive testing shall be performed using vacuum box, air pressure, or spark testing equipment.
- Non-destructive tests shall be performed by experienced technicians familiar with the specified test methods. The Geomembrane Installer shall demonstrate to the Owner's Representative all test methods to verify that the test procedures are valid.

- Extrusion seams shall be vacuum box tested by the Geomembrane Installer in accordance with ASTM D 4437 and ASTM D 5641 with the following equipment and procedures:
  - The vacuum pump shall be charged and the tank pressure adjusted to approximately 35 kPa.
  - The Geomembrane Installer shall create a leak tight seal between the gasket and geomembrane interface by wetting a strip of geomembrane approximately 0.3 m by 1.2 m (length and width of box) with a soapy solution, placing the box over the wetted area, and then compressing the box against the geomembrane. The Geomembrane Installer shall then close the bleed valve, open the vacuum valve, maintain initial pressure of approximately 35 kPa for approximately 5 seconds. The geomembrane should be continuously examined through the viewing window for the presence of soap bubbles, indicating a leak. If no bubbles appear after five seconds, the area shall be considered leak free. The box shall be depressurized and moved over the next adjoining area with an appropriate overlap and the process repeated.
  - All areas where soap bubbles appear shall be marked, repaired and then retested.
  - At locations where seams cannot be non-destructively tested, alternate non-destructive spark testing or equivalent should be substituted.
  - Equipment for Spark testing shall be comprised of, but not limited to a hand held holiday spark tester and conductive wand that generates a high voltage.
  - The testing activities shall be performed by the Geomembrane Installer by placing an electrically conductive tape or wire beneath the seam prior to welding. A trial seam containing a non-welded segment shall be subject to a calibration test to ensure that such a defect (non-welded segment) will be identified under the planned machine settings and procedures. Upon completion of the weld, enable the spark tester and hold approximately 25 mm above the weld moving slowly over the entire length of the weld in accordance with ASTM 6365. If there is no spark the weld is considered to be leak free.
  - A spark indicates a hole in the seam. The faulty area shall be located, repaired, and retested by the Geomembrane Installer.
  - Care should be taken if flammable gases are present in the area to be tested.

    - All seams that are vacuum tested shall be marked with the date tested, the name of the technician performing the test, and the results of the test.

- Double Fusion seams with an enclosed channel shall be air pressure tested by the Geomembrane Installer in accordance with ASTM D 5820 and ASTM D 4437 and the following equipment and procedures:
    - Equipment for testing double fusion seams shall be comprised of, but not limited to an air pump equipped with a pressure gauge capable of generating and sustaining a pressure of 210 kPa mounted on a cushion to protect the geomembrane; and a manometer equipped with a sharp hollow needle or other approved pressure feed device.
    - The Testing activities shall be performed by the Geomembrane Installer. Both ends of the seam to be tested shall be sealed and a needle or other approved pressure feed device inserted into the tunnel created by the double wedge fusion weld. The air pump shall be adjusted to a pressure of 210 kPa, and the valve closed. Allow two minutes for the injected air to come to equilibrium in the channel, and sustain pressure for five minutes. If pressure loss does not exceed 28 kPa after this five minute period, the seam shall be considered leak tight. Release pressure from the opposite end verifying pressure drop on needle to ensure testing of the entire seam. The needle or other approved pressure feed device shall be removed and the feed hole sealed.
    - If loss of pressure exceeds 28 kPa during the testing period or pressure does not stabilize, the faulty area shall be located, repaired, and retested by the Geomembrane Installer.
    - Results of the pressure testing shall be recorded on the liner at the seam tested and on a pressure testing record.

5.2.2.3.2.1 Destructive Field Seam Testing

- One destructive test sample per 150 linear m seam length or another predetermined length in accordance with GRI GM 14 shall be taken by the Geomembrane Installer from a location specified by the Owner's Representative. The Geomembrane Installer shall not be informed in advance of the sample location. In order to obtain test results prior to completion of geomembrane installation, samples shall be cut by the Geomembrane Installer as directed by the Owner's Representative as seaming progresses.

- All field samples shall be marked with their sample number and seam number. The sample number, date, time, location, and seam number shall be recorded. The Geomembrane Installer shall repair all holes in the geomembrane resulting from obtaining the seam samples. All patches shall be vacuum box tested or spark tested. If a patch cannot be permanently installed over the test location on the same day of sample collection, a temporary patch shall be tack-welded or hot air welded over the opening until a permanent patch can be affixed.
- The destructive sample size shall be 300 mm wide by 1 m long with the seam centered lengthwise. The sample shall be cut into three equal sections and distributed as follows: one section given to the Owner's Representative as an archive sample; one section given to the Owner's Representative for laboratory testing as specified in Paragraph 5 below; and one section retained by the Geomembrane Installer for field testing as specified in Paragraph 6 below.
- For field testing, the Geomembrane Installer shall cut 10 identical 25 mm wide replicate specimens from the sample. The Geomembrane Installer shall test five specimens for seam shear strength and five for peel strength as per ASTM 6392. Peel tests will be performed on both inside and outside weld tracks. To be acceptable, four of five test specimens must pass the stated criteria in Part 2 with less than 25% separation. If four of five specimens pass, the sample qualifies for testing by the testing laboratory if required.
- If independent seam testing is required by the specifications, it shall be conducted in accordance with ASTM 5820 or ASTM D4437 or GRI GM 6.
- Reports of the results of examinations and testing shall be prepared and submitted to the Owner's Representative.
- For field seams, if a laboratory test fails, that shall be considered as an indicator of the possible inadequacy of the entire seamed length corresponding to the test sample. Additional destructive test portions shall then be taken by the Geomembrane Installer at locations indicated by the Owner’s Representative; typically, 3 m on either side of the failed sample and laboratory seem tests shall be performed. Passing tests shall be an indicator of adequate seams. Failing tests shall be an indicator of non-adequate seams, and all seams represented by the destructive test location shall be repaired with a cap-strip extrusion welded to all sides of the capped area. All cap-strip seams shall be non-destructively vacuum box tested until adequacy of the seams is achieved. Cap strip seams exceeding 50 m in length shall be destructively tested.

- Destructive test results shall be reported prior to covering of liner or within 48 hours.

5.2.2.3.2.2 Identification of Defects and Evaluation of Defects

- Panels and seams shall be inspected by the Installer and Owner's Representative during and after panel deployment to identify all defects, including holes, blisters, undispersed raw materials, and signs of contamination by foreign matter.
- Each suspect location on the liner (both in geomembrane seam and non-seam areas) shall be non-destructively tested using one of the methods described previously. Each location which fails non-destructive testing shall be marked, numbered, measured and posted on the daily "installation" drawings and subsequently repaired.
  - If a destructive sample fails the field or laboratory test, the Geomembrane Installer shall repair the seam between the two nearest passed locations on both sides of the failed destructive sample location.
  - Defective seams, tears, or holes shall be repaired by re-seaming or applying an extrusion welded cap strip.
  - Re-seaming may consist of either:
    - Removing the defective weld area and rewelding the parent material using the original welding equipment; or
    - Re-seaming by extrusion welding along the overlap at the outside seam edge left by the fusion welding process.
  - Blisters, larger holes, and contamination by foreign matter shall be repaired by patches and/or extrusion weld beads as required. Each patch shall extend a minimum of 150 mm beyond all edges of the defects.
  - All repairs shall be measured, located and recorded.

5.2.2.3.2.3 Verification of Repairs on Seams

- Each repair shall be non-destructively tested using either vacuum box or spark testing methods. Tests which pass the non-destructive test shall be taken as an indication of a successful repair. Failed tests shall be re-seamed and retested until a passing test results. The number, date, location, technician, and test outcome of each patch shall be recorded.

5.2.2.3.2.4 Field Installation Reports

At the beginning of each day's work, the Installer shall provide the Owner's Representative with daily reports for all work accomplished on the previous work day. Reports shall include the following:

- Total amount and location of geomembrane placed
- Total length and location of seams completed, name of technicians doing seaming and welding unit numbers;
- Drawings of the previous day's installed geomembrane showing panel numbers, seam numbers, and locations of non-destructive and destructive testing;
- Results of pre-qualification test seams;
- Results of non-destructive testing; and
- Results of vacuum testing of repairs.
- Hourly temperatures during seaming which includes the actual temperature of the surface of the geomembrane (using a pyrometer) and the ambient air temperature measured approximately 1 m above the geomembrane.
- The method of removing frost from the area to be seamed (if any is present), as well as drying and cleaning of the surfaces involved should be described.
- The condition of the subgrade beneath the area being seamed should be assessed. If a rub sheet is used during the seam process, it should be noted.
- Complete identification of the field seaming system used, including material, methods, preheat, seaming rate, use of tents or enclosures and other details of the procedure should be documented.
- The type, nature, number, condition, and details of trial seams, as well as the results of such tests, should be detailed.
- The type, nature, number, and details of destructive samples and disposition of sections of the sample should be described. Proper identification is required to identify results of CQA laboratory testing in the final as-built plans of the project.
- Any unusual condition with respect to personnel, equipment, sampling, and/or testing that may be attributable to the cold weather should be described and documented.

5.2.2.3.2.5 Additional Documentation

- A panel is defined as the unit area of a geomembrane which is to be seamed in the field. If the liner is not fabricated into panels prior to delivery, then a panel is considered to be a roll or a portion of a roll of material.
- Each panel shall be given a Panel Identification Code consistent with the layout plan. The Panel I.D. Code will be used for all Quality Assurance records.
- Each Field-seam shall be identified and sequentially numbered on the as-built drawing. Include the date of seaming, identifying number of welding machine, and operator name. Identify on the drawing where the machine or operator was changed.
- If a fabricated panel is being used, the Contractor shall also indicate the locations of all factory seams on this drawing and shall differentiate between field seams and factory seams.

5.2.2.4 Liner Acceptance

The geomembrane liner will be accepted by the Owner's Representative when:

- The entire installation is finished or an agreed upon subsection of the installation is finished;
- All installer's QC documentation is completed and submitted to the owner.
- Verification of the adequacy of all field seams and repairs and associated geomembrane testing is complete.

5.3 Geotextile Testing

5.3.1 Geotextile Testing References

Where material properties are specified, the following standards are applicable:

American Society of Testing and Materials (ASTM)

1. ASTM D 4354 Practice for Sampling of Geosynthetics for Testing
2. ASTM D 4355 Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus);
3. ASTM D ASTM D 4533 Test Method for Trapezoidal Tearing Strength of Geotextiles.
4. ASTM D 4632 Test Method for Grab Breaking Load and Elongation of Geotextiles.
5. ASTM D 4759 Practice for Determining the Specification Conformance of Geosynthetics.

6. ASTM D 4833 Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products.
7. ASTM D 4873 Guide for Identification, Storage and Handling of Geotextiles.
8. ASTM D 5261 Test Method for Measuring Mass per Unit Area of Geotextiles.
9. ASTM D 5494 Test Method for the Determination of Pyramid Puncture Resistance of Unprotected and Protected Geomembranes.
10. ASTM D 6241 Test Method for Static Puncture Strength of Geotextiles and Geotextile Related Product Using a 50-mm Probe.

Geosynthetic Research Institute (GRI)

1. GRI GT12. Test Methods and Properties for Nonwoven Geotextiles Used as Protection (or Cushioning) Materials.

5.3.2 Quality Assurance

Deliver, store and handle geotextile with ASTM D4873.

- Delivery: 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. The plastic wrapping shall not be removed until deployment. Geotextile or plastic wrapping damaged during storage or handling shall be repaired or replaced as directed. Label each roll with the manufacturer's name, geotextile type, roll number, roll dimensions (length, width, gross weight), and date manufactured.
- 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. To protect geotextile from becoming saturated, either elevate rolls off the ground or place them on a sacrificial sheet of plastic in an area where water will not accumulate.
- Handling: Handle and unload geotextile rolls with load carrying straps, a fork lift with a stinger bar, or an axial bar assembly. Rolls shall not be dragged along the ground, lifted by one end, or dropped to the ground.

6.0 CONCLUSIONS

Based on the preliminary design provided by the Client, geotechnical and civil requirements were incorporated, and the pond capacity was designed to meet Site specific requirements. The proposed design basis is considered suitable for preliminary design and is intended to inform the design drawings provided in Appendix A.

7.0 RECOMMENDATIONS AND LIMITATIONS

Limited subsurface soil data is available for the planned ponds. There is potential that ice lenses occur within the upper soil horizon with the potential of seasonal weaking of subgrade support. It is therefore recommended that test pits be completed prior to construction of the ponds to verify the subsurface soil composition and presence/absence of ice within the upper subsurface soils. Deeper test pits outside of the proposed pond system footprint should be completed for this purpose.

Monitoring is recommended to identify potential permafrost-related performance issues that could affect pond integrity. Suggested monitoring includes:

1. Ground temperature monitoring using thermistors; and
2. Groundwater level monitoring and groundwater sampling using monitoring wells installed around the ponds.

APPENDIX A
DESIGN DRAWINGS (IFP)

PINCHIN

MARY RIVER MINE
LINED PONDS DETAILED DESIGN
BAFFIN ISLAND, NUNAVUT

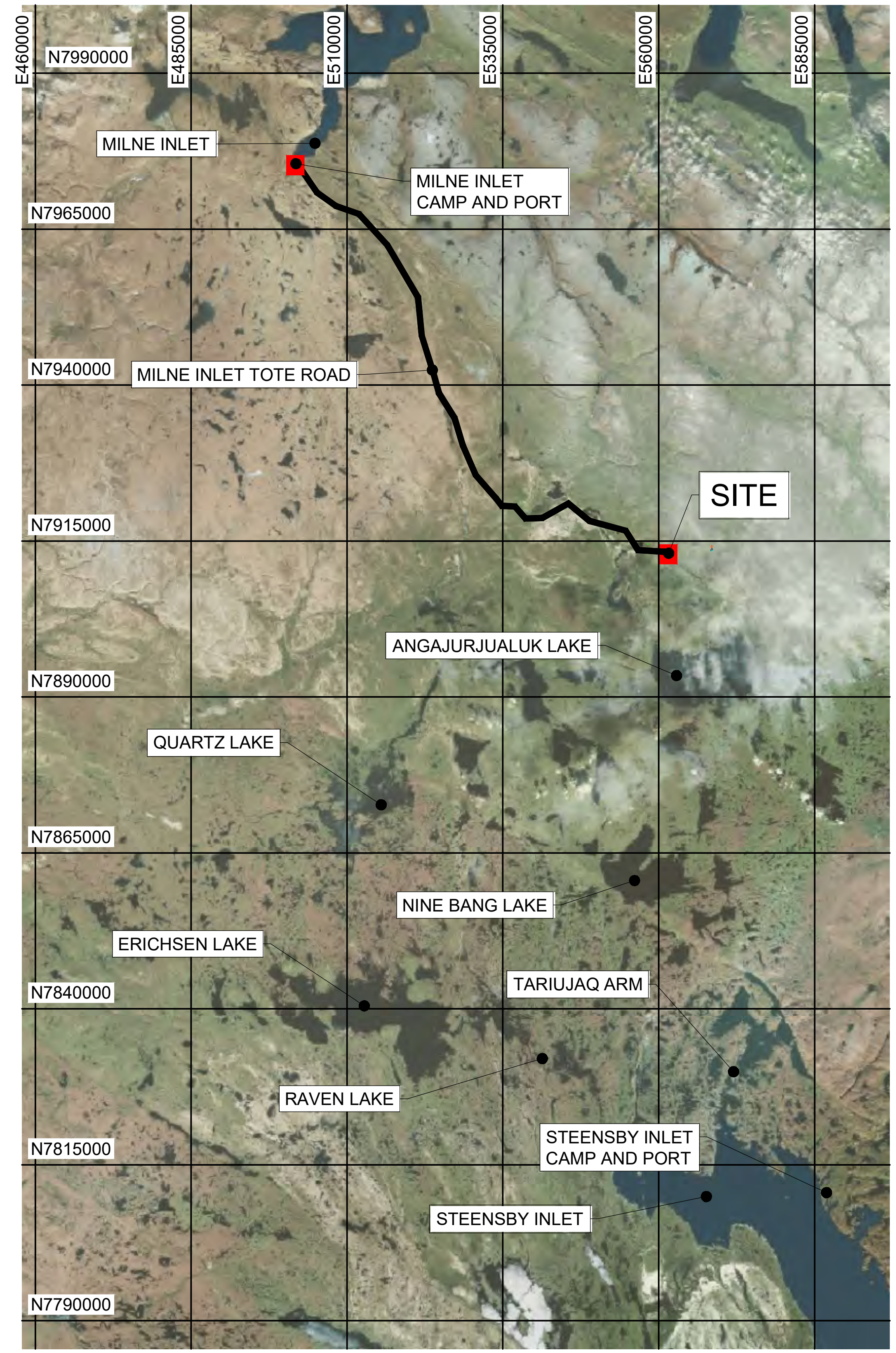
Prepared for:

Baffinland

Pinchin File: 369884.000

LIST OF DRAWINGS:

KEY MAP:



N

25 0 25 50 75
KILOMETRES

PRELIMINARY DRAWING:
NOT FOR CONSTRUCTION

REGISTERED PROFESSIONAL ENGINEER B. O'CONNOR LICENSEE NWT/NU

PERMIT TO PRACTICE PINCHIN LTD.
Signature
Date June 25, 2026
PERMIT NUMBER: P 860
NT/NU Association of Professional Engineers and Geoscientists

REV.	DESCRIPTION	DATE YY.MM.DD	DRWN. BY	CHKD. BY
A	ISSUED FOR PERMIT	26.06.25	A.S	K.C

DRAWN BY:	N. EESWARAPATHAM		
CHECKED BY:	K. COFFEY/B. O'CONNOR	SCALE:	AS SHOWN
DRAWING:	01	DATE:	2026.06.25

GENERAL NOTES

1. ALL DESIGN MEASUREMENTS ARE IN METRES UNLESS NOTED OTHERWISE.
2. COORDINATE SYSTEMS REFERENCES IN THE UTM NAD83 ZONE 17N DATUM
3. THE SPECIFICATIONS PRESENTED IN THE DRAWINGS ARE SUBJECT TO CHANGE AT THE DISCRETION OF THE PINCHIN ENGINEER OR DESIGNATE BASED ON ACTUAL PERFORMANCE AND CONDITIONS ENCOUNTERED IN THE FIELD.
4. THE CONTRACTOR SHALL VERIFY EXISTING GROUND LEVEL, DIMENSIONS, ELEVATIONS, AND COORDINATES IN THE FIELD PRIOR TO INITIATION OF CONSTRUCTION WORKS AND REPORT ANY DISCREPANCIES TO THE BIM CONSTRUCTION MANAGER.
5. THE CONTRACTOR IS RESPONSIBLE FOR ALL FIELD SURVEYING NECESSARY TO LAY OUT THE DESIGN ACCORDING TO THE DRAWINGS.
6. THE CONTRACTORS SHALL EXECUTE THE WORK IN A SAFE MANNER THAT MEETS BIM STANDARDS AND OH&S REQUIREMENTS.
7. THE DRAWING PACKAGE SHALL BE INTREPRETED IN CONJUNCTION WITH THE LATEST VERSION OF THE MARY RIVER PROJECT DESIGN BASIS MEMO, TECHNICAL SPECIFICATIONS DOCUMENTS, AND QUALITY MANAGEMENT PLAN.
8. THE BASE TOPOGRAPHY USED IN THIS DESIGN IS BASED ON TOPOGRAPHY PROVIDED BY BIM. LARGE DEVIATIONS SHOULD BE REPORTED TO THE BIM CONSTRUCTION MANAGER IMMEDIATELY FOR REVIEW AND COMPARISON.
9. LOCATION OF ALL EXISTING INFRASTURCUTRE AND DETAILS ARE APPROXIAMTE AND SHALL BE CHECKED AND VERIFIED BY CONTRACTOR PRIOR TO PROCEEDING WITH WORK.
10. INSTRUCTIONS FOR THE MANUFACTURERS OF EQUIPMENT, COMPONENTS, AND MATERIALS ARE TO BE FOLLOWED DURING INSTALLATION.
11. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE LOCATION AND PROTECTION OF ALL UTILITIES AND SERVICES. LOCATION OF UTILITIES SHALL BE DETERMINED BY FIELD REVIEWS, COMMUNICATIONS WITH THE CLIENT, AND COORDINATION WITH LOCAL AUTHORITIES.
12. ALL ITEMS ENCOUNTERED BELOW GRADE THAT ARE NOT SHOWN SHALL BE REPORTED TO BIM PROJECT MANAGER IMMEDIATELY.
13. MATERIALS AND INSTALLATION SHALL MEET APPLICABLE PROVINCIAL BUILDING, FIRE AND ELECTRICAL CODES, AND MUNICIPAL CODES.

BASE PREPARATION

1. CONSTRUCTION OF THE PONDS ARE TO OCCUR ON NATIVE GROUND. ENSURE THAT AREA IS LEVELED TO GRADE AT 174.00M.

CONSTRUCTION OF BERMS

1. CONSTRUCT BERM WITH TYPE 2 AGGREGATE WITH 2:1 EXTERIOR SLOPES ON NORTH, SOUTH, AND WEST ENDS OF THE POND BERMS, AND 5:1 EXTERIOR SLOPES ON EAST END OF THE POND BERMS. WITH 2:1 INTERIOR SLOPES ON NORTH, SOUTH, AND WEST ENDS OF THE POND, AND 5:1 INTERIOR SLOPE ON EAST END OF POND BERM.
2. BUILD BERMS TO MAX WATER HEIGHT (176.7M ABOVE GRADE).
3. BUILD MIDDLE BERM TO MAX WATER HEIGHT (176.7M ABOVE GRADE).
4. BUILD BERMS UP TO 2.85M ABOVE GRADE (150 MM ABOVE MAX WATER HEIGHT).
5. SEE LINER ANCHORING INSTRUCTIONS;
6. PLACE AND COMPACT 150 MM CAP OF SAND ON TOP OF THE BERMS.
7. PLACE GEOTEXTILES ON ALL INTERIOR SLOPES.
8. PLACE AND COMPACT 150 MM SAND LAYER ON TOP OF TYPE 2 AGGREGATE ON INTERIOR SLOPES LAYER TO ACT AS BUFFER BETWEEN TYPE 2 AGGREGATE AND LINER.

LINER PLACEMENT (POND BOTTOM)

1. INSTALL NON-WOVEN GEOTEXTILE BETWEEN NATIVE SOIL AND SAND (INSTALL AND TEST ACCORDING TO INSTALLATION INSTRUCTIONS FROM GEOTEXTILE MANUFACTURER)
2. PLACE 150 MM OF SAND ON POND BOTTOM AREA.
3. INSTALL NON-WOVEN GEOTEXTILE BETWEEN SAND AND LINER PLACEMENT (INSTALL AND TEST ACCORDING TO INSTALLATION INSTRUCTIONS FROM GEOTEXTILE MANUFACTURER)
4. PLACE LINER (INSTALL AND TEST ACCORDING TO INSTALLATION INSTRUCTIONS FROM LINER MANUFACTURER).
5. INSTALL NON-WOVEN GEOTEXTILE BETWEEN LINER AND TOP SAND LAYER (INSTALL AND TEST ACCORDING TO INSTALLATION INSTRUCTIONS FROM GEOTEXTILE MANUFACTURER)
6. PLACE 250 MM OF SAND ON TOP OF LINER;
7. INSTALL NON-WOVEN GEOTEXTILE BETWEEN SAND AND RIP-RAP MATERIAL;
8. PLACE 200 MM OF RIP RAP ON TOP OF NON-WOVEN GEOTEXTILE.
9. USE BOB-CAT (SKID-STEER VEHICLES) FOR INSTALLATION, IF LARGER VEHICLES ARE UTILIZED INSIDE OF THE POND IT COULD RISK TEARING LINER.

LINER PLACEMENT (SLOPED SIDES)

1. INSTALL NON-WOVEN GEOTEXTILE BETWEEN TYPE 2 AGGREGATE AND SAND (INSTALL AND TEST ACCORDING TO INSTALLATION INSTRUCTIONS FROM GEOTEXTILE MANUFACTURER)
2. PLACE 150 MM OF SAND ON POND BOTTOM AREA.
3. INSTALL NON-WOVEN GEOTEXTILE BETWEEN SAND AND LINER PLACEMENT (INSTALL AND TEST ACCORDING TO INSTALLATION INSTRUCTIONS FROM GEOTEXTILE MANUFACTURER)
4. PLACE LINER (INSTALL AND TEST ACCORDING TO INSTALLATION INSTRUCTIONS FROM LINER MANUFACTURER) (SEE ANCHORING INSTRUCTIONS SEPARATELY).
5. INSTALL NON-WOVEN GEOTEXTILE BETWEEN LINER AND TOP SAND LAYER (INSTALL AND TEST ACCORDING TO INSTALLATION INSTRUCTIONS FROM GEOTEXTILE MANUFACTURER)
6. PLACE 300 MM OF SAND ON TOP OF LINER (PLACE SAND BY BOBCAT);

LINER ANCHORING (SLOPED SIDES)

1. WHEN INSTALLING LINER ON SIDE SLOPES, LINERS REQUIRE SUFFICIENT ANCHORAGE AT THE TOPS OF THE BERMS. WHEN THE BERMS HAVE BEEN BUILT UP TO 2.85 M ABOVE GRADE PLACE LINERS ACCORDING TO SLOPED SIDE INSTRUCTIONS.
2. ENSURE THAT 150 MM LAYER OF SAND MAINAINED UNDERNEATH LINER TO AVOID DAMAGE. PLEASE REFER TO ANCHOR CALCULATIONS IN DESIGN BASIS MEMO FOR REFERENCE.
3. AT THE TOP OF THE BERM, BRING THE LINER AND GEOTEXTILES 300 MM ACROSS THE BERM AND DIG A 300 MM BY 300 MM TRENCH (IF REQUIRED UTILIZE A 2:1 SLOPE TO FORM TRAPEZOID TRENCH).
4. INSTALL THE LINER IN THE TRENCH, COVERING THE SIDE CLOSEST TO THE INTERIOR SLOPE OF THE POND AND THE BOTTOM, AND FILL WITH SAND.

MAINTENANCE ROAD

1. PLACE 250 MM OF SAND ON TOP OF LINER ON INTERIOR SLOPE WHERE MAINTENANCE ACCESS ROADS ARE TO BE INSTALLED.
2. PLACE NON-WOVEN GEOTEXTILE;
3. PLACE 200 MM OF RIP RAP ON 5 M MAINTENANCE ROAD ACCESS (REFER TO SITE LAYOUT DRAWINGS);
4. PLACE 150 MM SAND LAYER ON INDICATED AREAS OF EXTERIOR 5:1 SLOPE;
5. PLACE LINER ON INDICATED EXTERIOR 5:1 SLOPE AREAS (INSTALL AND TEST ACCORDING TO INSTALLATION INSTRUCTIONS FROM LINER MANUFACTURER).
6. PLACE 250 MM SAND LAYER ABOVE LINER;
7. PLACE NON-WOVEN GEOTEXTILE;
8. PLACE 200 MM OF RIP RAP ON 5 M MAINTENANCE ROAD ACCESS (REFER TO SITE LAYOUT DRAWINGS);

MATERIAL DESCRIPTION	CONSTRUCTION MATERIAL	TYPICAL PLACEMENT AND COMPACTION REQUIREMENTS
TYPE 2 AGGREGATE	ANGULAR ROCK FRAGMENTS OR SAND AND GRAVEL GRADED AT 100 CM-MINUS WITH LESS THAN 5% FINES PASSING 0.075 MM. MATERIAL TO BE DURABLE. MATERIAL TO BE FREE OF ICE, FROZEN MATERIALS, ORGANICS, AND DELETERIOUS MATERIALS.	INSTALL IN MAXIMUM 300 MM THICK LAYERS, COMPACTED TO 100% SPMDD USING A SMOOTH-STEEL DRUM NON-VIBRATORY ROLLER
SAND FILL	SAND OR SAND WITH SOME FINE GRAVEL, WITH LESS THAN 8% FINES PASSING 0.075 MM. FINES SHOULD NOT BE PLASTIC. PARTICLES TO BE SUBANGULAR OR SUBROUNDED. MATERIAL TO BE FREE OF ICE, FROZEN MATERIALS, ORGANICS, AND DELETERIOUS MATERIALS. WET MATERIALS NOT PERMITTED. REQUIREMENTS OF SAND FILL FOR LINER PROTECTION SHOULD BE CONFIRMED WITH LINER SUPPLIER.	INSTALL IN MAXIMUM 300 MM THICK LAYERS, COMPACTED TO 100% SPMDD USING A SMOOTH-STEEL DRUM NON-VIBRATORY ROLLER

1. NON-WOVEN GEOTEXTILE - SKRAPS GT160 OR EQUIVALENT;
2. LINER - LAYFIELD, ENVIRO LINER 6060 SMOOTH, TO BE PROVIDED BY BIM;

REGISTERED PROFESSIONAL ENGINEER B. O'CONNOR LICENSEE NWT/NU

PERMIT TO PRACTICE PINCHIN LTD. Signature Date PERMIT NUMBER: P 860 NT/NU Association of Professional Engineers and Geoscientists

GENERAL NOTES:

1. ALL DIMENSIONS ARE METRIC AND SHOWN IN METRES (UNLESS NOTED OTHERWISE).
2. ELEVATIONS ARE IN METRES, RELATIVE TO GEODETIC DATUM. CONTOURS ARE AT 5 METRE MAJOR INTERVALS AND 1 METRE MINOR INTERVALS.
3. THIS DRAWING MAY HAVE BEEN REDUCED. ALL SCALE NOTATIONS INDICATED ARE BASED ON THE IMPERIAL PAPERSIZE 11"x17".

PRELIMINARY DRAWING: NOT FOR CONSTRUCTION

REV.	DESC.	YY.MM.DD	BY
A	ISSUED FOR PERMIT	26.06.25	AS

PINCHIN

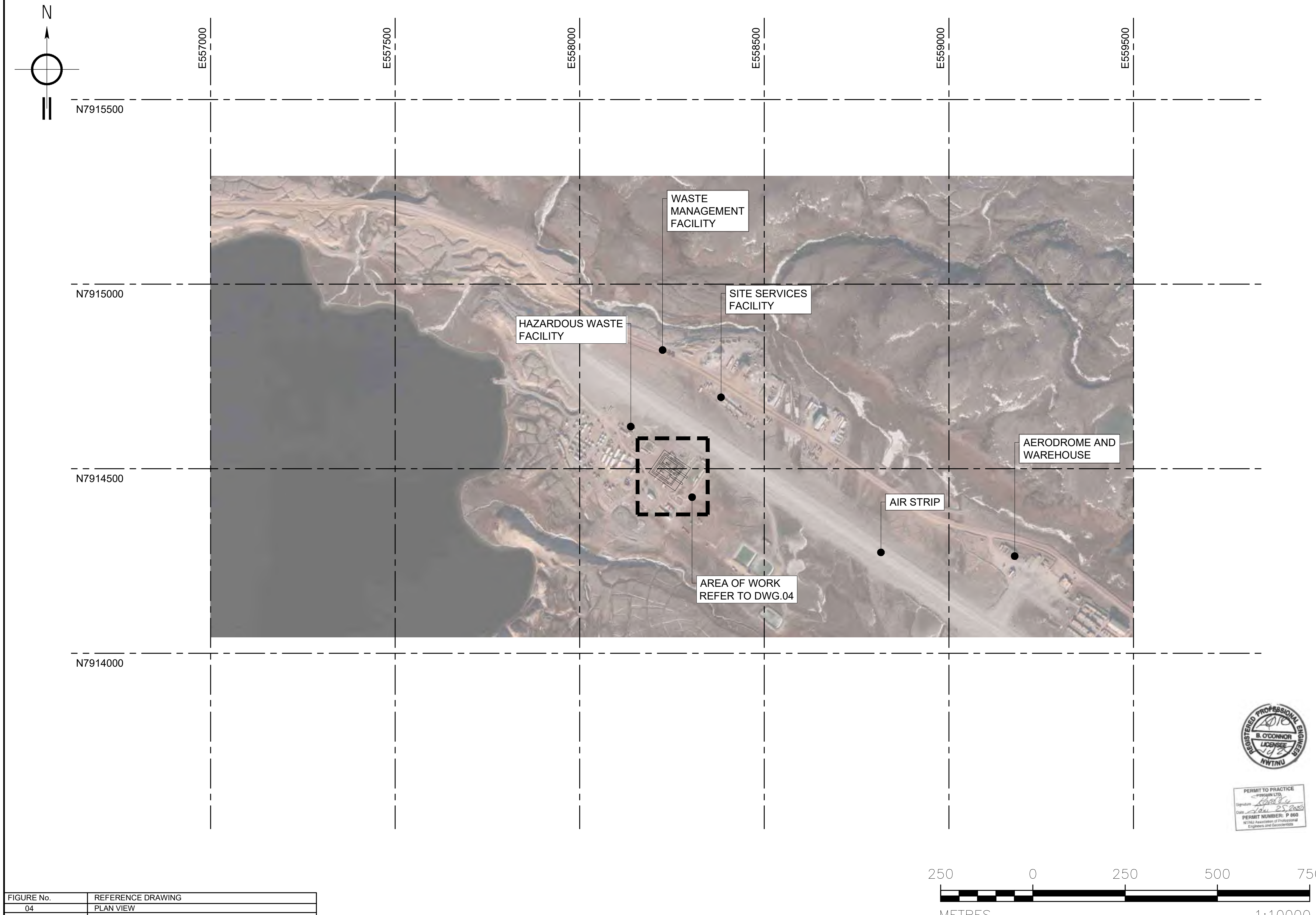
PROJECT NAME: LINED PONDS DETAILED DESIGN

CLIENT NAME: Baffinland

PROJECT LOCATION: MARY RIVER MINE BAFFIN ISLAND, NUNAVUT

FIGURE NAME: SPECIFICATIONS AND NOTES

PROJECT NUMBER: 369884.000	SCALE: N/A	
DRAWN BY: N.E	REVIEWED BY: K.C	
DATE: 26.06.25	FIGURE NUMBER: 02	REV. A



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REV.	DESC.	YY.MM.DD	BY

PINCHIN

PROJECT NAME: LINED PONDS DETAILED DESIGN

CLIENT NAME: Baffinland

PROJECT LOCATION: MARY RIVER MINE BAFFIN ISLAND, NUNAVUT

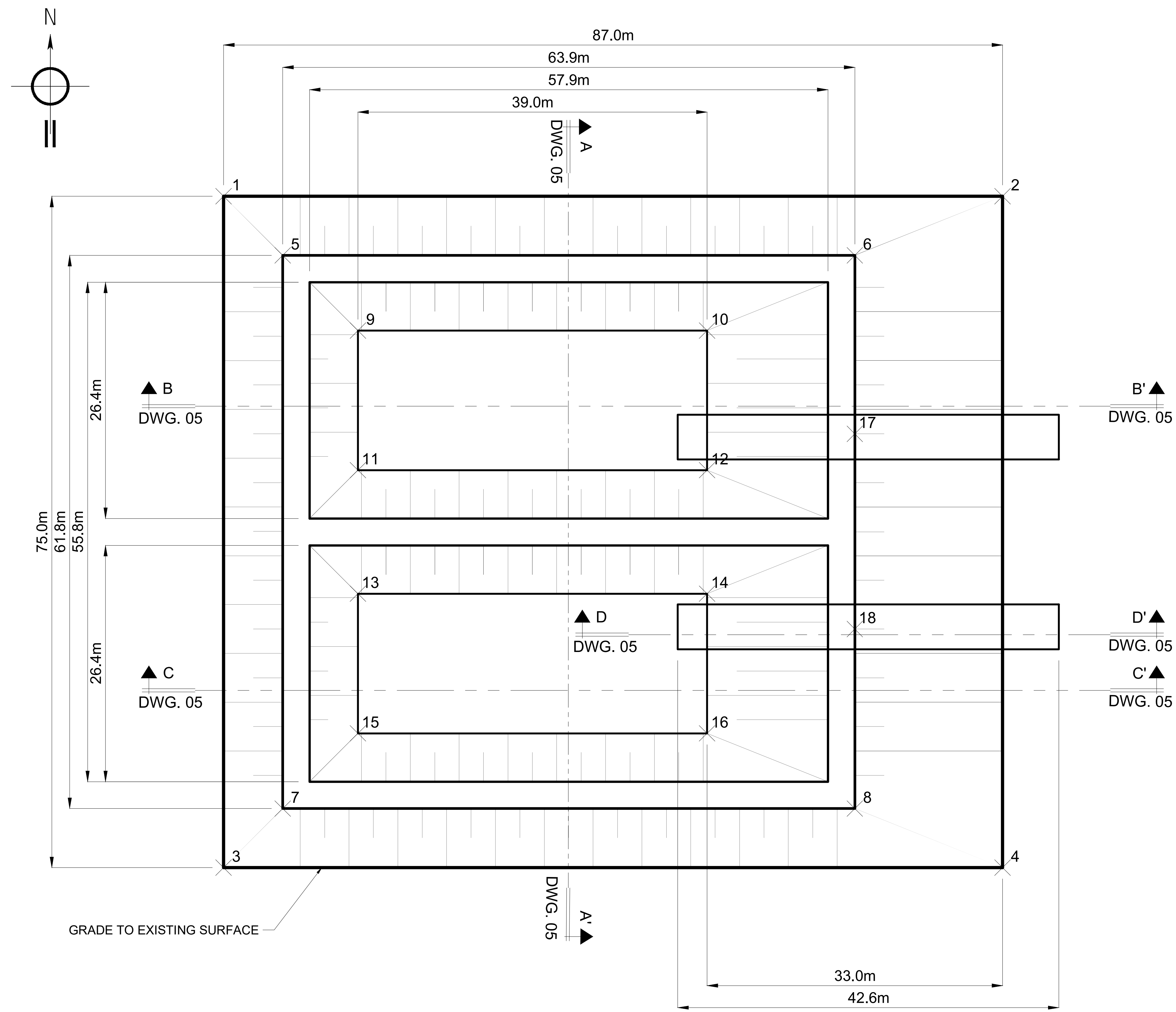
FIGURE NAME: SITE PLAN

PROJECT NUMBER: 369884.000	SCALE: 1:10,000
DRAWN BY: N.E	REVIEWED BY: K.C
DATE: 26.06.25	FIGURE NUMBER: 03 REV.: A

REGISTERED PROFESSIONAL ENGINEER B. O'CONNOR LICENSEE NWT/NU

PERMIT TO PRACTICE PINCHIN LTD. PERMIT NUMBER: P 860 NT/NU Association of Professional Engineers and Geoscientists

FIGURE No.	REFERENCE DRAWING
04	PLAN VIEW



VOLUME ESTIMATE:

POND VOLUME (PER POND):	2330.8	CU.M.
POND VOLUME TOTAL:	4661.6	CU.M.

MATERIAL ESTIMATE:

TYPE 2 AGGREGATE:	7,800.0	CU.M.
FINE SAND:	2,170.0	CU.M.
RIP-RAP:	280.0	CU.M.

LINER/GEOTEXTILE ESTIMATE:

NON-WOVEN GEOTEXTILE:	12,780.0	SQ.M.
ENVIRO LINER 6060 SMOOTH:	5,330	SQ.M.

POINT	NORTHING	EASTING	ELEVATION
1	7,914,551.26	558,229.08	GRADE TO EXISTING SURFACE
2	7,914,501.77	558,300.63	
3	7,914,489.57	558,186.42	
4	7,914,440.09	558,257.98	
5	7,914,542.07	558,230.75	177.30
6	7,914,505.73	558,283.31	177.30
7	7,914,491.24	558,195.60	177.30
8	7,914,454.90	558,248.16	177.30
9	7,914,530.01	558,232.62	174.60
10	7,914,508.21	558,264.96	174.60
11	7,914,517.56	558,224.01	174.60
12	7,914,495.37	558,256.09	174.60
13	7,914,506.21	558,216.16	174.60
14	7,914,484.02	558,248.24	174.60
15	7,914,493.37	558,207.29	174.60
16	7,914,471.19	558,239.37	174.60
17	7,914,489.33	558,271.97	177.45
18	7,914,471.39	558,259.56	177.45

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PERMIT NUMBER: P 860
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PINCHIN

PROJECT NAME: LINED PONDS DETAILED DESIGN

CLIENT NAME: Baffinland

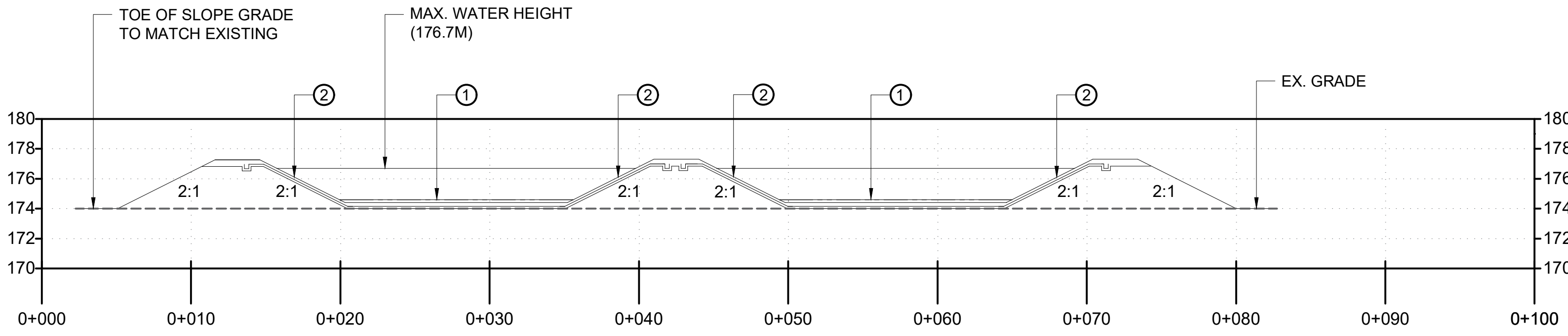
PROJECT LOCATION: MARY RIVER MINE BAFFIN ISLAND, NUNAVUT

FIGURE NAME: PLAN VIEW

PROJECT NUMBER: 369884.000	SCALE: 1:500
DRAWN BY: N.E	REVIEWED BY: K.C
DATE: 26.06.25	FIGURE NUMBER: 04 REV.: A

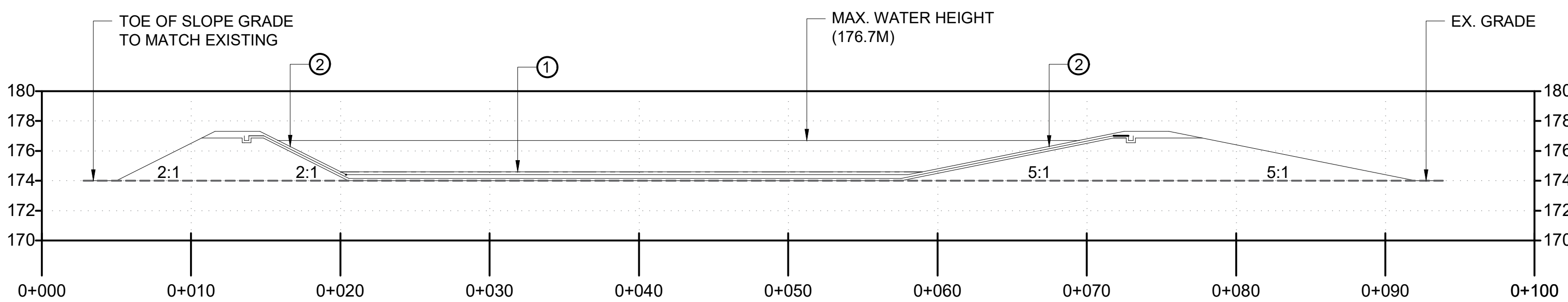
10 0 20 40
METRES 1:500

FIGURE No.	REFERENCE DRAWING
05	SECTIONS



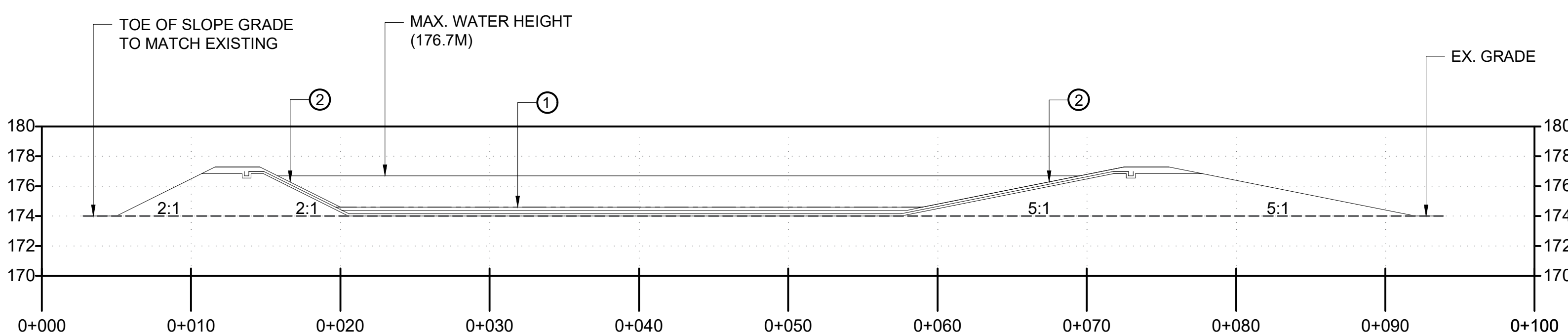
SECTION A-A'

SCALE 1:500



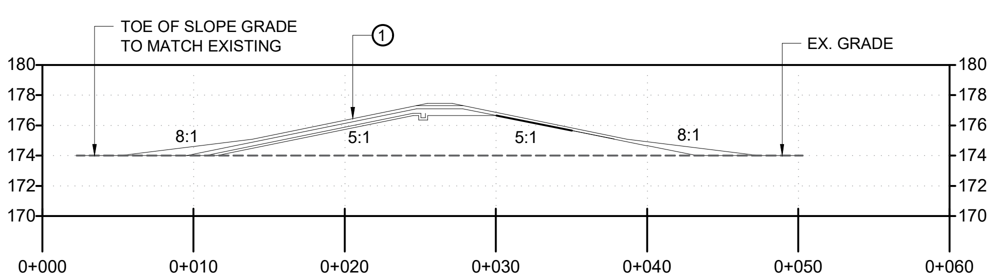
SECTION B-B'

SCALE 1:500



SECTION C-C'

SCALE 1:500

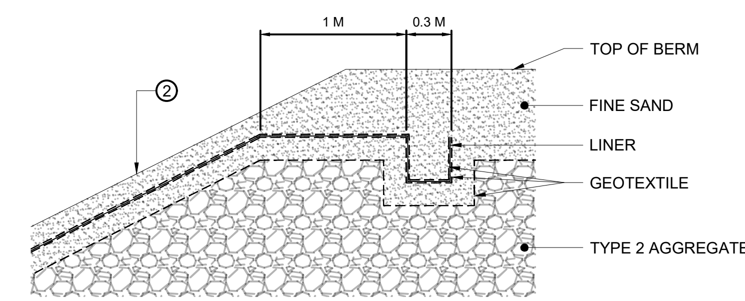


SECTION D-D'

SCALE 1:500

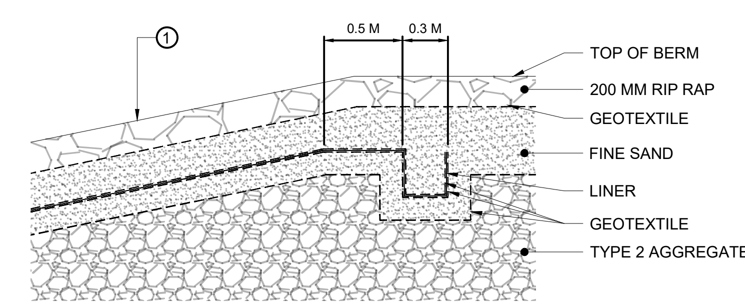
FIGURE No.	REFERENCE DRAWING
04	PLAN VIEW

① POND BOTTOM/ ACCESS ROAD	② TYPICAL INTERIOR SIDE SLOPE
200 MM RIP RAP	150 MM SAND
GEOTEXTILE	GEOTEXTILE
250 MM SAND	LINER
GEOTEXTILE	GEOTEXTILE
LINER	150 MM SAND
GEOTEXTILE	GEOTEXTILE
150 MM SAND	EX. GRADE
GEOTEXTILE	
EX. GRADE	



ANCHOR SYSTEM

SCALE 1:50



ROAD CROSS SECTION

SCALE 1:50

NOTE:
1. LINER OF INTERIOR POND STARTING AT 0.15M ABOVE GRADE (174.15M), TO ACCOUNT FOR FINE SAND LAYER BELOW LINER.
2. PONDS UTILIZE 0.6M FREEBOARD.

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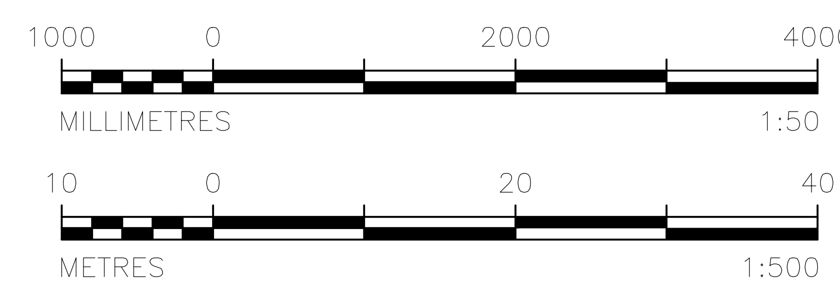

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REV.	DESC.	YY.MM.DD	BY
A	ISSUED FOR PERMIT	26.06.25	AS

PINCHIN

PROJECT NAME: LINED PONDS DETAILED DESIGN

CLIENT NAME: Baffinland

PROJECT LOCATION: MARY RIVER MINE BAFFIN ISLAND, NUNAVUT

FIGURE NAME: SECTIONS

PROJECT NUMBER: 369884.000	SCALE: AS SHOWN	
DRAWN BY: N.E	REVIEWED BY: K.C	
DATE: 26.06.25	FIGURE NUMBER: 05	REV. A

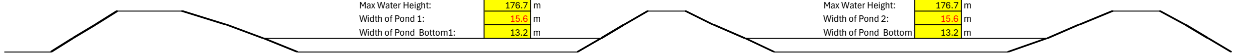
APPENDIX B
DESIGN CALCULATIONS

Project Name:	Baffinlands Pond
Project No.:	369884
Date:	06-22-2026

North - South Profile of Pond

26.4

6.6 5.4 16.5



Freeboard:	0.6	m
Max Water Height:	176.7	m
Width of Pond 1:	15.6	m
Width of Pond Bottom1:	13.2	m

Freeboard:	0.6	m
Max Water Height:	176.7	m
Width of Pond 2:	15.6	m
Width of Pond Bottom	13.2	m

Grade:
Is Pond below Grade

N	Y/N	
Grade:	174	m
Pond Bottom:	174	m

Exterior Slope:	2	X H: 1 V
Exterior Slope Bottom	174	m
Crest Top:	177.3	m
Width of Crest:	3	m
Does Slope Change:	N	Y/N
At What Height:	N/A	
Slope 1:		X H: 1 V
Slope 2:		X H: 1 V

Interior Slope:	2	X H: 1 V
Interior Slope Bottom	174.6	m
Does Slope Change:	N	Y/N
At What Height:	N/A	
Slope 1:		
Slope 2:		

Interior Slope Pond 1:	2	X H: 1 V
Interior Slope Bottom Pond 1	174.6	m
Crest Top:	177.3	m
Width of Crest:	3	m
Does Slope Change:	N	Y/N
At What Height:	N/A	
Slope 1:		X H: 1 V
Slope 2:		X H: 1 V
Interior Slope Pond 2:	2	X H: 1 V
Interior Slope Bottom Pond 2	174	m
Does Slope Change:	N	Y/N
At What Height:	N/A	
Slope 1:		X H: 1 V
Slope 2:		X H: 1 V

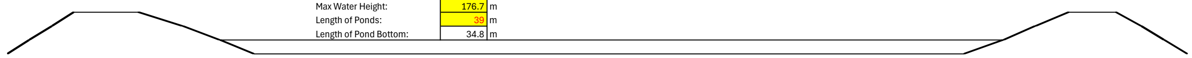
Interior Slope:	2	X H: 1 V
Interior Slope Bottom	174.6	m
Crest Top:	177.3	
Width of Crest:	3	m
Does Slope Change:	N	Y/N
At What Height:	N/A	
Slope 1:		X H: 1 V
Slope 2:		X H: 1 V

Exterior Slope:	2	X H: 1 V
Exterior Slope Bottom	174	m
Crest Top:	177.3	
Width of Crest:	3	m
Does Slope Change:	N	Y/N
At What Height:	N/A	
Slope 1:		X H: 1 V
Slope 2:		X H: 1 V

6.6

Estimated Total Length North to South End of Pond: 75.00 m

West - East Profile of Pond



Freeboard:	0.6	m
Max Water Height:	176.7	m
Length of Ponds:	39	m
Length of Pond Bottom:	34.8	m

Grade:
Is Pond below Grade

N	Y/N	
Grade:	174	m
Pond Bottom:	174	m

Exterior Slope:	2	X H: 1 V
Exterior Slope Bottom	174	m
Crest Top:	177.3	m
Width of Crest:	3	m
Does Slope Change:	N	Y/N
At What Height:	N/A	
Slope 1:		X H: 1 V
Slope 2:		X H: 1 V

Interior Slope:	2	X H: 1 V
Interior Slope Bottom	174.6	m
Does Slope Change:	N	Y/N
At What Height:	N/A	
Slope 1:		X H: 1 V
Slope 2:		X H: 1 V

Interior Slope:	5	X H: 1 V
Interior Slope Bottom	174.6	m
Crest Top:	177.3	
Width of Crest:	3	m
Does Slope Change:	Y	Y/N
At What Height:	175.5	
Slope 1:	8	X H: 1 V
Slope 2:	5	X H: 1 V
Width of Access Road	5	m
Change in Slope Applicable only to Access	Y	Y/N

Exterior Slope:	5	X H: 1 V
Exterior Slope Bottom	174	m
Crest Top:	177.3	
Width of Crest:	3	m
Does Slope Change:	Y	Y/N
At What Height:	175.5	
Slope 1:	8	X H: 1 V
Slope 2:	5	X H: 1 V
Width of Access Road	5	m
Change in Slope Applicable o	Y	Y/N

Volume of Road 16.2 m3

Estimated Total Length West to East End of Pond:	87.0	m
Confirmation Total Length Calc	87.0	m
Volume per Pond:	2330.8	m3
Empty Volume from Top of Berm to Max Water Height	844.18596	m3
Bottom Area	1288.8	m2
Top Area	1528.56	m2

calculated using the truncated pyramid calculation;
V = (1/3*H)*(A_bottom+A_top+SQRT(A_Bottom*A_Top)
A_Bottom = Pond Bottom Area = L(bottom) x W(bottom)
A_Top = Pond Top Area = L(top) x W(top)
Where top is max water level;

Material Estimate for Type 2 Aggregate	7792.5	m3
Material Estimate rounded to nearest 10 m3	7800.0	m3
Bottom Area	6525.0	m2
Top Area	4264.4	m2

calculated using the truncated pyramid calculation;
V = (1/3*H)*(A_bottom+A_top+SQRT(A_Bottom*A_Top)
A_Bottom = Pond Bottom Area = L(bottom) x W(bottom)
A_Top = Pond Top Area = L(top) x W(top)
Where top is max water level;

Material Estimate for Fine Sand	2168.5	m3
Material Estimate rounded to nearest 10 m3	2170.0	m3
Bottom Area (Berms)	4264.4	m2
Top Area (Berms)	3949.0	m2
Invert Bottom Area (Open Space, Pond)	1528.6	m2
Invert Top Area (Open Space, Pond)	1346.9	m2
Bottom of Ponds (Bottom Area)	459.4	m2
Bottom of Ponds (Top Area)	794.1	m2
Lateral Area of sand and liners	1864.5	m2
h (lateral)	2.3	m
l_bottom	39.0	m
l_top	54.8	m
w_bottom	15.6	m
w-top	24.6	m

calculated using the truncated pyramid calculation;
V = (1/3*H)*(A_bottom+A_top+SQRT(A_Bottom*A_Top)
A_Bottom = Pond Bottom Area = L(bottom) x W(bottom)
A_Top = Pond Top Area = L(top) x W(top)
Where top is max water level;

Lateral Area = (l_bottom+l_top)*hl + (w_bottom+w_top)*hw
Where hl = SQRT((h^2+(l_bottom-l_top)^2), and hw = SQRT(h^2+(w_bottom - w_top)^2

Material Estimate for Rip Rap	273.7	m3
Material Estimate rounded to nearest 10 m3	280.0	m3
Bottom Area (Bottom of Rip Rap)	597.9	m2
Top Area (Top of Rip Rap)	608.4	m2

calculated using the truncated pyramid calculation;
V = (1/3*H)*(A_bottom+A_top+SQRT(A_Bottom*A_Top)
A_Bottom = Pond Bottom Area = L(bottom) x W(bottom)
A_Top = Pond Top Area = L(top) x W(top)
Where top is max water level;

Material Estimated for Type 2 Aggregate	7800.0	m3
Material Sand	2170.0	m3
Material Rip Rap	550.0	m3
Material Non-Woven Geotextile (GT180 Skaps or equiv.)	12774.6	m2
Material Liner (Enviro Liner 6060 Smooth)	5330.0	m2

APPENDIX C

Liner Specification, Chemical Resistance, and Liner Installation Instructions

Geomembrane [Enviro Liner 6060 Smooth]

The Enviro Liner® 6000 formulation is a proprietary polyolefin flexible geomembrane liner material designed for outstanding durability, chemical resistance, and flexibility. North American made Enviro Liner® 6000 is available as a black/white coextruded structure and is an excellent material choice for secondary containment, brine containment ponds and other water waste water applications. Enviro Liner® 6000 is also potable water safe.

Property	ASTM	EL6060 Smooth
Thickness	D5199	60 mil 1.50 mm
Thickness, Lowest Individual for 8 out of 10 values	D5199	54 mil 1. 37 mm
Sheet Density	D792	≤0.939 g/cc
Melt Index (Resin)	D1238	0.35 g/10 min
Tensile Properties (min. avg) ASTM D 638; Modified Type IV Die Gage length @ break: 1.5”	Strength @ Break Elongation @ Break	255 ppi 44.5 kN/m 1000%
Modulus of Elasticity (2% Modulus), max	D5323 GRI GM17	3600 lb/inch
Trapezoidal Tear	D751	108 lbs 480 N
Puncture Resistance (min. avg)	D4833	90 lbs 400 N
Hydrostatic Burst Strength	D 751	1863 kPa 270 psi
Oxidative Induction Time	D3895	200 mins
High Pressure Oxidative Induction Time (HPOIT)	D5885	>2000 mins
Carbon Black[1]	D4218	2.0-3.0%
PERFORMANCE PROPERTIES (FOR REFERENCE PURPOSES)		
Multi-axial Elongation	D5617	80%
Stress Cracking, molded sample Appendix	D5397	1000 hrs
Oven aging, 85 deg C, HOPIT % retained after 90 days	D5721 D5885	60%
UV Resistance, HPOIT retained after 1600 hrs	D7238 D5885	35%
Long Term UV Resistance @ 30,000 hrs Tensile Strength Retained	D4329	90%
Brine Resistance @ 90 deg C HPOIT retained after 2400 hrs	D1693	1000 mins
Water Vapour Permeability[2]	F1249	$3x10^{-13}$ cm/sec
Methane Permeability[2]	D1434	2.11x10-4 m^3/m^2.day
Solvent Vapour Permeability[3]	D814	ASTM Fuel C: ≤ 10 grm/m2.hr ASTM IRM 902: ≤ 10 grm/m2.hr
Brittleness Temperature	D1790	-40°F -40°C
Low Temperature Impact Resistance	D746	-94°F -70°C
Potable Water Certification	NSF 61/AS/NZ 4020	Pass
Typical Roll Dimensions **(Rolls dimensions may vary ± 1%)**		
Roll Width	-	22.5 feet 6.86 mtrs
Roll Length	-	520 feet

158 mtrs

Updated specs are available on our website at www.layfieldgroup.com

Notes:

1 Per GRI, Other methods such as D 1603 (tube furnace) or D 6370 (TGA) are acceptable if an appropriate correlation to D 4218 (muffle furnace) can be established; black layers only.

2Tested on a 30 mil thickness

3Tested on a 40 mil thickness

Chemical Resistance Tables

July 2023	Chemical Resistance Ratings
Rev	
A	Fluid has little or no effect
B	Fluid has minor to moderate effect
C	Fluid has severe effect
X	No Data - Likely severe effect
T	No Data - Likely minor effect

July 2023	Geomembrane Material Codes
Rev	
HD	High Density Polyethylene (HDPE)
PV	Polyvinyl Chloride (PVC)
EL	Enviro Liner®
OR	Oil Resistant RPE® (OR RPE®)
PU	Polyurethane
EI	Ethylene Interpolymer Alloy (EIA) (HAZGARD 5000HT)

July 2023 — Geomembrane Materials Chemical Resistance Ratings

Material	%	HDPE	PVC	Enviro Liner	Oil Resistant RPE	Polyurethane	Ethylene Interpolymer Alloy (EIA) (HAZGARD 5000 HT)
Acetic Acid	5%	A	A	A	A	A	A
Acetic Acid	50%	A	X	A	B	X	C
Acetic Acid	Gla.	A	C	A	B	X	X
Acetic Anhydride		A	X	C	C	X	X
Acetone		A	C	B	A	C	X
Alkyl Alcohol			C	A		T	T
Alkyl Chloride			C			X	X
Aluminum Chloride		A	B	A	A	T	T
Aluminum Flouride		A	X	A	A	T	T
Aluminum Sulfate		A	A	A	A	T	T
Ammonium Carbonate		A	A	A	A	T	T
Ammonium Chloride		A	A	A	A	T	T
Ammonium Fluoride	20%	A	T	A	A	T	T
Ammonium Hydroxide	30%	A	25	A	A	T	A
Ammonium Nitrate		A	25	A	A	T	T
Ammonium Phosphate		A	T	A	A	T	T
Ammonium Sulphate		A	A	A	A	T	B
Ammonium Sulphide		A	22		A	T	T
Amyl Acetate		B	C	C	C	T	X
Amyl Alcohol		A	T	A	B	T	T
Amyl Chloride		B	T	A	C	T	X
Aniline		A	X	B	C	X	X
Animal Oil		T	B	A	A		A
Antimony Chloride		A	T		A	A	T
Aqua Regia		B	B	C	C	X	X
ASTM Fuel A		T	X		T	A	A
ASTM Fuel B		T	C		T	A	B

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Geomembrane Materials Chemical Resistance Ratings

Material	%	HDPE	PVC	Enviro Liner	Oil Resistant RPE	Polyurethane	Ethylene Interpolymer Alloy (EIA) (HAZGARD 5000 HT)
ASTM Fuel C		T	C		T	B	
ASTM Oil #1		T	T		T	T	T
ASTM Oil #2		T	X		T	T	A
ASTM Oil #3		T	X		T	T	T
Asphalt		A	C	A	A	T	T
Barium Carbonate		A	T	A	A	T	T
Barium Hydroxide		A	T	A	A	T	T
Barium Sulphate		A	T	A	A	T	T
Benzene	<1%	T	T	B	T	T	T
Benzene	25%	T	X	C	T	T	T
Benzene	100	B	X	C	C	T	C
Benzoic Acid		A	T	A	A	T	T
Borax Solutions		A	T	A	A	T	T
Boric Acid		A	T	A	A	T	T
Bromic Acid	10%	A	T		A	X	T
Bromine; Anhydrous		B	X	C	C	X	
Butyl Acetate		B	X	B	B	X	X
Butyl Phenol		A	X		A	X	X
Butyric Acid		A	T	C	C	X	X
Calcuim Bisulphate		A	T	A	A	T	T
Calcium Carbonate		A	A	A	A	T	T
Calcium Chloride		A	A	A	A	T	T
Calcium Hydroxide		A	T	A	A	T	T
Calcium Hypochlorite		A	A	A	A	T	A
Calcium Nitrate	50%	A	T	A	A	T	T
Calcium Sulphate		A	2%	A	A	A	T
Carbon Disulfide		B	X	C	C	X	X
Carbon Tetrachloride		C	C	C	C	C	X
Carbonic Acid		A	T	A	A	T	T
Castor Oil		A	X	A	B	T	T
Chlorine Gas		C	X	X	C	X	T
Chloracetic Acid		A	X	A	A	X	X
Chlorobenzene		B	C	C	C	X	X
Chloroform		C	C	C	C	X	X
Chlorosulfonic Acid		C	C	C	C	X	X
Chrome Alum		A	T		A	T	T
Chromic Acid	30%	A	T	A	B	X	B
Chromium Trioxide		A	T		A	X	
Citric Acid		A	A	A	B	T	T
Copper Chloride		A	T	A	A	T	T
Copper Nitrate		A	T	A	A	T	T
Copper Sulphate		A	T	A	A	T	T
Corn Oil		A	C	A	A	T	A
Cottonseed Oil		A	C	A	B	T	A
Crude Oil		T	C	B		T	T
Cyclohexane		C	X	C	C	T	
Cyclohexanol		A	X	C	A	T	
Cyclohexanol		A	X	C	A	T	
Cyclohexanone		C	C	C	C	X	X

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Geomembrane Materials Chemical Resistance Ratings

Material	%	HDPE	PVC	Enviro Liner	Oil Resistant RPE	Polyurethane	Ethylene Interpolymer Alloy (EIA) (HAZGARD 5000 HT)
Dextrin		A	T	A	A	T	T
Dibutyl Phthalate		B	X	B	B	X	C
Diesel Fuel		A	C	B	A	A	A
Diethyl Ether		B	X	C	B	X	X
Diethyl Keytone		B	X	B	B	X	X
Diethyl Sebacate			X			X	X
Dimethylamine		C	C	C	C	X	X
Dioctyl Phthalate		A	X		A	X	C
Disodium Phosphate		A	T		A	T	T
Epichlorohydrin		A	X		A		
Ethyl Acetate		B	C	B	B		C
Ethyl Alcohol		A	A	A	A		A
Ethyl Bromide		A	X		B		X
Ethyl Chloride		C	X	C	C		X
Ethylene Dichloride		B	X	C	B	X	X
Ethylene Glycol		A	A	A	A	T	A
Ethylene Oxide		A	X	B	A	X	X
Ferric Chloride		A	T	A	A	T	T
Ferric Nitrate		A	T	A	A	T	T
Ferrous Chloride		A	T	A	A	T	T
Ferrous Sulfate		A	T	A	A	T	T
Fluosilicic Acid		A	A	A	A	X	T
Formaldehyde	40%	A	C	A	A	B	
Formic Acid		A	C	A	A	X	
Furfural		B	X	C	B	X	X
Gallic Acid		A	T	A	B	X	
Gasoline	<25 BXT	B	C	B- C	B	A	A
Gasoline	>25 BXT	B	C		B	A	
Glucose		A	T	A	A	T	T
Glycerine		A	X	A	A	T	A
Hexane		B	C	B	B	A	T
Hydraulic Fluid		A	C	B	A	X	A
Hydrazine		A	X	C	A	X	X
Hydrobromic Acid		A	T	A	A	X	T
Hydrochloric Acid	20%	A	A	A	A	X	A
Hydrochloric Acid	37%	A	A	A	A	X	A
Hydrocyanic Acid		A	T	A	A	T	T
Hydrofluoric Acid	20%	A	T	A	A	X	T
Hydrofluoric Acid	75%	A	T	A	A	X	T
Hydrofluosilicic Acid	30%	A	A		A		T
Hydrogen Peroxide	3%	A	A	A	A	A	A
Hydrogen Peroxide	10%	A	A	A	A	T	T
Hydrogen Sulfide		A	A	A	A	T	T
Hydroquinone		A	T	A	A		
Iso Octane		A	X		A	A	T
Iso Octane		A	X		A	A	T
Isopropyl Alcohol	10%	A	T	A	A	A	A
JP-4 Jet Fuel		A	X		A	A	A

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Geomembrane Materials Chemical Resistance Ratings

Material	%	HDPE	PVC	Enviro Liner	Oil Resistant RPE	Polyurethane	Ethylene Interpolymer Alloy (EIA) (HAZGARD 5000 HT)
Jet A		A	X	B	A	T	T
Jet B		A	X		A	T	T
Kerosene		B	A	B	B	A	A
Lactic Acid		A	B	A	A	X	T
Lead Acetate		A	T	A	A	T	T
Linseed Oil		A	X	B	A	T	A
Lubricating Oil		A	C	B	A	T	T
Magnesium Carbonate		A	A	A	A	T	T
Magnesium Chloride		A	T	A	A	T	T
Magnesium Hyroxide		A	T	A	A	T	A
Magnesium Nitrate		A	T	A	A	T	T
Magnesium Sulphate		A	T	A	A	T	T
Malic Acid		A	T		A	T	T
Mercuric Chloride		A	T		A	T	T
Methyl Alcohol		A	T	A	T		A
Methyl Ethyl Keytone		C	C	C	C	C	C
Mineral Oil		A	B	B	B	A	T
Mineral Spirits		A	X	B	A	T	T
Naptha		B	B	B	B	X	T
Napthalene		A	C	C	B	X	X
Nitric Acid	10%	A	B	A	A	X	A
Nitric Acid	50%	A	B	A	A	X	C
Nitric Acid	70%	A	X	B	B	X	X
Nitro Benzene		C	C	C	C	X	X
Oleic Acid		B	T		B	T	T
Oleum	25%	C	X		C	X	
Oxalic Acid		A	A	A	A	T	
Palmatic Acid		A	T		A	T	T
Perchloroethylene	<1%	T	T	B	T	T	T
Perchloroethylene	100	C	X	C	C	C	C
Phenol		A	X	C	A	C	B
Phenol Formaldahyde			C			X	T
Phosphoric Acid	50%	A	A	A	A	C	B
Phosphoric Acid	75%	A	A	A	A	X	X
Phosphorous Yellow			X			X	T
Phosphorous Pentoxide		A	T		A	X	X
Photographic Solutions		A		A	A	T	T
Phthalate Plasticizer		A	X		A	C	C
Pickling Solutions		A		A	A	X	X
Potassium Bicarbonate		A	A	A	A	T	T
Potassium Carbonate		A	A	A	A	T	T
Potassium Chromate	40%	A	T	A	A	T	T
Potassium Cyanide		A	T	A	A	T	T
Potassium Dichromate		40	T	A	A	T	T
Potassium Hydroxide		A	25	A	A	T	T
Potassium Nitrate		A	A	A	A	T	T
Potassium Perchlorate	10%	A	T	A	A	T	T
Potassium Permaganate		20	T	A	A	T	T
Potassium Sulfate		A	T	A	A	A	T

July 2023

Geomembrane Materials Chemical Resistance Ratings

Material	%	HDPE	PVC	Enviro Liner	Oil Resistant RPE	Polyurethane	Ethylene Interpolymer Alloy (EIA) (HAZGARD 5000 HT)
Pyradine		A	X	A	A	X	X
Salt Water		A	A	A	A	A	A
Silicone Grease		A	T	A	A		T
Silver Nitrate		A	X	A	A	T	T
Skydrol Hydraulic Fluid			X	C		C	C
Soap Solutions		B	A	A	B	A	A
Sodium Acetate		A	T	A	A	A	T
Sodium Bicarbonate		A	A	A	A	A	T
Sodium Bisulphite		A	T	A	A	T	T
Sodium Borate		A	T	A	A	T	T
Sodium Carbonate		A	A	A	A	T	T
Sodium Chlorate		A	T	A	A	T	T
Sodium Chloride		A	A	A	A	A	T
Sodium Dichromate	20%	100	T	A	A	T	T
Sodium Ferrocyanide		A	T	A	A	T	T
Sodium Fluoride		A	T	A	A	T	T
Sodium Hydroxide	25%	A	A	A	A	T	A
Sodium Hydroxide	60%	A	X	A	A		A
Sodium Hypochlorite		A	12	A	A	A	A
Sodium Nitrate		A	T	A	A	T	T
Sodium Sulphate		A	A	A	A	T	T
Soybean Oil		A	X		A	T	A
Stannous Chloride		A	T	A	A	T	X
Stearic Acid		A	T	A	B	A	A
Styrene		C	X		C	X	X
Sulphuric Acid	10%	A	A	A	A	X	A
Sulphuric Acid	40%	A	B	A	A	X	
Sulphuric Acid	98%	B	C	B	B	X	C
Tannic Acid		10	T	A	A	X	T
Tataric Acid		A	T	A	A	T	T
Tetrahydrofuran		B	C	C	C	X	X
Toluene	<1%	T	T	B	T	T	T
Toluene	25%	T	X	C	T	T	T
Toluene	100	B	X	C	B	C	C
Transformer Oil		A	C	B	A	T	T
Triethanolamine		A	X		A	B	X
Trisodium Phosphate		A	T	A	A	T	T
Tung Oil			X				T
Turpentine		B	T	C	B	B	T
Urea		A	30	A	A	T	T
Vegetable Oil		A	C	B	A	A	A
Water		A	A	A	A	A	A
Xylene	<1%	T	T	B	T	T	T
Xylene	25%	T	X	C	T	T	T
Xylene	100	C	X	C	C	X	C
Zinc Chloride		A	A	A	A	T	T
Zinc Sulphate		A	T	A	A	T	T

LAYFIELD
GEOSYNTHETICS

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GEOMEMBRANE INSTALLATION
QUALITY ASSURANCE MANUAL

Revised 09.23.2020

CONTENT

1. OVERVIEW

1.1. This manual is a guide to the duties and responsibilities of the Layfield Project Manager, Layfield Project Supervisor, Layfield QA/QC Designate, and Layfield Technician on every project.

1.2. This document is not intended to be prescriptive for every possible application, project or material. Each practice, standard, and/or test method should be guided by (and applied with) good engineering principles and judgment, project specifications and the expertise of qualified Layfield personnel.

1.3. This document does not address any health, safety or environmental concerns related to practices, standards, test methods, regional regulations, or site-specific rules.

2. REFERENCES

ASTM D4437	Standard Practice for Determining the Integrity of Field Seams Used in Joining Flexible Polymeric Sheet Membranes
ASTM D4439	Terminology for Geosynthetics
ASTM D4873	Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples
ASTM D5641	Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber
ASTM D5820	Standard Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembranes
ASTM D6214	Standard Test Method for Determining the Integrity of Field Seams Used in Joining Geomembranes by Chemical Fusion Methods
ASTM D6365	Standard Practice for the Nondestructive Testing of Geomembrane Seams Using the Spark Test

ASTM D6392	Standard Test Method for Determining the Integrity of Non-reinforced Geomembrane Seams Produced Using Thermo-Fusion Methods
ASTM D6497	Standard Guide for Mechanical Attachment of Geomembrane to Penetrations or Structures
ASTM D7177	Standard Specification for Air Channel Evaluation of Polyvinyl Chloride Dual Track Seamed Geomembranes
ASTM D7272	Standard Test Method for Determining the Integrity of Seams Used in Joining Geomembranes by Pre-manufactured Taped Methods
ASTM D7408	Standard Specification for Non-Reinforced PVC (Polyvinyl Chloride) Geomembrane Seams
ASTM D7700	Standard Guide for Selecting Test Methods for Geomembrane Seams
ASTM D7747	Standard Test Method for Determining Integrity of Seams Produced Using Thermo-Fusion Methods for Reinforced Geomembranes by the Strip Tensile Method
ASTM D7865	Standard Guide for Identification, Packaging, Handling, Storage and Deployment of Fabricated Geomembrane Panels
GRI Standard GM 6	Pressurized Air Channel Test for Dual Seamed Geomembranes
GRI Standard GM13	Test Methods, Properties and Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes
GRI Standard GM14	Selecting Variable Intervals for Taking Geomembrane Destructive Seam Samples Using the Method of Attributes
GRI Standard GM17	Test Methods, Properties and Testing Frequency for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes
GRI Standard GM18	Test Methods, Properties and Testing Frequency for Flexible Polypropylene (fPP and fPP-R) Non-reinforced and Reinforced Geomembranes
GRI Standard GM19	Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes
GRI Standard GM 25	Test Methods, Test Properties and Testing Frequency for Reinforced Linear Low Density Polyethylene (LLDPE-R) Geomembranes
GRI Standard GM 29	Field Integrity Evaluation of Geomembrane Seams (and Sheet) Using Destructive and/or Nondestructive Testing

3. MATERIAL DELIVERY

3.1. Overview

3.1.1. Layfield is usually responsible for geosynthetic material transport to the work site. The Layfield Project Manager is responsible for ensuring that Layfield produced and procured materials are packaged and identified in a manner that complies with ASTM D4873 and/or ASTM D7865.

3.1.2. When Layfield is directly responsible for on-site geosynthetic material receiving, storage and handling, the Layfield Project Supervisor or QA/QC Designate will ensure that this is done in a manner that complies with ASTM D4873 and/or ASTM D7865. However, Layfield often does not have direct control of these activities on-site and the Project Supervisor or QA/QC Designate is only able to give guidance, which may or may not be followed.

3.2. Procedure

3.2.1. The Project Supervisor or QA/QC Designate shall perform an inventory of all materials on-site for use in the scope of work.

3.2.2. All geomembrane, geotextile, geonet, geocomposite, etc roll or panel numbers shall be entered in the Inventory Log (Appendix B) and will be cross-referenced with bills of lading.

3.2.3. The Inventory Log must be returned to the Layfield office along with the remainder of the project QA/QC documentation at the end of the project for inclusion in the final QA/QC turnover package.

3.2.4. All damages must be noted on the Geomembrane Inventory Log. If damages are substantial, notify the Project Manager immediately so that the appropriate claim process may be started and/or PIR process initiated.

4. SUBGRADE SURFACE INSPECTION

4.1. Overview

4.1.1. All projects must have all Certificate(s) of Subgrade Surface Inspection (Appendix A) signed by the Owner's Representative prior to the deployment of any covering material.

4.1.2. It is important to note that there are cases where a total work area cannot or will not be turned over to Layfield. The Certificate of Subgrade Surface Inspection does make provision for partial areas being turned over to Layfield. The Project Supervisor or QA/QC Designate shall ensure that the extents of the inspected area are clearly expressed on the Certificate of Subgrade Surface Inspection. A separate certificate shall be generated for each partial area.

4.1.3. The Certificate of Subgrade Surface Inspection is generated in duplicate with a white (original) and yellow (copy). The white copy is kept with Layfield's QA/QC documentation and is turned over to the Layfield Project Manager at the Project Closeout Meeting. The yellow copy is turned over to the countersigning party (Contractor's QA, Owner's Representative, etc) immediately upon signature for their records. Electronic copies may also be used in lieu of hard copy sheets.

4.2. Procedure

4.2.1. The General Contractor is responsible for preparing and maintaining the subgrade. The subgrade must be prepared and maintained per the individual project specifications.

4.2.2. The Project Supervisor or QA/QC Designate will be responsible for visually inspecting the subgrade surface.

4.2.2.1. If the subgrade is deemed unsuitable by the Project Supervisor or QA/QC Designate, they must alert the Owner's Representative and/or General Contractor as soon as possible. The Project Supervisor or QA/QC Designate shall communicate why the subgrade is unsuitable and may give some guidance for subgrade remedy.

4.2.2.2. Alternatively, the Owner's Representative may direct the Project Supervisor to begin deployment despite the unsuitable subgrade. The Project Supervisor will confer with the Project Manager prior to deployment.

4.2.3. When the subgrade has been inspected and deemed acceptable, the Project Supervisor or QA/QC Designate will complete and sign the Certificate of Subgrade Surface Inspection and submit to the Owner's Representative for countersignature.

4.2.3.1. The Certificate(s) of Subgrade Surface Inspection must be completed, signed and countersigned prior to beginning any deployment.

4.2.4. Prior to material installation, the Layfield Supervisor or QA/QC Designate should measure the area to be covered and compare it to the area included in the contract. Any differences must be communicated immediately to the Layfield Project Manager.

5. DEPLOYMENT

5.1. Overview

5.1.1. Material shall be deployed under the direction of the Project Supervisor or QA/QC Designate.

5.1.2. Material shall be deployed in a logical sequence and in a manner that allows for efficient seaming.

5.1.3. Equipment used to handle geomembrane panels or rolls shall not contact the material directly and shall not cause damage to the material.

5.1.4. Adjacent rolls will be overlapped by an amount suitable for the material and the seaming method being used.

5.2. Procedure

5.2.1. Each prefabricated panel or roll stock length shall be assigned a unique Panel Number as detailed below.

5.2.1.1. It is essential that Layfield's identification system and the Owner's Representative are the same. Do not use different systems.

5.2.2. Panel numbers shall be written in large block letters in the center of each deployed panel. The roll number, date of deployment and length (gross) should be noted below the panel number. Panel numbers should be made so that they are easily visible from a distance. On long panels this information should be written at both ends.

5.2.3. Panel Numbers shall be logged on the Geomembrane Deployment Log (Appendix C) along with the deployment date, roll number, length, width, and air temperature.

5.2.4. Deployment of geomembrane panels shall be performed in a manner that will comply with the following guidelines:

5.2.4.1. Unroll geomembrane using methods that will not damage geomembrane and will protect the underlying surface from damage.

5.2.4.2. To prevent wind uplift, place ballast that will not damage the geomembrane (usually sandbags).

5.2.4.3. Personnel walking on geomembrane shall not engage in activities or wear footwear that could damage the material. Smoking is not permitted on the geomembrane.

5.2.4.4. Do not allow heavy equipment or road vehicle traffic directly on geomembrane. Rubber-tired/ tracked UTVs are acceptable if ground pressure is less than 8 psi.

5.2.4.5. If required, place a protective cover over the geomembrane in areas of heavy traffic. The type of cover will vary according to material and traffic types.

5.2.4.6. All tires/tracks shall be inspected for sharp edges, embedded rocks or other potentially damaging materials prior to driving on any geosynthetic layer.

5.2.4.7. All UTVs must drive as straight as possible while on any geosynthetic layer. No sharp turns, sudden stops or quick starts.

5.2.4.8. Areas, where driving occurs, shall be continuously and thoroughly inspected throughout the deployment process by the Layfield Project Supervisor or QA/QC Designate and the Owner's Representative.

6. QUALIFICATION WELDS

6.1. Overview

6.1.1. Wedge, Hot Air and Extrusion Qualification Welds

6.1.1.1. When performing Wedge, Hot Air, and/or Extrusion Qualification Welds, each welding apparatus will be assigned to a Layfield Technician.

6.1.1.2. Each welding apparatus along with its designated Layfield Technician must pass a qualification weld prior to use for production welds. This will occur prior to any production seaming and in 4.0 hour increments as a minimum.

6.1.1.2.1. In addition, qualifications must be performed whenever there is a power interruption, dramatic change in climate conditions, if equipment settings are modified or adjusted, or a technician (operator) change.

6.1.1.3. Wedge, Hot Air, and Extrusion Qualification Welds must be destructively tested by a calibrated tensiometer. The tensiometer shall be calibrated by a certified third-party calibration agency. The Project Manager shall ensure that the Project Supervisor or QA/QC Designate is in possession of a copy of the calibration certificate prior to mobilization to the worksite.

6.1.1.4. Wedge, Hot Air, and Extrusion Qualification Welds shall be tested in accordance with ASTM D6392, ASTM D7177, ASTM D7408, ASTM 7747, GRI Standard GM6, GRI Standard GM13, GRI Standard GM17, GRI Standard GM19, or GRI Standard GM25; whichever is applicable to the material being welded.

6.1.2. Chemical Fusion Qualification Welds

6.1.2.1. Chemical Fusion is a versatile technique, but is only applicable to materials containing PVC, EVA, and CSPE.

6.1.2.2. Chemical Fusion does not provide the same peel strengths as thermo-fusion welding methods. For example, it is possible to create a wide chemical fusion bond that will develop the same shear strength as the material, but peel strengths will be lower than thermo-fusion welded samples.

6.1.2.3. Chemical Fusion welds typically require 8 to 24 hours curing time. As such, it is not usually practical to perform QA Chemical Fusion Qualification Welds in the field.

6.1.2.4. Chemical Fusion welds can be tested as a QC measure as part of Field Destructive Testing, which is covered below in this document.

6.1.3. Prepared Tape Seams

6.1.3.1. Prepared Tape seams are only used on materials such as vapor barrier and RPE type materials where Thermo-Fusion techniques cannot be used due to material properties.

6.1.3.2. Prepared Tape seams do not provide the same peel or shear strength values as thermo-fusion welding methods. The joint must be secured in some other fashion to create strength.

6.1.3.3. If Qualification Welds are required by the project specifications, Prepared Tape seams shall be tested in accordance with ASTM D7272.

6.2. Wedge, Hot Air, and Extrusion Qualification Procedure

6.2.1. All welding equipment shall be allowed to warm up a minimum of 15 minutes before performing Qualification Welds.

6.2.2. The Project Supervisor, QA/QC Designate and/or Technician must verify:

6.2.2.1. The equipment used is functioning properly and is the correct style for the welding to be performed.

6.2.2.2. Welding personnel are competent, working in a professional manner and are attentive to their duties.

6.2.2.3. Welding will only be performed when conditions allow for the conclusion of successful welds which will meet the project specifications.

6.2.3. Wedge welds must be performed on samples at least 5’ long. Hot Air Welds must be performed on samples at least 2’ long and the welded width must be at least 2”. Extrusion welds must be performed on samples at least 3’ long.

6.2.4. All Qualification Welds must be performed in the same conditions that exist on the worksite.

6.2.5. Use a 1” (25 mm) die cutter to cut ten (10) test specimens (or coupons) from the Qualification Weld samples. The Qualification Weld samples should be free of sand and grit prior to cutting sample. Cut one sample at a time to avoid damaging the coupons and/or the die cutter.

6.2.5.1. Because of the thickness of Embedment liner precludes doing “standard” Qualification procedures (I.e. testing peel and shear via a tensiometer), Qualification Welds will be checked with a Point Stress test to ensure proper bonding of extrudate to the Embedment liner.

6.2.6. When cutting coupons from the Qualification Weld samples, the inside and outside tracks on the coupon must be identified to assist in troubleshooting if the weld fails. This only applies to a dual track wedge welding apparatus.

6.2.6.1. The outside track will be identified as the track which is closest to the edge of the top sheet. The inside track will be identified as the track closest to the edge of the bottom sheet. Inside/outside labeling only applies to a dual track wedge welding apparatus.

6.2.7. Allow coupons to cool prior to testing.

6.2.8. Qualification Weld testing should occur at 21oC (+/- 4oC). Coupon temperatures greater than 21 degrees may result in artificially low strengths while colder temperatures lower may result in artificially high test values. If possible, allow the coupons to temperature stabilize to these conditions prior to testing.

6.2.9. Visually inspect the coupons for squeeze-out, footprint, pressure and general appearance.

6.2.10. Five (5) coupons will be tested in peel, and five (5) more coupons will be sampled in shear on the calibrated field tensiometer at a separation rate dictated by the applicable ASTM or GRI test method.

6.2.11. Criteria for passing Qualification Welds will be as follows:

6.2.11.1. Weld must exhibit a film tear bond (FTB). Qualification Welds must have no more than 25% incursion into the weld in all samples.

6.2.11.2. Peel and shear values must meet or exceed the values that are applicable to the geosynthetic material. Peel and Shear values for the following typical materials can be found in:

6.2.11.2.1. HDPE, Smooth and Textured – GRI Standard GM 19

6.2.11.2.2. LLDPE, Smooth and Textured – GRI Standard GM 17

6.2.11.2.3. LLDPE, Reinforced – GRI Standard GM 25

6.2.11.2.4. EnviroLiner® Series – GRI Standard GM17

6.2.11.2.5. Nonreinforced PVC – ASTM D7408

6.2.11.2.6. Reinforced Geomembranes - ASTM D7747

6.2.11.2.7. Flexible Polypropylene, Reinforced & Nonreinforced – GRI Standard GM18

6.2.11.3. Both tracks of Dual Track wedge welded samples must pass for the Qualification Weld to be considered acceptable. If the applicable specification passing criteria is not met, the Qualification Weld must be re-done. Repeat the Qualification Weld process until passing values are obtained.

6.2.11.4. Solid Wedge, Hot Air Welded, Chemical Bonded and Hot Shoe Welded samples must pass for the Qualification Weld to be considered acceptable. If the applicable specification passing criteria is not met, the Qualification Weld must be re-done. Repeat the Qualification Weld process until passing values are obtained.

6.2.12. The Layfield Project Supervisor or QA/ QC Designate will give the approval to proceed with welding after observing and recording all Qualification Weld results.

6.2.13. All qualification weld data shall be recorded on the following logs:

6.2.13.1. Wedge Qualification Weld data will be recorded in the Geomembrane Seam & Test Log (Appendix D).

6.2.13.2. Extrusion and Hot Air Qualification Weld data will be recorded in the Geomembrane Detail & Test Log (Appendix E)

7. FIELD PRODUCTION SEAMING

7.1. Overview

7.1.1. All seams shall be recorded.

7.1.2. Field wedge welds shall be recorded on the Geomembrane Seam & Test Log (Appendix D).

7.1.3. Extrusion welds are usually performed on details, defects or repairs and as such will be recorded on the Geomembrane Detail & Test Log (Appendix E).

7.1.4. Chemical Fusion welds shall be recorded on the Geomembrane Seam & Test Log (Appendix D). If they are performed as part of a detail or repair, they shall be recorded on the Geomembrane Detail & Test Log (Appendix E).

7.1.5. Prepared Tape welds shall be recorded on the Geomembrane Seam & Test Log (Appendix D) if they are production welds. If they are performed as part of a detail or repair, they shall be recorded on the Geomembrane Detail & Test Log (Appendix E).

7.1.6. Hot air welds shall be recorded on the Geomembrane Seam & Test Log (Appendix D). If they are performed as part of a detail or repair, they shall be recorded on the Geoemembrane Detail & Test Log (Appendix E).

7.2. Wedge Welding Procedures

7.2.1. All wedge welding equipment must use the same settings that were used during the Qualification Weld process. If changes are made to any settings, the wedge welder must be re-qualified.

7.2.2. The seam shall be identified by the unique Panel Numbers on each side. These Panel Numbers and the seam lengths shall be recorded in the Geomembrane Seam & Test Log.

7.2.3. Welding Technicians will mark their initials, machine number, date and time at the start of every seam.

7.2.4. Welding should not be performed in ambient air temperatures or adverse weather conditions that would jeopardize the integrity of the liner installation.

7.2.4.1. Allowable welding temperatures and/or weather conditions shall be dictated by the project specifications, material specifications and/or the successful geomembrane Qualification Weld.

7.2.4.2. Welding may proceed in adverse conditions if sufficient precautionary measures have been implemented to protect the welding area and/or geomembrane.

7.2.5. The Layfield Technician shall verify the following as part of weld preparation:

7.2.5.1. Ensure that the seam is overlapped properly for Wedge welding.

7.2.5.2. Clean the seam area as required. The seaming area must be kept free of moisture, dust, dirt, sand or debris of any nature.

7.2.5.2.1. A slip sheet or geotextile working surface may be used to maintain a clean work area.

7.2.5.3. Align wrinkles on seams to minimize unmatched wrinkles or “fish mouths”.

7.2.6. Proceed with Wedge weld.

7.3. Hot Air Welding Procedures

7.3.1. All Hot Air welding equipment must use the same settings that were used during the Qualification Weld process.

7.3.2. The seam shall be identified by the unique Panel Numbers on each side. These Panel Numbers and the seam lengths shall be recorded in the Geomembrane Detail & Test Log.

7.3.3. Welding Technicians will mark their initials, machine number, date and time at the start of every seam or weld.

7.3.4. Welding should not be performed in ambient air temperatures or adverse weather conditions that would jeopardize the integrity of the liner installation.

7.3.4.1. Allowable welding temperatures and/or weather conditions shall be dictated by the project specifications, material specifications and/or the successful geomembrane Qualification Weld.

7.3.4.2. Welding may proceed in adverse conditions if sufficient precautionary measures have been implemented to protect the welding area and/or geomembrane.

7.3.5. The Layfield Technician shall verify the following as part of weld preparation:

7.3.5.1. Ensure that the seam or weld area is overlapped properly for Hot Air welding.

7.3.5.1.1. A slip sheet or geotextile working surface may be used to maintain a clean work area.

7.3.5.2. Clean the seam or weld area as required. The seam or weld area must be kept free of moisture, dust, dirt, sand or debris of any nature.

7.3.5.3. Weld the seam or weld area by heating using the Hot Air Welder and apply continuous downward pressure along the area (roller apparatus for applying even pressure is recommended for thinner, flexible materials). Weld width should be a minimum of 2” wide continuous throughout the weld.

7.4. Extrusion Welding Procedures

7.4.1. All Extrusion welding equipment must use the same settings that were used during the Qualification Weld process.

7.4.2. The seam shall be identified by the unique Panel Numbers on each side. These Panel Numbers and the seam lengths shall be recorded in the Geomembrane Detail & Test Log or Seam & Test Log depending on the nature of the work.

7.4.3. Welding Technicians will mark their initials, machine number, date and time at the start of every seam or weld.

7.4.4. Welding should not be performed in ambient air temperatures or adverse weather conditions that would jeopardize the integrity of the liner installation.

7.4.4.1. Allowable welding temperatures and/or weather conditions shall be dictated by the project specifications, material specifications and/or the successful geomembrane Qualification Weld.

7.4.4.2. Welding may proceed in adverse conditions if sufficient precautionary measures have been implemented to protect the welding area and/or geomembrane.

7.4.5. The Layfield Technician shall verify the following as part of weld preparation:

7.4.5.1. Ensure that the seam or weld area is overlapped properly for Extrusion welding.

7.4.5.1.1. A slip sheet or geotextile working surface may be used to maintain a clean work area.

7.4.5.2. Clean the seam or weld area as required. The seam or weld area must be kept free of moisture, dust, dirt, sand or debris of any nature.

7.4.5.3. Tack the seam or weld in place by using a Hot Air welder.

7.4.5.4. Abrade the welding surface(s) by either grinding or abrasion. For Embedment Liner, ensure that the sheets/cap/patch has been beveled to allow weld penetration.

7.4.5.5. Purge the machine of heat-degraded extrudate prior to use.

7.4.6. Proceed with Extrusion weld.

7.5. Chemical Fusion Welding Procedures

7.5.1. Chemical Fusion Welding requires the use of solvents or bodied solvents.

7.5.2. The seam shall be identified by the unique Panel Numbers on each side. These Panel Numbers and the seam lengths shall be recorded in the Geomembrane Seam & Test Log or Geomembrane Detail & Test Log, as applicable.

7.5.3. Welding Technicians will mark their initials, date and time at the start of every seam or weld.

7.5.4. Welding should not be performed in ambient air temperatures or adverse weather conditions that would jeopardize the integrity of the liner installation.

7.5.4.1. Allowable welding temperatures and/or weather conditions shall be dictated by the project specifications, Chemical Fusion manufacturer specifications, and/or material specifications.

7.5.4.2. Welding may proceed in adverse conditions if sufficient precautionary measures have been implemented to protect the welding area and/or geomembrane.

7.5.5. The Layfield Technician shall verify the following as part of weld preparation:

7.5.5.1. Ensure that the seam or weld area is overlapped properly for Chemical Fusion welding.

7.5.5.1.1. A slip sheet or geotextile working surface may be used to maintain a clean work area.

7.5.5.1.2. If the subgrade is not rigid enough, a rigid slip sheet can be used to help with compression during the seaming process.

7.5.5.2. Clean the seam area or weld area as required. The area must be kept free of moisture, dust, dirt, sand or debris of any nature.

7.5.6. Proceed with Chemical Fusion weld.

7.6. Prepared Tape Seaming Procedures

7.6.1. Prepared Tape Seaming requires the use of mastics, putties, asphalt, or butyl tapes.

7.6.2. The seam shall be identified by the unique Panel Numbers on each side. These Panel Numbers and the seam lengths shall be recorded in the Geomembrane Seam & Test Log or Geomembrane Detail & Test Log, as applicable.

7.6.3. Welding Technicians will mark their initials, date and time at the start of every seam.

7.6.4. Seaming should not be performed in ambient air temperatures or adverse weather conditions that would jeopardize the integrity of the liner installation.

7.6.4.1. Allowable seaming temperatures and/or weather conditions shall be dictated by the project specifications, Prepared Tape manufacturer specifications, and/or material specifications.

7.6.4.2. Seaming may proceed in adverse conditions if sufficient precautionary measures have been implemented to protect the welding area and/or geomembrane.

7.6.5. The Layfield Technician shall verify the following as part of seam preparation:

7.6.5.1. Ensure that the seam is overlapped properly for Prepared Tape seaming.

7.6.5.2. Clean the seam area as required. The seaming area must be kept free of moisture, dust, dirt, sand or debris of any nature.

7.6.6. Proceed with Prepared Tape seam.

8. FIELD NONDESTRUCTIVE TESTING

8.1. Overview

8.1.1. Layfield shall non-destructively test the entire length of all seams and welds using the applicable non-destructive test method for the material as indicated by ASTM D7700. The table below can be used as a quick reference

Material	ASTM Test Method				
	D5641 Vacuum Chamber	D4437 Air Lance	D4437 Point Stress	D5820 Pressurized Air Channel[3]	D6365 Spark Test
HDPE	X	X	X	X[2]	X
LLDPE & fPP	X	X	X	X[2]	X
Embedment Liner	X		X		X[4]
Non-reinforced PVC	X	X	X		X
Reinforced Geomembrane	X	X	X	X	X
Reinforced PVC	X	X	X		X
fPP-R	X	X	X	X	
EnviroLiner® Series	X	X	X	X[2]	X

[1] Layfield will usually restrict the use of ASTM D5641 (Vacuum Chamber) to Extrusion welds and other short weld lengths such as details and repairs.

[2] Layfield will usually perform Dual Track Wedge welds on this material if the thickness is 40mil or greater. Layfield will usually perform Solid Wedge welds if the material thickness is below 40mil.

[3] GRI Standard GM6 is also applicable to this test method.

[4] Spark Testing is the standard test method for Embedment liner.

8.2. Procedure

8.2.1. Vacuum Chamber

8.2.1.1. This method is used to inspect welds and seams for unbonded areas and/or pinholes. A Vacuum Chamber consists of a rectangular box with an open bottom, a soft rubber type gasket along the perimeter of the open bottom, a clear plastic viewing panel at the top, and a vacuum gauge.

8.2.1.2. Apply a soap solution (or other approved foaming agent) to the area to be tested.

8.2.1.3. Place Vacuum Chamber over the area to be tested.

8.2.1.3.1. This test method is performed in increments of approximately 18" with a 6" overlap of the previous length tested.

8.2.1.4. Apply a vacuum to the Vacuum Chamber.

8.2.1.5. Inspect the testing area through the clear plastic viewing panel for bubbles at unbonded areas or pinholes.

8.2.1.5.1. Bubbles near the edge of the vacuum chamber may be caused by an incomplete seal. If bubbles are detected near the edges of the vacuum chamber, move the vacuum chamber and retest to verify if the bubbles were caused by an actual defect or pinhole.

8.2.1.6. Mark all unbonded areas or pinholes for repair with a white paint marker.

8.2.1.7. Record results on the Geomembrane Seam & Test Log and/or Detail & Test Log, as appropriate.

8.2.2. Air Lance

8.2.2.1. This method is used to test welds and seams for unbonded areas by using an air nozzle directed on the upper edge and surface. Layfield typically uses this test method on Solid Wedge welds, Chemical Bonding and Hot Air Welds.

8.2.2.2. Use a minimum 50 psi (345 kPa) air supply directed through a 3/16" nozzle. Hold the nozzle approximately 2" away from the edge and surface.

8.2.2.3. While performing Air Lance testing, inspect testing areas for loose edges, riffles indicating unbonded areas, and other unacceptable conditions.

8.2.2.4. Mark all unbonded areas for repair.

8.2.2.5. Record results on the Geomembrane Seam & Test Log and/or Detail & Test Log, as appropriate.

8.2.3. Point Stress

8.2.3.1. This method is used to manually inspect and test seam and weld edges with a rounded screwdriver (or similar device).

8.2.3.2. Layfield requires this to be done on all seams and welds in addition to other applicable testing methods.

8.2.3.3. Using the appropriate tool, manually test the edges of seams and welds.

8.2.3.3.1. Ensure that this procedure does not puncture or otherwise damage the sheet material, seams or welds, but enough pressure is applied to perform the test.

8.2.3.4. While performing Point Stress testing, inspect for signs of unbonded areas.

8.2.3.5. Mark all unbonded areas for repair.

8.2.3.6. Record results on the Geomembrane Seam & Test Log and/or Detail & Test Log, as appropriate.

8.2.4. Pressurized Air Channel

8.2.4.1. This method is used to test Dual Track Wedge welded seams. A Dual Track Wedge weld consists of parallel thermo-fusion welds separated by an unwelded air channel.

8.2.4.2. After a Dual Track Wedge weld has been completed and allowed to cool, perform the following:

8.2.4.2.1. Seal the two ends of the continuous air channel.

8.2.4.2.2. Connect the air pressure gauge assembly directly to the air channel.

8.2.4.2.3. Connect an air pump to the air pressure gauge assembly and pressurize the air channel to the appropriate pressure for the geomembrane material.

8.2.4.2.4. Disconnect the air pump from the air pressure gauge assembly.

8.2.4.2.5. Allow the air channel pressure to stabilize.

8.2.4.2.5.1. If required, increase or decrease the pressure to the specified starting value.

8.2.4.2.6. Record the test start time and pressure, and seam location.

8.2.4.2.7. Wait 5 minutes. During this period perform the following:

8.2.4.2.7.1. Visually inspect the air channel along its full length to ensure that pressure is present throughout the entire length of the seam.

8.2.4.2.7.2. Listen for escaping air along the full length of the air channel.

8.2.4.2.8. After the 5 minute testing period, observe and record the test end time and pressure.

8.2.4.2.9. For a seam to pass, it must meet the following criteria:

8.2.4.2.9.1. Compare the recorded test results against the Maximum Pressure Drop testing values table for the material. If the pressure does not drop below the value listed, proceed to the next step.

8.2.4.2.9.2. Open the air channel at the opposite end from the pressure gauge. Pressurized air should escape and the pressure gauge should register an immediate drop in pressure. This indicates that the entire length of the seam has been tested and the seam passes. If not, there is likely a blockage in the air channel.

8.2.4.2.9.2.1. If there is a blockage, the channel should be inflated up to the blockage. Cut the air channel on the gauge side of the blockage and verify pressure loss. Repeat as necessary until the blockage is identified. Retest all sections and repair as required.

8.2.4.2.9.3. If the pressure drops below the allowable pressure value, Layfield personnel must trace and identify the defect by following these steps:

8.2.4.2.9.3.1. Check the seals at the ends of the air channel. Reseal and retest if the seal was defective.

8.2.4.2.9.3.2. Inspect the seam for deficiencies in the weld tracks (spinouts, wrinkles, fish mouths, etc).

8.2.4.2.9.3.3. Remove the overlap and apply a soap solution. Retest the seam in increments to identify the defect location. If the defect is found, effect localized repairs.

8.2.4.2.9.3.4. If the defect in the air channel cannot be identified, reconstruct the seam (or part of the seam) by installing a Dual Track wedge welded cap strip and retest.

8.2.4.3. Record all test results on the Geomembrane Seam & Test Log (Appendix D).

8.2.5. Spark Test

8.2.5.1. This method is used to test an Extrusion weld that includes a conductive material (i.e. copper wire or similar) inserted into or behind the weld.

8.2.5.2. Set the voltage source to the voltage needed for the expected distance.

8.2.5.3. The spark tester shall be held and operated approximately ½” to 1” away from the weld.

8.2.5.4. Sweep the spark tester over the welded materials along the weld length.

8.2.5.5. Spark arcing indicates a suspect area in the weld.

8.2.5.6. Mark all pinholes or unbonded areas for repair.

8.2.5.7. Record all test results on the Geomembrane Seam & Test Log and/or Detail & Test Log, as appropriate.

9. DETAILS, DEFECTS & REPAIRS

9.1. Overview

9.1.1. All seam and non-seam areas of the geomembrane shall be inspected for damages and defects.

9.1.1.1. At a minimum, all seams and welds shall be non-destructively tested. Where a seam is tested destructively, it shall be repaired and recorded as part of this process.

9.1.1.2. All non-seam areas shall be inspected throughout the work and as part of Final Inspection and Acceptance.

9.1.2. All details, defects and repairs shall be physically marked on the geomembrane and recorded on the Geomembrane Detail & Test Log (Appendix E) and their location recorded on the As-Built Drawing.

9.2. Identification

9.2.1. Details are identified in the Scope of Work, Construction Drawings, or another contract document. Examples are a pipe or pile penetrations, rub sheets, etc.

9.2.2. Damages and defects are identified in one of two ways: an inspection, or as part of a destructive or non-destructive test. Examples are punctures in the sheet, defects in a seam, etc.

9.3. Details & Repairs

9.3.1. Typical detail types include: grind & weld, patches, boots, caps, reconstructed seams and skirts.

9.3.2. All details must be constructed using equipment that has been through the Qualification Weld process, and follow the applicable welding procedures.

9.3.3. Any damage or defect found in a seam or on the sheet (pinholes, tears, punctures, etc) shall be marked on the geomembrane.

9.3.4. Each detail shall be assigned a unique Detail Code.

9.3.5. The detail shall be constructed and tested non-destructively using an appropriate method for the detail type, geomembrane material type and project specifications.

9.3.6. The location, detail type, repair date & time, test date, and test type shall be recorded on the Geomembrane Detail & Test Log.

9.3.7. The location and unique Detail Code shall be recorded on the As-Built Drawing.

10. FIELD DESTRUCTIVE TESTING

10.1. Overview

10.1.1. Destructive seam tests are performed to evaluate and confirm that production welds are conforming to the material and/or project specifications.

10.1.2. The sampling frequency of destructive testing shall be one (1) sample per 150 lineal meters of field welded seam, as guided by GRI Standard GM14 and GRI Standard GM29.

10.1.2.1. Project specifications and field considerations may modify this frequency.

10.2. Procedure

10.2.1. The Project Supervisor or QA/QC Designate shall identify the area from which the sample will be collected.

10.2.1.1. Alternatively, project specifications may dictate that the Owner's Representative shall be responsible for identifying the area from which the sample will be collected.

10.2.2. Each destructive test sample will be assigned a unique Destruct Sample Number.

10.2.3. The sample size should be approximately 300mm (12”) x 900mm (36”). This may vary based on project specification and sample distribution; however the typical distribution is as follows:

10.2.3.1. 300mm x 300mm sample for Layfield QA/QC Designate to be field tested.

10.2.3.2. 300mm x 300mm sample sent to Office for archiving or future testing if required.

10.2.3.3. 300mm x 300 mm sent to the third party for independent testing, if required.

10.2.4. All samples shall be labeled with the unique Destruct Sample Number, seam location, machine number, Layfield project number, date welded, Technician, and geomembrane roll numbers.

10.2.5. The sample shall be tested using the same procedure as Qualification Welds for that welding apparatus.

10.2.5.1. Each geomembrane material has its own pass criteria. References are given in Section 6.2.11.2

10.2.5.2. The mechanical values of four out of five specimens must meet or exceed the specified values, and the fifth specimen must meet or exceed 80% of the value. In addition, the average value of each set of five specimens must meet GRI GM 19 specifications.

10.2.6. All destructive test data will be recorded on the Geomembrane Destruct Log (Appendix F).

10.2.7. If a destructive test sample fails, it is necessary to destructively sample and test the seam until a pass is found on both sides of the defect.

10.2.7.1. Cut additional samples 3 meters on each side of the defect and retest. These will be labeled A (after) & B (before). This procedure continues until a passing sample in each direction is achieved. The total length of the defective seam between the two passing tests must be capped, or cut out and re-seamed.

10.2.7.2. After reconstructing the defective seam, the entire seam length must be non-destructively tested using the appropriate method for the repair type.

10.2.8. Destructive test samples should be repaired, but this may not be necessary depending on sample location (for example anchor trench or end of tie-in).

11. AS-BUILT DRAWING REQUIREMENTS

11.1. As-built Drawings can be done on Layfield drafting paper, or overlay an Owner supplied construction/survey drawing. Drawings may be done in ink or pencil, but writing must be neat.

11.2. The scale must be indicated and consistent throughout the drawing. Not to Scale (NTS) is acceptable if imperative dimensions are provided on the drawing. Each As-built drawing must also include a Legend and North Arrow.

11.3. Deployed geomembrane panels must be accurately located on the As-Built Drawing. The panels must be identified by the unique Panel Number that is physically written on the panel, and it must match the Geomembrane Deployment Log.

11.4. Details must be accurately located on the As-Built Drawing. The details must be identified by the unique Detail Codes that are recorded in the Geomembrane Detail & Test Log.

12. FINAL INSPECTION AND ACCEPTANCE

12.1. Overview

12.1.1. All projects must have all Certificate(s) of Final Inspection and Acceptance signed by, or on behalf of, both parties prior to the installation of any covering material.

12.1.2. It is important to note that there are cases where a total work area cannot or will not be completed and turned over to the Owner's Representative. The Certificate of Final Inspection and Acceptance does make provision for partial areas being completed and turned over to the Owner's Representative. The Layfield Site Supervisor shall ensure that the extents of the inspected area are clearly expressed on the Certificate of Final Inspection and Acceptance. A separate certificate shall be generated for each partial area.

12.1.3. The Certificate of Final Inspection and Acceptance is generated in duplicate with a white (original) and yellow (copy). The white copy is kept with Layfield's QA/QC documentation and is turned over to the Layfield Project Manager at the Project Closeout Meeting. The yellow copy is turned over to the countersigning party (Contractor's QA, Owner's Representative, etc) immediately upon signature for their records.

12.2. Procedure

12.2.1. The Project Supervisor or QA/QC Designate will arrange a final site inspection with Owner's Representative when the contracted Scope of Work has been completed.

12.2.2. The Project Supervisor or QA/QC Designate and Owner's Representative will inspect, measure, and validate all deliverables and components of the Scope of Work together.

12.2.2.1. If any deficiencies are found, they shall be remedied as soon as practical using the applicable procedures detailed above.

12.2.2.2. When the deficient item(s) have been remedied, the Project Supervisor or QA/QC Designate and Owner's Representative can re-inspect. Repeat this step as necessary.

12.2.3. When all deliverables and components have been inspected, measured and validated by the Owner's Representative, the Project Supervisor or QA/QC Designate will complete and sign the Certificate of Final Inspection and Acceptance and submit to the Owner's Representative for countersignature.

12.2.3.1. A Certificate of Final Inspection and Acceptance must be signed prior to Layfield demobilization.

Appendix A – Certificate of Subgrade Surface Inspection

CERTIFICATE OF SUBGRADE SURFACE INSPECTION
PROJECT NAME: ______________________________
PROJECT NUMBER: ______________________________
OWNER/CONTRACTOR: ______________________________
LOCATION: ______________________________

I, the undersigned, a duly appointed representative of Layfield Canada Ltd. (Layfield), have visually observed the subgrade surface described below, and:

- ☐ *found it to be an Acceptable surface on which to install geomembrane; OR*
- ☐ *found it to be an Unacceptable surface on which to install geomembrane*

Area Inspected (☐ Partial ☐ Complete): ______________________________
Dimensions of Subgrade Inspection: ______________________________
Anchor Trench Dimensions: ______________________________
Comments: ______________________________
____

This certification is based on observations of the surface of the subgrade only. No subterranean inspections or tests have been performed by Layfield and Layfield makes no representations or warranties regarding conditions which may exist below the surface of the subgrade. Layfield accepts no responsibility for conformance of the subgrade to this project's specifications.

The subgrade inspected on this date refers to its present condition. Any changes in the subgrade condition that result from the effects of inclement weather and/or other forces beyond the control of Layfield and remedial work to correct the resulting deficiencies, will be the direct responsibility of the General Contractor.

LAYFIELD REPRESENTATIVE:
Date: ______________________________
Signature: ______________________________
Name: ______________________________
Title: ______________________________

OWNERS REPRESENTATIVE:
I, the undersigned, a duly appointed representative of the Owner, hereby understand the subgrade surface inspection described above and authorize Layfield to proceed with deployment of Geosynthetics on the subgrade provided.
Date: ______________________________
Signature: ______________________________
Name: ______________________________
Title: ______________________________
Company: ______________________________

Appendix B – Inventory Log

PROJECT NUMBER ____________________

PROJECT TITLE ____________________

DATE OF INVENTORY ____________________

PRODUCT TYPE ____________________

MATERIAL MANUFACTURER ____________________

#	ROLL NUMBER	MATERIAL DIMENSIONS			REMARKS
		THICKNESS	LENGTH (m)	WIDTH (m)	
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
28					
29					
30					

QC Tech ____________________ **Sheet Number** ____________________

Submission Date ____________________

Supervisor Date ____________________ **Total Page Area** [   ] **m**

GEOMEMBRANE DEPLOYMENT LOG

PROJECT NUMBER ______________________ AREA / LAYER ______________________

PROJECT TITLE ______________________ DEPLOYMENT DATE ______________________

PANEL NUMBER	ROLL NUMBER	LENGTH (m)	WIDTH (m)	AIR TEMP °C	PANEL CONDITION	CHECKED BY	SUBGRADE CONDITION

TOTAL PAGE AREA ________ m²

QC TECH ______________________

SUPERVISOR ______________________

SUBMISSION DATE ______________________

SHEET NUMBER ______________________

LS-10-QF-002

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LAYFIELD

GEOMEMBRANE SEAM & TEST LOG

PROJECT NUMBER ____________________ AREA / LAYER ____________________

PROJECT TITLE ____________________ SEAM DATE ____________________

TRIAL SEAMS

#	MACHINE NUMBER	TIME	WELD TECH	AIR TEMP °C	SPEED	WEDGE TEMP °F	INSIDE PEEL (PPI)					OUTSIDE PEEL (PPI)					SHEAR (PPI)					CHK'D BY	LINER TO LINER TYPE AND REMARKS

WELD SEAMS									QC		AIR PRESSURE TEST (PSI)				VERIFY	
PANEL NUMBERS	SEAM SECTION FROM	SEAM SECTION TO	START TIME	AIR TEMP	WELD TECH	MACHINE NUMBER	WELD LENGTH	DESTRUCT NUMBER	TEST METH.	TEST DATE Y-M-D	TIME START	TIME END	PRESSURE START	PRESSURE END	PASS	QC TECH
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/																
						PAGE TOTAL										

TEST METHOD

AL - AIR LANCE	ST - SPARK TEST
AP - AIR PRESSURE	VB - EXTRUDED
PS - POINT STRESS	& VAC BOX

REMARKS: ____________________

QC TECH ____________________

SUPERVISOR ____________________

SUBMISSION DATE ____________________

SHEET NUMBER ____________________

LS-10-QF-004

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GEOMEMBRANE DETAIL & TEST LOG

LAYFIELD

PROJECT NUMBER ______________________ AREA / LAYER ______________________

PROJECT TITLE ______________________

TRIAL SEAMS																			
#	MACHINE NUMBER	DATE YYYY-MM-DD	TIME	WELD TECH	AIR TEMP °C	PREHEAT TEMP °F	EXTRUSION TEMP °F	PEEL (PPI)					SHEAR (PPI)					CHK'D BY	REMARKS
1																			
2																			
3																			
4																			
5																			
6																			

DETAIL CODE	PANEL NUMBER(S)	LOCATION DESCRIPTION	DETAIL TYPE	REPAIR TYPE	MACHINE NUMBER	REPAIR DATE YYYY-MM-DD	START TIME	WELD TECH	AIR TEMP °C	TEST DATE YYYY-MM-DD	TEST METH.	QC TECH
A	/											
B	/											
C	/											
D	/											
E	/											
F	/											
G	/											
H	/											
I	/											
J	/											
K	/											
L	/											
M	/											
N	/											
O	/											
P	/											
Q	/											
R	/											
S	/											
T	/											

DETAIL TYPE:

- AD - ANIMAL DAMAGE
- ATL - AIR TEST LEAK
- BO - FUSION WELDER BURN
- CR - CREASE
- D - INSTALLATION DAMAGE
- DS-# - DESTRUCT SAMPLE NUMBER
- EE - EARTHWORK EQUIPMENT DAMAGE
- EXT - EXTENSION
- FM - FISHMOUTH
- FS - FAILED SEAM LENGTH
- IO - INSUFFICIENT OVERLAP
- MD - MANUFACTURER/DELIVERY DAMAGE
- P - PENETRATION
- PT - PRESSURE TEST CUT
- SI - SOIL SURFACE IRREGULARITY
- T - THREE PANEL INTERSECTION
- VL - VACUUM TEST LEAK
- WR - WRINKLE
- WS - WELDER RESTART
- OTHER:

TEST METHOD:

- AL - AIR LANCE
- VB - VAC BOX
- PS - POINT STRESS
- ST - SPARK TEST

REPAIR TYPE:

- B - BOOT
- G&W - GRIND & WELD
- C - CAP
- RS - RECONSTRUCTED SEAM
- P - PATCH
- S - SKIRT

REMARKS

QC TECH ______________________

SUPERVISOR ______________________

SUBMISSION DATE ______________________

SHEET NUMBER ______________________

LS-10-QF-007

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LAYFIELD

GEOMEMBRANE DESTRUCT LOG

PROJECT NUMBER ______________________ AREA / LAYER ______________________

PROJECT TITLE ______________________ 3RD PARTY ______________________

ARCHIVE LAYFIELD ☐ OWNER ☐ ENGINEER ☐

DESTRUCT SAMPLE NUMBER	TYPE OF SEAM	PANEL NUMBERS	TEST DATE YYYY-MM-DD	TEST TEMP °C	INITIALS			INSIDE PEEL STRENGTH (PPI)					OUTSIDE PEEL STRENGTH (PPI)					SHEAR STRENGTH (PPI)				
SAMPLE LOCATION					3RD PARTY PRESENT	LAYFIELD PASS	3RD PARTY PASS	LOCUS OF BREAK					LOCUS OF BREAK					LOCUS OF BREAK				
DS-																						
DS-																						
DS-																						
DS-																						
DS-																						
DS-																						
DS-																						
DS-																						

TYPE OF SEAM: SPF - SPLIT FUSION SOF - SOLID FUSION SLV - SOLVENT EXT - EXTRUSION HAF - HOT AIR FUSION

QC TECH ______________________

SUBMITTED BY ______________________

SUBMISSION DATE ______________________

SHEET NUMBER ______________________

LS-10-QF-008

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Appendix G – Certificate of Final Inspection and Acceptance

PROJECT NAME: ____
PROJECT NUMBER: ____________________ **DATE:** __________________
OWNER: ____
LOCATION: ____

Scope of Installation(s): **THE WORK**
Area/Layer: ______________________________ Area Inspected: ☐ Partial or ☐ Complete
Dimensions: ____
____
____
____

Part 1 – LAYFIELD CANADA LTD.

I, __________________________, a duly appointed representative of Layfield Canada Ltd. (Layfield), have visually observed the installations (as outlined above), and have found the Work to be complete and free of defects and declare that the Work was completed in accordance with the project specifications, Layfield's QC program and the terms and conditions of the contract.

Layfield Representative:

Name: ____
Title: ____
Date: ______________ **Signature:** ______________________________

Part 2 – OWNER (or Representative)

I, __________________________, a duly appointed representative of ____________________ ___________________________________, do hereby accept and receive the installation(s) described above, and confirm that the work has been completed in accordance with the project specifications and the terms and conditions of the contract.

I have evaluated and measured the work together with the Layfield representative, and agree that the measurements shown are both true and correct, and that the installation has met our approval.

Owners Representative:

Name: ____
Title: ____
Company: ____
Date: ________________ **Signature:** ______________________________

Comments: ____
____
____

Notes:

Notes:

About Layfield: The Layfield Group is the only integrated organization that provides tailored polymer-based solutions that are proven to protect our families, communities, and environment.

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APPENDIX D

Liner Anchor Calculations

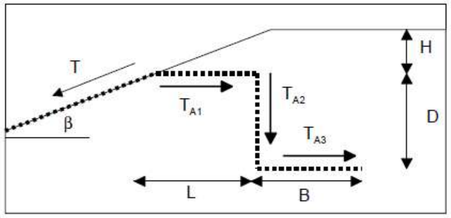
Anchoring Calculations

Considering the soils studied have no cohesion and that the layer of soil deposited on the length L moves with the GTX, we get:

$$T_{A1} = \gamma HL tan\phi_{s,GTX}$$

$$T_{A2} = 2\gamma K_0 D \left(\frac{D}{2} + H\right) tan\phi_{s,GTX}$$

$$T_{A3} = 2\gamma B(D + H) tan\phi_{s,GTX}$$



γ	Specific weight of the soil	Specific weight of soil (sand) to be taken as 1600 kg/m3 (1.6 kN/m3)
ϕ_(s, GTX)	friction angle at the soil/GTX interface	As per (Rizwan, M., et al., 2022), interface angles have been reported to vary between 23.9 and 31.4. 27.65 will be utilized for the friction angle.
Ko	(1-sinϕ) at-rest earth pressure coefficient	0.54 based on selected angle above

γ	1.6	kN/m3	Rizwan, M., et al. 2022 - https://www.mdpi.com/2079-6439/10/10/84
ϕ_(s, GTX)	27.65	angle	
Ko	0.54	Unitless	
D	0.3	m	
H	0.45	m	
L	1	m	
B	0.3	m	

T-A1	0.377207	kN/m
T-A2	0.162954	kN/m
T-A3	0.377207	kN/m

The anchoring capacity of the trench studied is the sum of these three forces for a horizontal extraction of the GTX.

Influence of Slope Angle

$$T = \gamma HL tan\phi_{s,GTX} \left(\frac{1}{cos\beta - sin\beta tan\phi_{s,GTX}}\right)$$

β	Slope angle	
β	2:1 slope	26.57 degrees
β	5:1 slope	11.31 degrees

T (2:1 slope)	0.57148	kN/m
T (5:1 slope)	0.429702	kN/m

(T-A1+T-A2+T-A3)-T(2:1 slope)	0.345888	kN/m
(T-A1+T-A2+T-A3)-T(5:1 slope)	0.487666	kN/m

Based on this, the tension from the slope angle is surpassed by the friction generated by the anchor, and the anchor is deemed sufficient.