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25 October 2012

Matthew R. Morgia, P.E.
Aubertine and Currier, PC
516 Bradley Street
Watertown, New York 13601

via Email (mrm@aubertinecurrier.com)

Subject: **DRAFT WORK PLAN**
Limited Subsurface Investigation to Define Waste Limits/Landfill Liner
Revised Conceptual Running Track - Airfield Sanitary Landfill
Fort Drum, New York

Dear Mr. Morgia:

H2H Associates, LLC (H2H), in support of Aubertine and Currier, PC (A&C), is pleased to provide a Work Plan for the above referenced project.

Project Understanding

The government is looking to pursue a modified version (15 feet in width) of the running track component at the Fort Drum Airfield Sanitary Landfill (ASL), reducing the overall width of the subject track and moving segments of the track inward onto the existing liner where it was reported that the waste was not present (Reference: Aubertine and Currier, PC; 10 February 2010 Feasibility Assessment). Most of the running track and fence is depicted outside the limits of the cap. However, there are areas along Anaconda and Falcon Trail that are depicted to be over the existing cap and areas along MSP Tampa that are adjacent or on the cap.

The northeasterly 14 acres of the ASL site (Phase 1) were covered with an impermeable 20-mil PVC liner, 6-inches of soil cover, and re-vegetated. The Phase 1 area contained thirteen gravel gas vents. The gas vents had purportedly silted in and their whereabouts are no longer visible from the surface. Solid waste was disposed of on 23 acres southwest of and adjacent to the Phase 1 area until October 1987 (the southwesterly portion of the landfill referred to as Phase 2). In 1990, Phase 2 was closed by installing a 40-mil PVC liner, 18 PVC gas vents, 12 inches of soil cover, and vegetation. The total cover over the entire ASL was increased to 18 inches in 1998 and 1999.

The ASL is not permitted, so there is no permit to amend or modify. It is identified as a Solid Waste Management Unit (SWMU), and as such, the New York State Department of

Environmental Conservation (NYSDEC) must approve any work that may impact the landfill materials and liner performance.

The NYSDEC stated that the 10 February 2010 Feasibility Assessment and Conceptual Development Report does not conclusively prove that landfill materials are not under all portions of the liner; however, they have demonstrated a willingness to work with Fort Drum PW to review and approve a proper design as previously summarized in pages 17 and 18 of the Feasibility Assessment. Any further testing that could impact the liner would require a Work Plan to be submitted through the Fort Drum PW-Environmental Division to obtain NYSDEC's approval.

Currently, the NYSDEC has not approved a specific investigation and/or liner testing program for this specific project. However, recent discussions with Ft. Drum PW-Engineering and past discussions and experience on similar projects reviewed by the NYSDEC lend us to determine that the best approach will be to use intrusive techniques to confirm that there is no waste under the proposed running track. Further, our objective will be to confirm the liner location, define and/or confirm the non-existence of waste under the liner, or verify that the location of the 40-acre landfill mass is at least 20 feet away from the proposed running track.

Provided below is a description of our approach, a contingency emergency response plan, and addendum to the Accident Prevention Plan/Site Safety and Health Plan.

Approach

Direct push hydraulic drilling techniques are considered to be the least destructive means to gather site data and accomplish project objectives. The intent of this intrusive approach, as opposed to test pitting, is to minimize impacts to the subject 20-mil liner or 40 mil liner, which have been in-place for at least 22 years. Our investigational approach proposes 43 borehole locations along 100-foot spacing to fully address concerns that may be raised by the NYSDEC. The only exception to this approach is along the northwestern boundary where the spacing is slightly greater. Each proposed borehole location will be surveyed prior to installation. A proposed borehole location map is provided as Figure 1.

Prior to advancement of each borehole, a 5-foot by 5-foot area of the liner will be exposed by hand and a small, precise incision will be established for the borehole installation. Specific care will be taken to minimize damage to the liner.

Each borehole will be advanced to 25 feet below grade using a Geoprobe® 6600 rubber-tracked drilling unit to minimize damage to the existing cover. Our proposed drilling subcontractor will be Zebra Environmental Corp. Each borehole will be sampled continuously, the objective being to confirm the presence and/or absence of waste with the entire length of the borehole. A Macro Core (MC) open sampler will be utilized to collect the soil samples. These samplers are open tube design and measure approximately 2-inches in diameter by 58-inches in length. The samplers are fitted with a removable cutting shoe and clear acetate liner. Samples will be collected at five-foot intervals below land surface to define subsurface conditions. If borehole

"cave in" is significant at the lower depths, it may be necessary to use the closed piston assembly that fits into the MC cutting shoe to ensure sample is collected from the desired interval.

If waste is not encountered, a two-foot by two-foot 30-mil PVC patch will be re-seamed into the liner, in accordance with the manufacturer's recommendations and NYSDEC regulations (Attachment 1). A cut sheet is also provided in Attachment 1. Our proposed lining subcontractor will be Chenango Contracting, Inc. The PVC glue is not recommended to be used in temperatures less than 40 to 50° Fahrenheit; there is a section in the attached manual which discusses cold weather chemical seaming that will be executed by our proposed lining subcontractor (Chenango Contracting, Inc. (Attachment 1).

If waste is encountered, another borehole will be added to the investigation to define the limits of waste. H2H assumes up to five boreholes may be required when such conditions are encountered. Any borehole stepout will be communicated to A&C as well as Fort Drum PW-Environmental Division.

Contingency Emergency Response Plan

Unknown items (i.e., unidentifiable waste, UXO, drums) may be encountered that require additional characterization or special handling prior to disposal. H2H will meet with Fort Drum PW-Environmental Division to develop a site-specific plan to describe the processes to assess and stabilize unknown or unexpected items (i.e., unidentifiable waste, UXO, drums). The plan will address the process for assessing and stabilizing unknown items that are discovered during excavation and sorting of landfill material in the areas in which intrusive activities will be conducted.

The initial assessment of unknown items will consist of characterization by visual or physical inspection means to: (a) determine immediate hazards, (b) tentatively identify the type of container or item and the contents, (c) determine whether the item is safe to move, and (d) establish guidelines for segregating, stabilizing, or overpacking the assessed item for proper disposal. In extreme cases, an immediate threat may be identified and the containment or stabilization of the unknown item(s) may include emergency response.

Various methods will be used to characterize and stabilize the items for disposal. In some cases, item-specific disposition plans may need to be written to direct stabilization. Special enclosures including use of filtered portable ventilation systems may be used to limit exposure to concentrations of airborne contaminants in excess of the relevant PEL (permissible exposure limit) or TLV (threshold limit value). A flow chart will be developed to outline the process for handling unknown items.

It is anticipated at this time that the following proposed actions will be performed if during drilling an item or soil is exposed and there is any immediate response trigger such as an obvious fire or any indication of spontaneous reaction such as visible emissions, discoloration, blistering, rising temperature, or smoke. Fort Drum PW-Environmental Division review and approval of these proposed actions is required.

- The driller will cover the material with sand or soil staged nearby;
- Drilling personnel will activate the portable fire suppressant system if further reduction of flame spread is needed;
- Personnel in the drilling work area shall notify the operations supervisor and evacuate; and,
- Operations will call the designated site emergency personnel.

For clarification, unknown items are defined as*: Items (containers) whose contents may not be immediately apparent. Examples include gas cylinders, drums, cans, bottles or other containers that appear to be intact and may contain radioactive, reactive or hazardous gases, liquids, solids, or fine powders. Contents may pose an immediate danger to workers because of content or configuration.*

During the investigation, other conditions may occur that are not expected and may trigger an immediate response. These include: surveillance and diagnostic instruments indicating unusually high emissions and VOC measurements, significant release of chemicals from containers or soil, non-meteorological rising temperature, and exothermic reactions including explosion or deflagration. Immediate response will follow the steps provided for in the procedures to be developed. Unknown items suspected to pose an imminent danger have the highest priority and are managed first. If a potentially explosive unknown item is identified, site investigative/remedial activities will be paused, operations notified, and passive means used to assess the potential hazard or condition. Unknown items will not be permitted outside of the drilling area unless specifically authorized.

A list of chemicals that were used or may have been disposed of in the landfill will be included in the contingency plan. The list will include chemical compounds and substances that were identified during historical review. Chemicals to be included in the listing are those that have one or more of the following characteristics: known human carcinogens, high acute or chronic toxicity, and known human reproductive toxins.

Accident Prevention Plan/Site Safety and Health Plan Addendum

H2H will amend the site-specific Accident Prevention Plan/Site Safety and Health Plan (APP/SSHP) for the ASL SOW. The APP will detail how safety and health will be managed during the project. The APP will be prepared in accordance with Engineer Manual (EM) 385-1-1 and submitted to Fort Drum DPW for review and/or approval. The health and safety documentation will include:

- Background information; A description of H2H's health and safety policy;
- A statement of applicability;
- An outline of responsibilities and lines of authority;
- Identification of subcontractors and suppliers;
- A summary of training, safety and health inspections;
- Accident reporting procedures;
- A description of our medical support plan;

- Identification of personal protective equipment (PPE) required for each subtask; and
- A presentation of required plans and site-specific hazards and controls for this phase of the project.

The amended APP will also include applicable figures, tables, and key health and safety documentation such as a site-specific Activity Hazard Analysis (AHA), resumes of key health and safety personnel, a SSHP along with applicable safety forms, and material safety data sheets (MSDS) for applicable chemicals brought on-site to be used during field activities. The amended APP will be specifically developed for use for the ASL SOW.

It is anticipated that H2H will provide task oversight, health and safety oversight, borehole logging/documentation, and reporting. A&C will pin flag and survey the proposed boreholes outlined in the Final Work Plan while Zebra Environmental will provide geoprobe drilling services and Chenango Lining will perform lining repair/testing services. It is anticipated that this task will take twenty days to complete; which will be initiated after the Work Plan and APP/SSHP are finalized and approved. A summary report will be prepared to document the existing condition of the landfill cap, revise and/or confirm the location for the extent of liner and waste mass, and identify further data needs (if any).

H2H appreciates the opportunity to work on this important project. If you have any questions regarding details of this scoping feel free to contact me at (518) 270.1620 ext. 106.

Very truly yours,

H2H Associates, LLC

Mark A. Williams, P.G.
Task Manager

Attachment

Copy: P. Favret (USACE-NAN Fort Drum)
P. Zang (Fort Drum – PW Environmental)
F. Stone (Fort Drum – PW Engineering)
B. Hanchek (Fort Drum – PW Engineering)
R. May (Fort Drum – PW Engineering)
S. St. Joseph (Fort Drum – PW Engineering)
A. Hall (H2H Associates, LLC)

PROPOSED GEOPROBE® BOREHOLE LOCATION (NOVEMBER 2012)

SCALE IN FEET (APPROXIMATE)
0 50 100 200

N

DATE		REVISIONS RECORD/DESCRIPTION
	1	
	2	
	3	
	4	
	5	
	6	

THIS DRAWING IS NOT TO BE USED FOR ENGINEERING PURPOSES

DRAWN BY :	MVF
DESIGN BY :	MVF
CHECK BY :	MAW
PROJ. NO :	PROJ. NO
SCALE :	1"=100'-0"
DATE :	10/24/12

BOREHOLE LOCATION MAP

FORT DRUM PUBLIC WORKS - AIRFIELD SANITARY LANDFILL STUDY

FORT DRUM — JEFFERSON COUNTY NY

H2H Associates

FIGURE 1

P:\2012\A&C - Ft. Drum (ASL)\CAD DRAWINGS\BOREHOLE LOCATION MAP.dwg, 10/25/2012 8:39:33 AM, mvanlue

ATTACHMENT 1

WATERSAVER PVC

GEOMEMBRANE LINER
ENGINEERING SPECIFICATION GUIDE

POLYVINYL CHLORIDE (PVC)

PROPERTIES	TEST METHOD	SPECIFIED VALUES				
Thickness	ASTM D 5199	20 ± 1 mil 0.51 ± 0.03 mm	30 ± 1.5 mil .76 ± .04 mm	40 ± 2 mil 1.02 ± .05 mm	50 ± 2.5 mil 1.27 ± .06 mm	60 ± 3 mils 1.52 ± .08 mm
Tensile Properties	ASTM D 882 Min					
Strength at Break		48 lbs/in 8.4 kN/m	73 lbs/in 12.8 kN/m	97 lbs/in 17.0 kN/m	116 lbs/in 20.3 kN/m	137 lbs/in 24.0 kN/m
Elongation		360%	380%	430%	430%	450%
Modulus @ 100%		21 lbs/in 3.7 kN/m	32 lbs/in 5.6 kN/m	40 lbs/in 7.0 kN/m	50 lbs/in 8.8 kN/m	60 lbs/in 10.5 kN/m
Tear Strength	ASTM D 1004 Min.	6 lbs 27 N	8 lbs 35 N	10 lbs 44 N	13 lbs 58 N	15 lbs 67 N
Dimensional Stability	ASTM D 1204 Max Chg	4%	3%	3%	3%	3%
Low Temperature Impact	ASTM D 1790 Pass	-15ºF -26ºC	-20ºF -29 ºC	-20ºF -29ºC	-20ºF -29ºC	-20ºF -29ºC
Index Properties						
Specific Gravity	ASTM D 792 Typical	1.2 g/cc	1.2 g/cc	1.2 g/cc	1.2 g/cc	1.2 g/cc
Water Extraction % loss (max.)	ASTM D 1239 Max Loss	0.15%	0.15%	0.20%	0.20%	0.20%
Average Plasticizer Molecular Weight	ASTM D 2124	400	400	400	400	400
Volatility Loss	ASTM D 1203 Max Loss	0.9%	0.7%	0.5%	0.5%	0.5%
Soil Burial Break Strength Elongation Modulus at 100%	G160 Max Chg	 5% 20% 20%	 5% 20% 20%	 5% 20% 20%	 5% 20% 20%	 5% 20% 20%
Hydrostatic Resistance	ASTM D 751 Min.	68 psi 470 kPa	100 psi 690 kPa	120 psi 830 kPa	150 psi 1030 kPa	180 psi 1240 kPa
Seam Strengths						
Shear Strength	ASTM D 882 Min	38.4 lbs/in 6.7 kN/m	58.4 lbs/in 10 kN/m	77.6 lbs/in 14 kN/m	96 lbs/in 17 kN/m	116 lbs/in 20 kN/m
Peel Strength	ASTM D-882 Min	12.5 lbs/in 2.2 kN/m	15 lbs/in 2.6 kN/m	15 lbs/in 2.6 kN/m	15 lbs/in 2.6 kN/m	15 lbs/in 2.6 kN/m

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QUALITY STANDARDS

MANUFACTURE, PRE-ASSEMBLY, AND INSTALLATION

OF

GEOMEMBRANES

2005

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TABLE OF CONTENTS

1 GENERAL INFORMATION

1.1 PURPOSE

The purpose of this manual is to provide details of Manufacturing Quality Control (MQC), Manufacturing Quality Assurance (MQA), Construction Quality Control (CQC), and Construction Quality Assurance (CQA) for the manufacture, pre-assembly, and installation of geomembrane products supplied by Watersaver Company, Inc (WCI).

1.2 CONFORMANCE WITH PROJECT SPECIFICATIONS

It is the intent of WCI to comply with the generally recognized MQC, MQA, CQC and CQA standards and practices for governmental, manufacturing, pre-assembly and installing industries. If required, modification to this manual can be made via addendum in order to accommodate individual job specific requirements.

2 GEOMEMBRANE MANUFACTURING

2.1 RAW MATERIALS

WCI requires all manufacturers to certify that their sheeting is formulated and manufactured from 100% virgin raw materials that are specifically compounded for use in hydraulic structures. See Appendix V for additional raw material qualifications.

The manufacturers are required to submit written certification that each lot of material meets or exceeds WCI specifications located in Appendix I.

2.2 ROLL GOODS

All roll goods received from WCI suppliers are visually inspected for imperfections and contaminants. Manufacturer certifications show that physical property testing is conducted on each lot of roll goods. Materials tested must meet or exceed the values specified. The following properties are evaluated:

PROPERTY	TEST METHOD (Non-reinforced)	TEST METHOD (Reinforced)
Thickness (inches, nominal)	ASTM D751	ASTM D751
Breaking Factor (lbs/in)	ASTM D882	ASTM D751
Elongation at Break (percent)	ASTM D882	N/A
Modulus @ 100% Elongation	ASTM D882	N/A

3 GEOMEMBRANE FABRICATION

3.1 FACTORY FABRICATION

Individual calendered widths (roll goods) are factory pre-assembled into large panels to minimize field seaming during installation.

Factory seams are produced using chemical, dielectric or thermal method. Each seaming method is tailored for optimum seam strength.

Nominal seam widths, Non-reinforced 1" / Reinforced 1 ½" scrim to scrim.

Factory pre-assembly production records identify each panel by panel number, size, date of pre-assembly, material lot number and seam station identification. Each panel is prominently marked with the panel number and panel size to coincide with production records.

3.2 IN-FACTORY SEAM TESTING

Visual and non-destructive inspection is performed on 100% of factory pre-assembled seams, including ASTM D4545, through a combined use of sections 7.1.1 (OSHA limits) and 7.1.4. Seam type will determine procedure and ratio. All seams are warranted for two (2) years.

In addition, WCI performs destructive testing on factory fabricated seams in order to verify quality compliance.

Samples of factory seams are taken at the beginning and at the end of each production shift. All seams are tested for compliance and the results are archived at the WCI facility. Test results are available upon request (job specific).

3.3 FACTORY SEAM REQUIREMENTS

All factory seams are tested for Bonded Seam and Peel strength in accordance with industry (ASTM) standards. Specified values and test methods are listed in Appendix I.

Primary and secondary seaming methods are listed by material in Appendix IV.

4 PACKAGING, HANDLING, AND TRANSPORTATION

4.1 PACKAGING AND HANDLING

After factory pre-assembly, the geomembrane panels are double accordion folded on a pallet or rolled on a cardboard core. Folded panels are shrink wrapped (light reflectant) using a water and UV resistant polymer sheeting with outer cardboard insert banded to a heavy duty wooden pallet. Rolled panels are wrapped in a protective layer and shrink wrapped (light reflectant). All pallets/rolls are identified by panel size, type, and number. Geomembrane panels delivered to the jobsite are unloaded on level ground, stored in their original, unopened containers in a secure, dry area, and protected from weathering. Whenever possible, a six-inch minimum air space between the pallets should be maintained, especially when the geomembrane panels are to be stored over an extended period of time. Pallets must not be stacked. Banding is not to be removed from the pallet until actual deployment, to insure stability.

Material Safety Data Sheets (MSDS) to be provided on all chemicals which include handling and personal protection during usage.

4.2 TRANSPORTATION

Transportation of the geomembrane will be arranged by WCI through an independent trucking firm, and will be shipped via a closed or flat bed trailer. Adequate tarps (flat bed) are recommended during transport. It is the responsibility of the receiver at the time of delivery to indicate condition of shipment on the Bill of Lading. Any visual damage MUST be noted in WRITING and WCI should be contacted within 24 hours or (extreme conditions) before accepting delivery.

5 INSTALLATION

5.1 ANCHORAGE SYSTEM

Unless otherwise specified, the anchor trench should be excavated by the earthwork contractor or others to the lines and grades shown on the design drawings. Store excavated material away from the area to be lined.

Complete trenching process prior to geomembrane placement.

A smooth transition surface from anchor trench to subgrade should be provided.

Following the completion of the seaming operation, the anchor trench shall be backfilled and compacted (as soon as possible) by the earthwork contractor to lock in the geomembrane. During ongoing backfilling operations, backfill should be kept a minimum of 10 feet from un-seamed areas.

5.2 SUBGRADE

5.2.1 Preparation

Surfaces to be lined will be free of all rocks, roots, vegetation, sharp objects, or debris of any kind. The surface shall provide a firm, unyielding foundation for the geomembrane with no sharp or abrupt changes in grade.

If an herbicide is required, it must be suitable for use with geomembranes and shall be applied as per the manufacturer recommendations. Suitability for use with the geomembrane shall be confirmed by the herbicide manufacturer.

5.2.2 Repair and Maintenance

Prior to geomembrane installation, the surfaces to be lined shall be inspected for acceptability by the installers. Any necessary repairs will be made by the owner or earthwork contractor. It is the responsibility of the owner or earthwork contractor to maintain the integrity of the subgrade prior to, and during the geomembrane installation. This includes the control of ground water in the area to be lined.

5.3 GEOMEMBRANE PANEL PLACEMENT

5.3.1 Panel Location

Install the geomembrane as indicated in the approved layout drawing. The installer may modify the proposed layout to best meet the intent of the project specification and/or to accommodate existing site conditions.

5.3.2 Weather Conditions

Consideration must be given to low temperature (<40°F) handling characteristics of the geomembrane before installation, in some cases, before the liner is actually ordered. Please contact Watersaver Company, Inc. if the above condition exists.

5.3.3 Geomembrane Panel Deployment

The number of panels to be deployed in any day shall be limited to the number of panels which can be seamed or secured that day.

The geomembrane shall be installed in a relaxed manner and free of tension and stress. In areas where grade transitions occur, “bridging” or “trampolining” of the geomembrane shall not be allowed. To accommodate grade transition, adequate slack is necessary. Wrinkling of the geomembrane is acceptable and indicates proper slack consideration.

Deploy geomembrane panels to meet a minimum panel overlap of six inches. During cold weather deployment, consideration must be given to residual packaging geometry (ability to lay flat) as it relates to installation quantity. Shingle all panels in the down gradient direction whenever possible.

5.3.4 Preparation for Seaming

WCI approved installer shall verify the following:

- All personnel walking on the geomembrane liner shall have smooth soled shoes. Personnel working on the geomembrane shall not smoke and shall not engage in activities that could damage the geomembrane.
- Tools used in the installation process shall be properly stored and carried. Knives and other sharp objects shall be carried in protective sheaths.
- The method used to unfold panels will not cause damage to the geomembrane or underlying geosynthetics.
- Any geosynthetic elements directly underlying the geomembrane shall be clean and free of debris.
- Adequate temporary anchoring shall be placed to prevent wind uplift of the geomembrane panels. Typical items are sandbags and ballast tubes. In cases of high wind, continuous loading may be required along the edges of the geomembrane panel.
- High traffic areas may require temporary wear surfaces (i.e. geotextile, additional geomembrane, clean fill, etc.).
- Vehicles shall not be allowed on the geomembrane unless approved by the installer.
- Chemical cleaners, seaming agents and fuels shall be stored separately, away from geomembrane panels. Spill resistant containers shall be used while working directly on the liner and shall be stored upon a sacrificial material such as scrap geomembrane or heavy cardboard.

5.4 FIELD SEAMING

5.4.1 Seam Preparation

See Appendix IV for Primary and Secondary Field Seaming Methods

The overlapped geomembrane panels must be clean at the surfaces to be joined. Any foreign material (e.g. dirt, moisture) must be removed with clean, dry rags before seaming commences.

If seaming must be conducted over rough substrate, seaming boards are recommended. A one-foot by eight or ten-foot pine shelf board will work well as a seaming platform.

5.4.1.1 Repairs

All fish mouths shall be slit, laid flat, bonded, then patched with a round or oval patch of the same geomembrane material. All patches shall extend a minimum of six inches beyond the repair area in all directions, and seamed along the entire perimeter.

5.4.2 Chemical Fusion Field Seaming

Chemical fusion agent shall be applied between the two surfaces to be joined. These surfaces shall be mated together and pressure applied to the upper surface by means of a roller (high durometer rubber, nylon, or steel).

A sufficient amount of chemical fusion agent shall be applied between the two geomembrane surfaces to be joined so when rolled, a thin excess of agent will be forced out of the seam. Any excess chemical agent shall be wiped from the geomembrane. The lower of the two surfaces to be joined shall be completely wet by the chemical fusion agent. See Field Seam Geometry Table in Appendix III.

If any discontinuities are noted, allow approximately ½ hour before reapplying agent. This process can be expedited by using artificial heat.

5.4.3 Cold Weather Chemical Fusion Field Seaming

Generally for cold weather seaming, when the geomembrane surface is below 50°F, the surfaces to be joined must be preheated.

If the soil beneath the geomembrane is frozen, the application of heat to the area to be seamed may result in moisture condensing between the surfaces to be joined. This condition may be eliminated by placing a seaming board, or slip-sheet made from the same geomembrane material, between the frozen surface and the geomembrane to be seamed.

See Field Seam Geometry Table in Appendix III.

5.4.4 Thermal Fusion Field Seaming (Continuous Width)

The two most common seaming methods are Hot Wedge and Hot Air. Either method is capable of producing a quality seam. These units are equipped with speed and temperature controls with digital (LED) readout along with pressure adjustment.

- Thin gauge materials (<30 Mil) combined with high ambient temperatures can affect seam quality.
- Hand Held Leister or equal can be used for pipe boots, details and patching for the majority of non-crystalline geomembranes.
- Each method must be capable of producing sufficient amount of controlled heat and pressure applied to the seam overlap contact zone, resulting in a continuous thermal weld.
- Pressure squeeze out along seam edge to be kept to a minimum in order to maximize overall seam thickness.
- Exercise caution when operating welder in direct contact with subgrade. Drive (pressure) rollers must be kept clean at all times.

5.4.5 Pipe Penetrations

Penetrations are sealed via the use of WCI factory fabricated pipe seals. Pipe seals are thermally constructed using the same material as the specified geomembrane. For reinforced material, the tube section of the pipe seal can be constructed using non-reinforced parent material. The method of bonding is as outlined in the field seaming section.

5.5 LINING SYSTEM ACCEPTANCE

WCI authorized installer shall retain responsibility for the geomembrane installation until acceptance by the Engineer and/or Owner.

The geomembrane liner installation will be accepted by the Owner when the following conditions have been met:

1. Installation of the geomembrane is complete.

2. Verification of the integrity of all seams and repairs, as required by the specifications, is complete.

3. All documentation pertaining to the geomembrane installation is completed and submitted to the Owner/Engineer.

6 FIELD QUALITY ASSURANCE

6.1 OVERVIEW

Field seam quality shall be demonstrated by non-destructive (NDT) and destructive (DT) test methods.

The primary purpose of the NDT method is to demonstrate continuity along the entire length and to validate 100% of the field seam. NDT methodology is described in section 6.3 below.

The purpose of the DT method is to determine the quality of a given seam by removing a representative seam sample, and testing the given sample for compliance with accepted applicable industry standards. Testing may be conducted either at the job site, or at a remote testing laboratory. DT methodology is discussed in section 6.4 below.

6.2 TEST STRIP/TRIAL SEAMS

A general requirement of most CQA Documents is that “test seams” or “test strips” be made on a periodic basis. Test strips generally reflect the quality of field seams but should never be used solely for the final field seam acceptance. Final field seam acceptance requirements should be specified in the contract specification and should include a minimum level of destructive testing of the field seams. Test strips are made to minimize the amount of destructive sampling/testing on the finished panels. Typically these test seams, for each seaming crew, are made once per day, or every time equipment is changed, or if significant changes in site conditions are noted, or as required in the contract specification. The purpose of these tests is to establish that proper seaming materials, temperatures, pressures, rates, and techniques along with the necessary geomembrane pre-seaming preparation are being accomplished. Test strips may be used for CQA/CQC evaluation, and must be of sufficient size in order to conduct required testing.

While cursory test seams are evaluated, the seaming crew may begin and continue to work as long as the field seam being constructed is completely traceable and identifiable. If a test seam fails to meet the field seam design specification, then an additional test seam sample is constructed and re-tested by the same seaming crew, equipment, and materials.

Field seams will not be accepted unless CQC seam test result criteria as per the design specification are met.

One of the following procedures shall apply whenever a sample fails a destructive test:

1. The field seam shall be reconstructed between two test locations shown to have acceptable results; one located on either side of the failed sample.

2. The seam shall be traced outward to intermediate points (a maximum of 10 feet from the failed sample in each direction) and sampled for additional testing. If the samples are found to provide acceptable test results, the seam is reconstructed between these two sample locations. If an intermediate sample fails, the process is repeated to establish the zone in which the seam is to be reconstructed. All reconstructed seams shall be defined by two locations from which samples passing other destructive tests have been taken.

Reconstruction of field seams shall be accomplished by removing the suspect seam, repositioning panels and re-seaming, or by installing a cap strip to cover the seam under reconstruction. Cap stripping shall extend a minimum of six inches beyond the reconstructed seam in all directions.

For geomembrane seams that are bonded by the chemical fusion method, the seams must be cured prior to testing. Without the application of heat, the cure times can range from a few hours to a few days. Accelerated curing for on site CQC testing requires the use of an oven or other suitable heat source to condition the seam samples from 1 to 16 hours in a temperature range of 122°F to 158°F. Following the accelerated cure period, a post-cure conditioning period of at least ½ hour at ambient conditions prior to testing is required.

During the CQC and CQA test requirement periods, a liner should not be covered, and it cannot be placed into service. This will insure the ease of repairing or reconstructing in the event it is required. During this period, it is imperative that the liner be properly ballasted and otherwise secured so as to prevent wind or unusual weather damage.

6.3 NON-DESTRUCTIVE SEAM TESTING

6.3.1 Test Methods

The following test methods are acceptable for non-destructive testing of field seams:

A. Air Lance
B. Vacuum Chamber

See Appendix II for application of these methods based on seam type or location.

Testing Reference Refer to ASTM D 4437-84.

6.3.2 Remedial Action

If unbonded areas are located, they can often be repaired by using detail method 5.4 or 5.4.1.1. All patches shall extend a minimum of six inches beyond the area in all directions.

6.4 DESTRUCTIVE SEAM TESTING

6.4.1 Sampling Frequency

Destructive seam testing can be conducted along completed field seams at intervals of 1000 feet (or at intervals indicated in the project specification, and as addressed by addendum to this document). Wherever possible, test strips should be taken out of the anchor trenches so as not to disturb the integrity of the functional lining system.

6.4.2 Sampling Procedure

Samples shall be removed from the completed geomembrane seam by the installer. The sample shall be labeled in a clear and logical manner. The sample location must be identified and recorded.

Any holes in the geomembrane resulting from destructive seam sampling shall be immediately repaired by patching the sampled area with identical geomembrane material. The patch must extend a minimum of six inches beyond the repair area in all directions. The continuity of repaired sampling locations shall be confirmed via NDT methods described above.

6.4.3 Sample Geometry

The *minimum* sample geometry shall be as follows:

Sample width shall be determined as the width of the field seam plus six inches on both sides of the seam.

Sample length can be up to forty-eight (48”) inches for non-reinforced material and can be up to one hundred four (104”) inches for reinforced material.

See Appendix III for seam diagram.

6.4.4 Disposition of Samples

The sample described above shall be cut into three equal segments. One segment of the sample shall be submitted for laboratory (or field) testing; one segment to the installer, and the remaining segment to the owner.

6.4.5 Sampling and Testing

6.4.5.1 Conditioning

Conditioning of all samples prior to testing is imperative. Field seams produced using a chemical fusion agent must be allowed to cure until the required strength values can be achieved. *Accelerated curing can be accomplished by conditioning the samples at temperature of 122°F-158°F for sixteen hours. Following the accelerated cure period, a post-cure conditioning period of at least ½ hour at ambient conditions prior to testing is required. *Ref: EPA/530/SW-91-051-5/91

Chemical seam samples shall be considered ready for testing when the chemical fusion agent odor is no longer detectable.

6.4.5.2 Sampling

Test specimens shall be prepared as per Section 6.4.3.

6.4.5.3 Testing

Specimens shall be tested in order to determine bonded seam strength and peel adhesion. Testing Methods per ASTM procedures indicated by Appendix I.

A. Bonded Seam Strength (ASTM D882)

Non-reinforced Material

Specimen dimensions shall be one inch in width and shall extend a distance of four inches (4") on both sides of field seam. Samples must be cut in a manner which eliminates nicks or tears in the specimen which could cause premature failure (refer to ASTM D882 for further information). Specimens must be cut so that the long dimension of the specimen is perpendicular to the length of the seamed sample.

Reinforced Material (ASTM D751)

Specimen dimensions shall be four inches (4") in width and shall extend a distance of four and one-half (4-1/2") on both sides of field seam. Samples must be cut in a manner which eliminates nicks or tears in the specimen which could cause premature failure (refer to ASTM D882 for further information). Specimens must be cut so that the long dimension of the specimen is perpendicular to the length of the seamed sample.

B. Peel Adhesion (ASTM D882)

Non-reinforced and reinforced material.

Prepare specimens as described above for bonded seam strength.

C. Quantity of Specimens

A total of ten specimens shall be cut from the sample. Five specimens will be used to perform bonded seam strength testing with the remaining five specimens to be used for peel adhesion testing. Details of the test procedures are outlined in ASTM D751, Modified (Bonded Seam Strength), and ASTM D413, Modified (Peel Adhesion). Specimens to be selected (cut) alternately from samples (i.e. peel, shear, peel).

6.4.6 Acceptance of Destructive Test Results

See Appendix I for minimum specified seam strength values.

6.4.7 Remedial Action – Destructive Test Failure

One of the following procedures shall apply whenever a sample fails a destructive test:

1. The field seam shall be reconstructed between two test locations shown to have acceptable results; one located on either side of the failed sample.

2. The seam shall be traced outward to intermediate points (a maximum of 10 feet from the failed sample in each direction) and sampled for additional testing. If the samples are found to provide acceptable test results, the seam is reconstructed between these two sample locations. If an intermediate sample fails, the process is repeated to establish the zone in which the seam is to be reconstructed. All reconstructed seams shall be defined by two locations from which samples passing other destructive tests have been taken.

Reconstruction of field seams shall be accomplished by either removing the suspect seam, repositioning panels and re-seaming, or by installing a cap strip to cover the seam under reconstruction. Cap stripping shall extend a minimum of six inches beyond the reconstructed seam in all directions.

6.4.8 Verification of Repairs

Any repair requiring a patch or cap strip shall be identified on the as-built drawing. Each repair shall undergo non-destructive testing as described in section 6.3 above. Repairs which pass the NDT shall be taken as an indication of proper repair. Failed NDT's will result in reconstruction and re-testing of the repair area until a passing result is obtained.

REFERENCES

ENVIRONMENTAL PROTECTION AGENCY (EPA)
Lining for Waste Containment and Other Impoundment Facilities
EPA/600/2-88/052
Inspection Techniques for the Fabrication of Geomembrane Field Seams
EPA/530/SW-91/051 – 5/91

AMERICAN SOCIETY FOR TESTING AND MATERIALS

NATIONAL SANITATION FOUNDATION (NSF)
Joint Committee on Flexible Membrane Liners

Standard 54-1991

PVC Geomembrane Institute

ASTM Committee D – 35.10

APPENDIX I PRODUCT SPECIFICATIONS

Section I	
Polyvinyl Chloride *PVC*	PGI 1104

Section II	
Polypropylene *PP-R*	Carlisle-Syntec Stevens Geomembranes

Section III	
XR-5 **8130 / 8140** *High Performance Geomembrane* **XR-3** **8130** *Potable Water Applications NSF 61*	Seaman Corp

Section IV	
Hypalon *Chlorosulfonated Polyethlene (CSPE)*	Stevens Geomembranes

WATERSAVER PVC

GEOMEMBRANE LINER
ENGINEERING SPECIFICATION GUIDE

POLYVINYL CHLORIDE (PVC)

PROPERTIES	TEST METHOD	SPECIFIED VALUES				
Thickness	ASTM D 5199	20 ± 1 mil 0.51 ± 0.03 mm	30 ± 1.5 mil .76 ± .04 mm	40 ± 2 mil 1.02 ± .05 mm	50 ± 2.5 mil 1.27 ± .06 mm	60 ± 3 mils 1.52 ± .08 mm
Tensile Properties	ASTM D 882 Min					
Strength at Break		48 lbs/in 8.4 kN/m	73 lbs/in 12.8 kN/m	97 lbs/in 17.0 kN/m	116 lbs/in 20.3 kN/m	137 lbs/in 24.0 kN/m
Elongation		360%	380%	430%	430%	450%
Modulus @ 100%		21 lbs/in 3.7 kN/m	32 lbs/in 5.6 kN/m	40 lbs/in 7.0 kN/m	50 lbs/in 8.8 kN/m	60 lbs/in 10.5 kN/m
Tear Strength	ASTM D 1004 Min.	6 lbs 27 N	8 lbs 35 N	10 lbs 44 N	13 lbs 58 N	15 lbs 67 N
Dimensional Stability	ASTM D 1204 Max Chg	4%	3%	3%	3%	3%
Low Temperature Impact	ASTM D 1790 Pass	-15ºF -26ºC	-20ºF -29 ºC	-20ºF -29ºC	-20ºF -29ºC	-20ºF -29ºC
Index Properties						
Specific Gravity	ASTM D 792 Typical	1.2 g/cc	1.2 g/cc	1.2 g/cc	1.2 g/cc	1.2 g/cc
Water Extraction % loss (max.)	ASTM D 1239 Max Loss	0.15%	0.15%	0.20%	0.20%	0.20%
Average Plasticizer Molecular Weight	ASTM D 2124	400	400	400	400	400
Volatility Loss	ASTM D 1203 Max Loss	0.9%	0.7%	0.5%	0.5%	0.5%
Soil Burial Break Strength Elongation Modulus at 100%	G160 Max Chg	 5% 20% 20%	 5% 20% 20%	 5% 20% 20%	 5% 20% 20%	 5% 20% 20%
Hydrostatic Resistance	ASTM D 751 Min.	68 psi 470 kPa	100 psi 690 kPa	120 psi 830 kPa	150 psi 1030 kPa	180 psi
Seam Strengths						
Shear Strength	ASTM D 882 Min	38.4 lbs/in 6.7 kN/m	58.4 lbs/in 10 kN/m	77.6 lbs/in 14 kN/m	96 lbs/in 17 kN/m	116 lbs/in 20 kN/m
Peel Strength	ASTM D-882 Min	12.5 lbs/in 2.2 kN/m	15 lbs/in 2.6 kN/m	15 lbs/in 2.6 kN/m	15 lbs/in 2.6 kN/m	15 lbs/in 2.6 kN/m

WATERSAVER PP-R

GEOMEMBRANE LINER
ENGINEERING SPECIFICATION GUIDE

POLYPROPYLENE

Reinforced Geomembrane

Physical Property	Test Method	Property of Unaged Sheet	Property After Aging 30 days @ 185ºF
Tolerance on nominal thickness, %	ASTM D 5199	± 10	
Thickness over scrim, in (mm) 36-mil 45-mil 60-mil	ASTM D 4637 Optical Method	 0.010 (0.254) min 0.013 (0.330) min 0.018 (0.457) min	
Mass per unit area, lb/ft^2 (g/ft^2) (kg/m^2) 36-mil 45-mil 60-mil	ASTM D 5261	 0.17 (77) (0.83) typical 0.21 (95) (1.03) typical 0.29 (132) (1.42) typical	
Breaking strength, lbf (kN) (grab tensile at strain rate of 12 in./min) 36-mil 45 & 60-mil	ASTM D 751 Grab Method (A)	 200 (0.9) min 260 typical 250 (1.1) min 300 typical	 200 (0.9) min 260 typ. 250 (1.1) min 300 typ.
Elongation at break of fabric, %	ASTM D 751	25 typical	25 typical
Tearing strength, lbf (N) (2 in/min strain rate) 36-mil 45 & 60-mil	ASTM D 5884 (max. load)	 80 (356) min 130 (578) typ. 100 (445) min 160 (712) typ.	
Low temperature flexibility, ºF (ºC)	ASTM D2136 1/8 in mandrel 4 hour @ Temp.)	-40 (-40) max. -50 (-46) typical	
Linear Dimensional Change (shrinkage), %	ASTM D 1204		± 1.0 max. - 0.5 typical
Ozone resistance, 100 pphm, 168 hrs	ASTM D 1149	No cracks	No cracks
Resistance to water (distilled) absorption After 30 days immersion 122ºF (50ºC) Change in mass, %	ASTM D 471 (coating compound)	1.0 max. 0.5 typical	
Hydrostatic resistance, lbf/in^2 or psi (MPa) (Mullen burst) 36-mil 45-mil 60-mil	ASTM D 751 Procedure A	 350 (2.4) min 400 (2.8) typical 450 (3.1) typical 500 (3.4) typical	 350 (2.4) min 400 (2.8) typical 450 (3.1) typical 500 (3.4) typical
Water vapor permeance, Perms	ASTM E 96	0.10 max. 0.05 typical	
Puncture resistance, lbs (N) 36-mil & 45-mil 60-mil	ASTM D 4833 (index puncture)	85 (378) min. 110 (489) typical 120 (534) typical	
Resistance to xenon-arc weathering[1] Xenon-Arc, 10,080 kJ/m^2 total radiant exposure, visual condition at 10X	ASTM G 155 0.70 W/m^2 80ºC B.P.T.	No cracks No loss of breaking or tearing strength	
Typical Fabricated Seam Properties: [2]			
Bonded Seam Strength, lbs (kN/m)	ASTM D-751 Modified	200 (0.89)	
Peel Adhesion, lbs (kN/m)	ASTM D-413, Modified	20 (3.5) or FTB	

[1] Approximately equivalent to 8000 hours exposure at 0.35 W/m^2 irradiance B.P.T. is black panel temperature.
[2] Factory bonded seam strength is the responsibility of the fabricator.

WATERSAVER PP-R

GEOMEMBRANE LINER
ENGINEERING SPECIFICATION GUIDE

POLYPROPYLENE

Reinforced Geomembrane

Minimum Specifications

PROPERTY	TEST METHOD	TYPICAL VALUES		
Gauge (nominal) mils (mm)		.036 (0.90)	.045 (1.14)	.060 (1/52)
Plies, Reinforcing		1	1	1
Thickness, mils, Minimum 1. Overall, mil (mm 2. Over scrim, mil (mm)	ASTM D-751 Optical Method	.036 (0.90) 11 (0.28)	.044 (1.12) 12 (0.30)	.057 (1.45) 18 (0.46)
Breaking Strength-Fabric min. lbf. (kN)	ASTM D-751 Method A	275 (1.22)	300 (1.34)	325 (1.45)
Low Temperature °F (°C)	ASTM D-2136, 1/8 in. Mandrel, 4 hrs., Pass	-65 (-54)	-65 (-54)	-65 (-54)
Puncture Resistance, min Lbs (kN)	FTMS 101C Method 2031	350 (1.56)	400 (1.78)	425 (1.89)
Tear Strength, min lbf. (kN)	ASTM D-5884	100 (0.45)	100 (0.45)	100 (0.45)
Dimensional Stability, (% chg, max)	ASTM D-1204 180°F/82°C, 1 hr	-0.5 (-0.5)	-0.5 (-0.5)	-0.5 (-0.5)
Hydrostatic Resistance, min. psi, (MPa)	ASTM D-751 Method A, Procedure 1	375 (2.58)	400 (2.75)	425 (2.93)
Ply Adhesion, min, lbs./in. (kN/m)	ASTM D-413 Machine Method Mod.	30 (5.25)	30 (5.25)	30 (5.25)
Water Absorption, max, % wt chg	ASTM D-471, 30 days @ 70°F (21°C)	<1.0	<1.0	<1.0
Env. Stress Crack Resistance (Min. hrs. w/o failure)	ASTM D-1693 3000 hrs.	Unaffected by ESC	Unaffected By ESC	Unaffected By ESC
UV Resistance	ASTM G26 Xenon Arc @ 80°C, 4000 hrs.	Pass	Pass	Pass
Typical Fabricated Seam Properties.**				
Bonded seam strength, lbs (kN/m)	ASTM D-751, modified	175 (0.78)	200 (0.89)	200 (0.89)
Peel Adhesion, lbs (kN/m)	ASTM D-413, Modified	20 (3.5) or FTB	20 (3.5) or FTB	20 (3.5) or FTB

** Factory bonded seam strength is the responsibility of the fabricator

WATERSAVER XR-5®

GEOMEMBRANE LINER
ENGINEERING SPECIFICATION GUIDE

XR-5® 8130

High Performance Reinforced Geomembrane

XR-5® 8130 Reinforced	Standard	Metric
Base Fabric Type ASTM D3776	Polyester	
Basic Fabric Weight (nominal ASTM D3776	6.5 oz/yd^2	220/g/m^2
Thickness ASTM D751	30.0 mils min	0.76 mm min.
Weight ASTM D751	30.0 $\pm$ 2 oz/yd^2	1020 $\pm$ 70 g/m^2
Tear Strength ASTM D4533 Trapezoid Tear	35/35 lbs$_f$ min	155 / 155 N min.
Breaking Yield Strength ASTM D751 Grab Tensile	550/550 lbs$_f$ min	2450/2450 N min.
Low Temperature ASTM D2136 4 hr – 1/8" mandrel	Pass @ -30º F	Pass @ -35º C
Dimensional Stability ASTM D1204 212º F – 1 hr	1.5% max each direction	
Adhesion Heat Sealed Seam ASTM D751 Dielectric Weld	35 lb$_f$/2 in min	150 N/5 cm min
Dead Load - Seam Shear Strength ASTM751	2 in seam, 4 hr, 1 in strip 210 lb$_f$ @ 70ºF 105 lb$_f$ @ 160ºF	5 cm seam, 4 hrs, 2.5 cm strip 934 N @ 21º C 467 N @ 70 º C
Bursting Strength ASTM D751 Ball Tip	650 lb$_f$ min 800 lb$_f$ typical	2892 N min. 3560 N typical
Hydrostatic Resistance ASTM D751 Method A	800 psi min	540 N/sq.cm min.
Blocking Resistance ASTM D751 (180ºF/82ºC)	#2 Rating max.	
Adhesion – Ply ASTM D413	15 lbs$_f$/in min or Film Tearing Bond	65 N/2.5 cm min. or Film Tearing Bond
Bonded Seam Strength ASTM D751 as modified by NSF 54	550 lb$_f$ min	2447 N min.
Abrasion Resistance ASTM D3389 (H-18 Wheel 1000 g Load)	2000 cycles (min) before fabric exposure 50 mg/100 cycles max weight loss	
Weathering Resistance ASTM G23 (Carbon-Arc)	8000 hrs (min)-No appreciable changes or stiffening or cracking of coating	
Water Absorption ASTM D471 Section 12, 7 Days	0.025 kg/m^2 @ 70ºF/21ºC 0.14 kg/m^2 max @ 212ºF/100ºC	
Wicking ASTM D 751	1/8 in max.	0.3 cm max.
Puncture Resistance ASTM D4833	250 lb$_f$ min	1112 N min.
Coefficient of Thermal Expansion/Contraction ASTM D696	8 x 10^{-6} in/in/ºF max	1.4 X 10^{-5} cm/cm/ºC max.

WATERSAVER XR-5®

GEOMEMBRANE LINER
ENGINEERING SPECIFICATION GUIDE

XR-5® 8138

High Performance Reinforced Geomembrane

XR-5® 8138 Reinforced	Standard	Metric
Base Fabric Type ASTM D3776	Polyester	
Basic Fabric Weight (nominal) ASTM D3776	6.5 oz/yd^2	220 g/m^2
Thickness ASTM D751	40.0 mils nominal	1.0 mm nominal
Weight ASTM D751	38.0 $\pm$ 2 oz/yd^2	1288 $\pm$ 70 g/m^2
Tear Strength ASTM D4533 Trapezoid Tear	35/35 lbs$_f$ min	155 / 155 N min.
Breaking Yield Strength ASTM D751 Grab Tensile	550/550 lbs$_f$ min	2447/2447 N min.
Low Temperature ASTM D2136 4 hr – 1/8" mandrel	Pass @ -30º F	Pass @ -35º C
Dimensional Stability ASTM D1204 212º F – 1 hr	1.5% max each direction	
Adhesion Heat Sealed Seam ASTM D751 Dielectric Weld	35 lb$_f$/2 in min	150 N/5 cm min
Dead Load - Seam Shear Strength ASTM D751 (modified) Para 4.5.2.19	2 in seam, 4 hr, 1 in strip 210 lb$_f$ @ 70ºF 105 lb$_f$ @ 160ºF	5 cm seam, 4 hrs, 2.5 cm strip 934 N @ 21º C 467 N @ 70 º C
Bursting Strength ASTM D751 Ball Tip	650 lb$_f$ min 800 lb$_f$ typical	2892 N min. 3560 N typical
Hydrostatic Resistance ASTM D751 Method A	800 psi min	5.51 MPa min.
Blocking Resistance ASTM D751 (180ºF/82ºC)	#2 Rating max.	
Adhesion – Ply ASTM D413	15 lbs$_f$/in min or Film Tearing Bond	65 N/2.5 cm. min. or Film Tearing Bond
Bonded Seam Strength ASTM D751 as modified by NSF 54	550 lb$_f$ min	2447 N min.
Abrasion Resistance ASTM D3389 (H-18 Wheel 1000 g Load)	2000 cycles (min) before fabric exposure 50 mg/100 cycles max weight loss	
Weathering Resistance ASTM G23 (Carbon-Arc)	8000 hrs (min)-No appreciable changes or stiffening or cracking of coating	
Water Absorption ASTM D471 Section 12, 7 Days	0.025 kg/m^2 @ 70ºF/21ºC 0.14 kg/m^2 max @ 212ºF/100ºC	
Wicking Shelter-Rite® Procedure	1/8 in max.	0.3 cm max.
Puncture Resistance ASTM D4833	250 lb$_f$ min	1112 N min.
Coefficient of Thermal Expansion/Contraction ASTM D696	8 x 10^{-6} in/in/ºF max	1.4 X 10^{-5} cm/cm/ºC max.

WATERSAVER XR-3®

GEOMEMBRANE LINER
ENGINEERING SPECIFICATION GUIDE

XR-3® 8130 PW

For Potable Water Applications NSF 61 Approved

XR-3® 8130 PW	Standard	Metric
Base Fabric Type	Polyester	
Basic Fabric Weight (nominal	6.5 oz/yd^2	220/g/m^2
Thickness ASTM D751	30.0 mils min	0.75 mm min.
Weight ASTM D751	30.0 ± 2 oz/yd^2	1020 ± 70 g/m^2
Tear Strength ASTM D4533 Trapezoid Tear	35/35 lbs min	155 / 155 N min.
Breaking Yield Strength ASTM D751 Grab Tensile, Procedure A	550/550 lbs min	2450/2450 N min.
Low Temperature ASTM D2136 4 hr – 1/8" mandrel	Pass @ -30º F	Pass @ -35º C
Dimensional Stability ASTM D1204 212º F – 1 hr	1.5% max each direction	
Adhesion Heat Sealed Seam ASTM D751 Dielectric Weld	35 lb/2 in min	150 N/5 cm min
Dead Load - Seam Shear Strength ASTM D751, 4 hr Test	2 in seam, 1 in strip 210 lb @ 70ºF 105 lb @ 160ºF	5 cm seam, 2.5 cm strip 935 N @ 21º C 465 N @ 70 º C
Bursting Strength ASTM D751 Ball Tip	650 lb min 800 lb typical	2890 N min. 3560 N typical
Hydrostatic Resistance ASTM D751 Method A	800 psi min	540 N/sq cm min.
Blocking Resistance ASTM D751 (180ºF/82ºC)	#2 Rating max.	
Adhesion – Ply ASTM D413, Type A	15 lbs/in min or Film Tearing Bond	65 N/2.5 cm min. or Film Tearing Bond
Bonded Seam Strength ASTM D751, Grab Test Method , Procedure A	550 lb min	2450 N min.
Abrasion Resistance ASTM D3389 (H-18 Wheel 1000 g Load)	2000 cycles (min) before fabric exposure 50 mg/100 cycles max weight loss	
Weathering Resistance ASTM G 153 (Carbon-Arc)	8000 hrs (min)-No appreciable changes or stiffening or cracking of coating	
Water Absorption ASTM D471 Section 12, 7 Days	0.025 kg/m^2 @ 70ºF/21ºC 0.14 kg/m^2 max @ 212ºF/100ºC	
Wicking ASTM D 751	1/8 in max.	0.3 cm max.
Puncture Resistance ASTM D4833	250 lb$_f$ min	1110 N min.
Coefficient of Thermal Expansion/Contraction ASTM D696	8 x 10^{-6} in/in/ºF max	1.4 X 10^{-5} cm/cm/ºC max.

WATERSAVER HYPALON®

GEOMEMBRANE LINER
ENGINEERING SPECIFICATION GUIDE

INDUSTRIAL GRADE HYPALON® CHLOROSULFONATED POLYETHYLENE (CSPE)

PROPERTIES	TEST METHOD	SPECIFIED VALUES	
Gauge (nominal) mils (mm)	--	36 (0.9)	45 (1.14)
Plies, Reinforcing	--	1	1
Thickness, min Overall	ASTM D 751, Optical Method	34 (0.86)	41 (1.04)
Thickness, min. Over Scrim	ASTM D 751, Optical Method	11 (0.28)	11 (0.28)
Breaking Strength-fabric min lbf (kN)	ASTM D-751, Method A	220 (.89)	250 (1.1)
Low Temperature, Flex, °F (ºC)	ASTM D 2136, 1/8 in. mandrel, 4 hrs., Pass	-40 (-40)	-40 (-40)
Puncture Resistance, min, lbs, (kN)	FTMS 101C, Method 2031	190 (0.84)	200 (0.89)
Tear Strength, min. initial lbf, (Kn)	ASTM D 5884	70 (0.31)	70 (0.31)
Tear Strength, min After Aging lbf (kN)	ASTM D-5884	35 (0.16)	35 (0.16)
Dimensional Stability, (% chg, max)	ASTM D 1204 (180°F/82ºC) 1 hr.)	2%	2%
Hydrostatic Resistance min. psi ((MPa)	ASTM D 751, Method A Procedure 1	350 (2.4)	350 (2.4)
Ply Adhesion, min.lbs/in (kN/m)	ASTM D 413, Machine Method	7 (1.2) 10 (1.75)	7 (1.2) 10 (1.75)
UV Resistance	ASTM G26 Xenon Arc 80ºC/4000 hrs	Pass	Pass
Typical Fabricated Seam Properties**			
Bonded Seam Strength, lbf (kN/m) Peel Adhesion, lbs/in (kN/m)	ASTM D 751 ASTM D-413 *	160 (0.71) 10 (1.75)	200 (0.89) 10 (1.75)

* As modified in Annex A, NSF-54

** Factory bonded seam strength is the responsibility of the fabricator.

APPENDIX II NDT METHODS FOR FIELD SEAMS

A. Air Lance Testing

This method is applicable for all field seams, including seams around pipe penetrations, repairs and accessories. A description of the air lance test follows.

All field seams shall be non-destructively tested over their full length. An air lance apparatus shall be used for this testing as described in this Appendix. The air lance shall be capable of supplying 30 psi through a 3/16 inch diameter nozzle. The air stream shall be directed at the edge of the seam no more than two inches from the seam edge. Enough time shall be allowed for the seams to develop adequate strength before commencement of testing. Any defects found during testing shall be marked, repaired, and retested with the air lance. All repairs shall be performed as described in Section 6.3.2 (Remedial Action).

B. Vacuum Box Testing for Hot Air Field Welds

For areas where air lance or pressurized seam testing is inappropriate, vacuum box testing may be used.

> This method consists of creating a pressure differential across a seam and observing for bubbles in a film of liquid medium over the low pressure side, within the vacuum chamber. The vacuum chamber has a viewing port that allows observation of the seam area being tested. The sensitivity of the method is dependent on the pressure differential and the liquid used for testing. As long as the pressure differential can be maintained across the area tested, this method can be used. (ASTM E515, 5/90)

The following equipment comprises the vacuum box apparatus:

> **Vacuum Pump.** The vacuum pump shall be fuel or electric powered and capable of sustaining the required vacuum for the duration of the test.
>
> **Vacuum Gauge.** The vacuum gauge shall be capable of registering, as a minimum to 70kPa (10 psi) in increments of 5 kPa (3/4 psi).
>
> **Calibration and adjustment.** The calibration of the vacuum gauge shall be checked and adjusted periodically, and routinely at a minimum of once every 12 months.
>
> **Foaming Solution.** The foaming solution shall be pre-mixed with water at a ratio conducive to the formation of bubbles. It shall be dispensed by spray, brush, or any other convenient means. The foaming solution should not be detrimental to the geomembrane.
>
> NOTE: If the component to be tested has parts made of polyethylene or structural plastics, the test fluid must not promote environmental stress cracking (E.S.C.) (ASTM E515, 5/90)
>
> **Vacuum Chamber.** The vacuum chamber shall have an open bottom and a clear viewing panel on top. It shall be an appropriate and convenient size and shape, made of rigid materials and equipped with a vacuum gauge, valve, and soft, pliable gasket around the periphery of the open bottom.

Testing of the field seam proceeds as follows:

> The area of the seam to be evaluated should be clean and free of soil or foreign objects which might prohibit a good seal from being formed between the vacuum chamber and the geomembrane. Energize the vacuum pump.

Wet an area immediately adjacent to and including the geomembrane seam measuring approximately twice the width and length of the vacuum chamber with a foaming solution.

Place and center the long axis of the vacuum chamber over the long axis of the seam or defect with the gasket in contact with the geomembrane surface over the wet area of geomembrane seam or test area.

For evaluation of geomembrane defects, center the vacuum chamber over the defect.

Apply a normal force to the top of the vacuum chamber to affect a seal and open the vacuum valve.

Ensure that a leak tight seal is created between the vacuum chamber gasket and the geomembrane material. For most cases, minimum vacuum of 28 to 55 kPa (4 to 8 psi) should be registered on the vacuum gauge is appropriate.

With the vacuum applied, maintain the normal force and observe the geomembrane seam through the viewing port for bubbles resulting from the flow of air through defects in the seam. The vacuum should be held over the test site for a duration of not less than 10 seconds. If the vacuum cannot be held for the minimum 10 seconds, the test area shall be marked as untested.

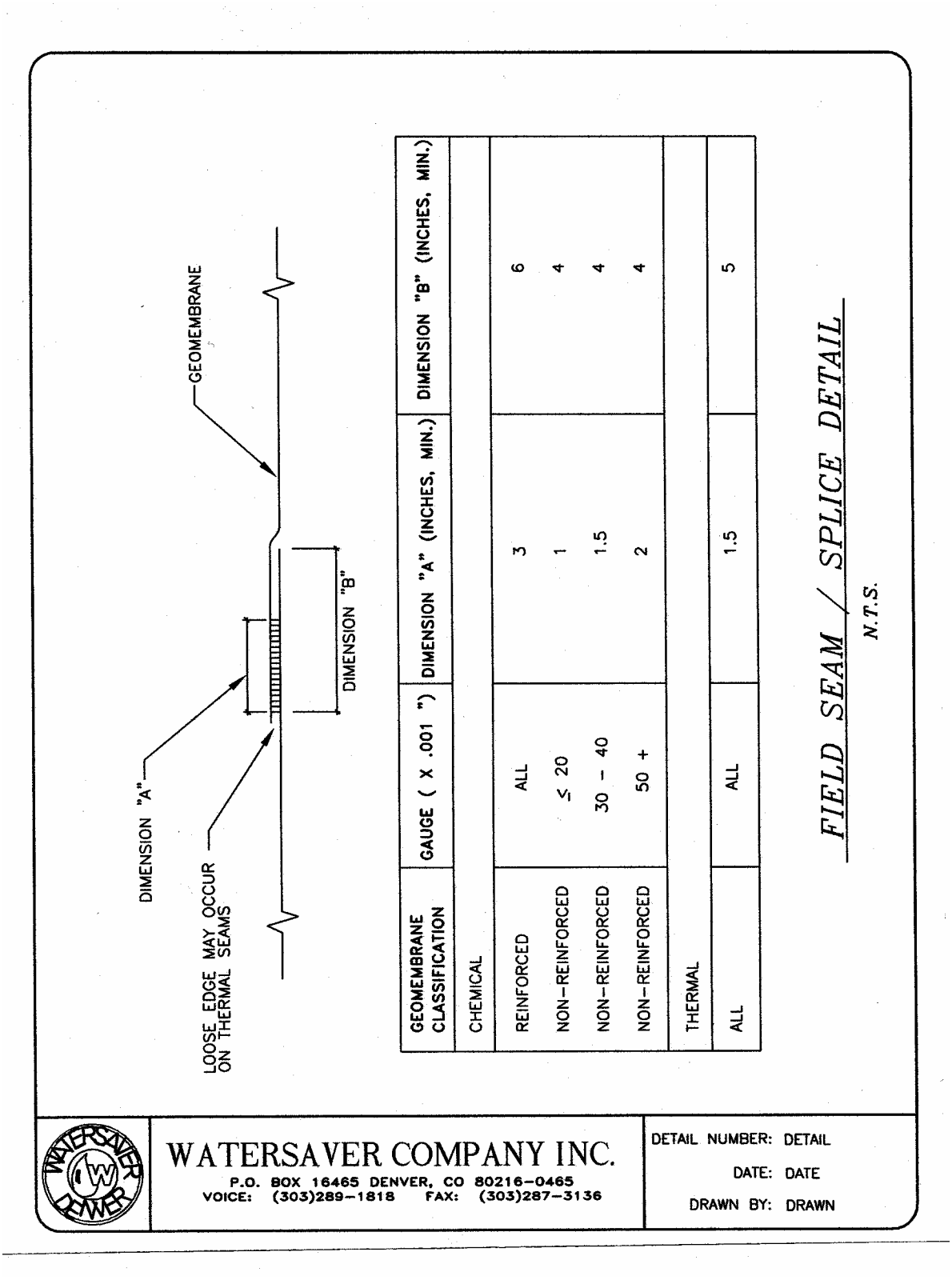
If bubbles appear on the geomembrane seam, turn the three-way vacuum valve to vent the chamber and remove the vacuum chamber from the seam. The defective area should then be marked for later repair.

If bubbles do not appear through the geomembrane seam within the specified dwell time, turn the vacuum valve to vent the chamber and remove the vacuum chamber from the seam.

Move the vacuum chamber to the adjoining portion of the seam length overlapping the previously tested area by a distance no less than 10 percent of the minimum chamber length or at least 50mm (2 inches), whichever is the greater and repeat the procedure until the entire seam has been tested.

Any defects found during testing shall be marked, repaired, and retested with the vacuum box. All repairs shall be performed as described in Section 6.3.2 (Remedial Action).

APPENDIX III FIELD SEAM DETAIL



GEOMEMBRANE CLASSIFICATION	GAUGE (X .001 ")	DIMENSION "A" (INCHES, MIN.)	DIMENSION "B" (INCHES, MIN.)
CHEMICAL			
REINFORCED	ALL	3	6
NON-REINFORCED	≤ 20	1	4
NON-REINFORCED	30 - 40	1.5	4
NON-REINFORCED	50 +	2	4
THERMAL			
ALL	ALL	1.5	5

FIELD SEAM / SPLICE DETAIL

N.T.S.

WATERSAVER COMPANY INC.
P.O. BOX 16465 DENVER, CO 80216-0465
VOICE: (303)289-1818 FAX: (303)287-3136

DETAIL NUMBER: DETAIL
DATE: DATE
DRAWN BY: DRAWN

APPENDIX IV SEAM REQUIREMENTS

PRIMARY FACTORY SEAM METHODS		
PVC	-	Chemical <1% Solids
PP-R		Thermal
CSPE		Thermal
XR PRODUCTS		Thermal
SECONDARY FACTORY SEAM METHODS		
PVC	-	Thermal
PRIMARY FIELD SEAMING METHODS		
PVC	-	Chemical <1% Solids or Thermal
PP-R	-	Thermal
CSPE	-	Thermal
XR PRODUCTS	-	Thermal
PRIMARY DETAIL & REPAIR METHODS		
PVC	-	Chemical <1% Solids or Thermal
PP-R	-	Thermal
CSPE	-	Thermal
XR PRODUCTS	-	Thermal

APPENDIX V RAW MATERIAL QUALIFICATIONS

2.1 RAW MATERIAL QUALIFICATION

2.1.1 PVC

Only first quality phthalate and/or phosphate plasticizers shall be used. The compound must also contain a biocide at a viable formation level. The use of water soluble ingredients is prohibited.

2.1.2 CSPE

Industrial Grade Hypalon sheeting is produced from a composition of high quality ingredients, suitably compounded, of which Hypalon 45 synthetic rubber resin is the sole elastomer. Zinc compounds of any kind, including zinc oxide, zinc stearate and zinc dusting agents are prohibited. Dusting agents of any kind are prohibited on the finished product.

APPENDIX VI PGI 1104 Appendix B

Testing Clarifications and Details

This appendix lists the clarifications and details of the testing methods used in the PGI specification. In some cases multiple test procedures exist within test methods and testing choices are required. This appendix makes note of the test criteria that was used to compile these specifications.

General When both US and metric values are shown the value for acceptance is the US value. Metric values are conversions and may contain rounding errors.

Test Method Clarification and Details

ASTM **D751** Test Methods for Coated Fabrics
- For Hydrostatic Burst use Section 33, Procedure A, "Pressure Application by Mullen Type Hydrostatic Tester"
- Units of pressure in pounds per square inch (psi) or kiloPascals (kPa)

ASTM **D882** Tensile Properties of Thin Plastic Sheeting
- Use Method A
- D882 method may be used for PVC film up to 60 mil (1.5mm) thick
- Units are in pounds of force per inch of width (lbs/in)
- Metric units are in kiloNewtons per meter of width (kN/m), or Newtons per millimeter of width (N/mm) which are equivalent units
- Factory Seam Shear Testing
  - Use ASTM D882 Method A
  - ASTM D882 may be used for thicknesses greater than 1.0 mm (40 mil) for seam testing
  - Use 25.4 mm wide (1") specimens
  - Use grip separation of 51 mm (2 in) plus the seam width
  - Crosshead speed of 510 mm/min (20 in/min)
- Factory Seam Peel Testing
  - Use ASTM D882 Method A
  - Use 25.4 mm wide (1") specimens
  - Position grips 13 mm (1/2") on either side of seam
  - Crosshead speed of 51 mm/min (2 in/min)

ASTM **D1004** Initial Tear Resistance of Plastic Film and Sheeting
- Units are in pounds of force to initiate tear in the specially die-cut specimen (lbs) or in Newtons of force (N)

ASTM **D1203** Volatile Loss from Plastics Using Activated Carbon Methods
- Use method A

ASTM **D1204** Linear Dimensional Changes of Thermoplastic Film at Elevated Temp.
- Test specimens at 100C for 15 minutes
- Measure percent change in lineal dimensions

ASTM **D1239** Resistance of Plastic Films to Extraction by Chemicals
- ASTM D1239 may be used for thicknesses greater than 1.0 mm (40 mil)
- Test specimens in 50° C (122° F) water for twenty-four hours
- Measure percent change in weight

ASTM **D1790** Brittleness Temperature of Plastic Sheeting by Impact
- 50% of specimens must pass at specified temperature

ASTM **D 2124** For plasticizer extraction, followed by GC or GCMS for identification and molecular weight determination.

ASTM **D5199** Measuring the Nominal Thickness of Geosynthetics

- US units of thousandths of an inch (0.001 inches = 1 mil)
- Metric unit of millimeters of thickness (mm)

ASTM **G160** Evaluating Microbial Susceptibility of Nonmetallic Materials by Soil Burial

- Bury sample in prepared soil for 30 days
- Perform test on actual liner sheet samples
- Measure maximum change in properties as shown in specification

APPENDIX VII Enhanced Testing Information For Reinforced Geomembranes.

ASTM D751 Test Methods for Coated Fabrics

Dimensions and Mass - (Thickness & Weight)

Breaking Strength
Procedure A - (Grab) 4" wide specimen / 1" Grip
Procedure B - (Strip) 1" wide specimen / 1" Grip

Elongation - % at fabric break

Bursting Strength - Tension Testing Machine with Ring Clamp (1.000" Dia. Steel Ball)

Hydrostatic Resistance
Procedure/Method A – Mullen Type Tester

Adhesion Coating (to fabrics) - Two 1" wide Specimens welded together leaving two free ends for peel.
"It can be difficult to separate the polymer directly from the scrim"

Seam Strength - NSF Modified – 4" Wide Specimen - Most field tensiometers are only wide enough for 1" Wide Specimens.

Dead Load Seam Test - TD & MD

ASTM D3776 - Mass Per Unit Area

ASTM D2136 – Low Temp - 5X Magnifier, 1" x 4" samples.

ASTM D5884 – Tear - D-35 Committee (index test)
Typically, the higher value indicates ganging of fibers,
Lower values indicate fibers breaking one at a time.
Standard strain rate (12 +/- 0.5"/min)

ASTM D4833 – Puncture – D-35 Committee (index test)
Rod Diameter 0.35"/flat end chamfered 45 deg.
May be inappropriate for some large interstices.

UV Resistance
(Weathering Wet/Dry Cycle) ASTM G26 withdrawn, replaced by G155
Weathering Resistance (Carbon-Arc) –ASTM G23 withdrawn, replaced by G152 &G153
See ASTM – D151 for detailed information covering difference between Carbon & Xenon – Arc.

Ply Adhesion (Modified Machine Method) Under ASTM D 413 Similar To ASTM D 751 ADHESIVE COATING.

FTMS 101C cancelled.
Incorporated into Mil-Std-3010, Puncture Resistance – Method 2065
Puncture Probe 1/8" Spherical Radius W \ 2" Long Taper. http://assist.daps.dla.mil

ASTM 1204 – Linear Dimensional Changes % (MFG Specified Test Temperatures)

UV Resistance (General *)

Shorter wavelengths of radiation contain more energy.
Narrow Band wavelengths used for testing in the US.
Broad Band wave lengths used for testing in Europe.

* Sun Spots, Atlas Testing.