



URS Corporation – North Carolina
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April 2, 2010

Mr. Chris E. Hews, Sr.
Environmental Manager
Roanoke Valley Energy Facility
290 Power Place
PO Box 351
Weldon, NC 27890

**Subject: Evaluation of Cell 2 Liner at the Halifax County Ash Monocells
Roanoke Valley Energy Facility**

Dear Mr. Hews:

In January 2010 Roanoke Valley Energy (ROVA) furnished URS with an audit report from North Carolina Department of Environment and Natural Resources (NCDENR) dated January 15, 2009. The report summarized an inspection NCDENR performed on the Halifax County Ash Monocells. A copy of the NCDENR audit report is attached with this report.

The NCDENR audit report did not state any violations at the ash monocells, but pointed-out areas where 10 to 12 feet of the liner along the Cell 2 sidewalls is continuing to be exposed to the weather. It is strongly recommended in the NCDENR report that an engineer certify the integrity of the exposed liner in Cell 2. The NCDENR report states that the Cell 2 liner was guaranteed against ultra violet damage for a five year period, and since the liner has been exposed to the environment for over 10 years, NCDENR is questioning the integrity of the liner.

To address NCDENR's concerns, URS recommended that cut samples be taken from the liner and that the samples be tested to evaluate the existing physical parameters, and the results be compared to the minimum physical parameter requirements required for the liner material at the time of construction. A secondary goal for collecting cut samples of the liner was to test and evaluate its condition and feasibility for patching, particularly since ROVA was aware of numerous locations along the exposed liner surface where puncture holes exist and need repair (although this was not noted in the NCDENR audit report).

To evaluate the Cell 2 liner condition, URS suggested that four samples be taken from the existing in-place liner. It was recommended that two sample pairs be collected from two different locations, and that the first part of each pair be taken from an exposed area and the second part of each pair be taken from an unexposed area. The purpose for collecting samples from exposed portions of the liner and unexposed portions of the liner was to compare the results and evaluate the possibility for any UV degradation of the liner due to its exposure.



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BACKGROUND

The Halifax County Coal Ash Monocell permit to construct (Cell 1) was approved by permit amendment number 42-04 dated May 12, 1993, which is attached to this report. The March 1992 Design Report, Halifax County Ash Monofill, prepared by Hazen and Sawyer, prescribed a 60-mil HDPE liner for the Cell 1 Ash Monocell. The original Cell 1 Ash Monocell was constructed using an HDPE liner; however, when the subsequent Cell 2 Monocell was constructed, a Polypropylene (PPE) liner was used. While researching events that led to changing from using an HDPE liner in Cell 1 to using a PPE liner in Cell 2, URS discovered a letter dated May 17, 1996 approving modifications to the construction of Cell 2. We believe that the following permit modifications were approved based on past Hazen and Sawyer correspondences (see Attachments):

1. Coal ash was approved for use as structural fill in the core of the perimeter embankments. The coal ash was covered by 2 feet of compacted soils on all embankment sidewalls, except in the inboard slopes, where the ash was covered by 3 feet of soil.
2. The use of a 40 mil PPE geomembrane liner was approved for Cell 2 instead of 60 mil HDPE.

FIELD SAMPLING

On March 1, 2010 URS and Geo-Synthetics LLC (GSI), a geosynthetic installation company, cut four samples from the existing Cell 2 liner. The liner samples were taken from both exposed areas and unexposed areas, as previously discussed, to evaluate any UV degradation on the liner. The unexposed samples came from cutting the sample pieces from the anchor trench, where it turns down below grade. The exposed samples came from atop the cell sidewalls, immediately adjacent to where the samples were cut from the anchor trench. The samples were also cut from both the west slope and the south slope to evaluate different exposure conditions (see attached photographic log).

After the liner samples were cut, GSI prepared the sample areas for patching using extrusion welding methods. Extensive preparation effort was used to prepare the areas for welding due to surface oxidation from UV exposure. The liner surfaces were cleaned with a scouring pad and denatured alcohol, and then sandpaper was used to further clean and scarify the liner surface. Even after extensive preparation, welding the new PPE patch pieces to the older in-place PPE liner material required care and time.

To assess the welding effectiveness of the test sample and patch areas, where new PPE pieces were to be welded to older in-place pieces, two additional "welded" samples were prepared for testing. The purpose for these additional "welded" samples and tests was to compare a weld fusing of two sheets of new material with a weld fusing of one new material sheet to an old material sheet. The objective was to attempt to replicate patching applications being proposed to replace the cut sample areas and to repair the numerous holes in the liner, and to evaluate the



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effectiveness of this proposed method. The attached photographic log documents the field welding process used to replace the cut sample areas and also being proposed to repair the numerous holes along the exposed liner sections.

LABORATORY TESTING

Physical Parameter Testing of Cut Liner Samples

URS sent the four cut samples of the Cell 2 PPE liner to an independent laboratory for physical parameter testing. The same physical parameters that were measured as part of the 1997 original construction conformance testing, when Cell 2 was being built, were also tested for and measured on the March 1, 2010 cut samples. The test results for the four different cut samples are summarized below:

	Carbon Black Content (%)	MD Tensile Load@ Break (lb/in)	MD Tensile Strain@ Break (%)	TD Tensile Load@ Break (lb/in)	TD Tensile Strain@ Break (%)	MD Tear Resistance (lbs)	Puncture Resistance (lbs)
Specification Requirement (Min)	2.00	90	600	90	600	14	45
South Side Exposed	3.24	88	652	90	726	18	52
South Side Unexposed	2.92	96	717	116	984	19	48
West Side Exposed	3.26	114	773	102	862	18	54
West Side Unexposed	3.05	113	903	116	1058	19	46

See the Attachments for the detailed laboratory test results.

URS obtained results of the conformance testing performed during the construction of Cell 2 from the "Halifax County Public Utilities Department, Cell 2 – Coal Ash Monocell, Construction Record, Documentation Report", dated April 2000. The conformance test results conducted originally on the PPE liner used for Cell 2 are the following:



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SUMMARY OF GEOMEMBRANE CONFORMANCE TEST RESULTS

Roll Number	Avg/Min Thickness (mils)	Specific Gravity (g/cc)	Carbon Black Content (%)	MD Tensile Load @ Break (lb/in)	MD Tensile Strain @ Break (%)	TD Tensile Load @ Break (lb/in)	TD Tensile Strain @ Break (%)	MD Tear Resistance (lbs)	Puncture Resistance (lbs)
2906200	46/43	0.90	2.92	102	610	105	697	21	52
2900174	47/46	0.88	3.20	106	602	101	660	19	56
2900181	46/46	0.91	2.85	113	686	100	701	17	58
2900195	46/46	0.88	3.32	111	688	103	695	17	59
2900218	48/46	0.89	2.79	113	648	116	789	20	57
2900335	43/43	0.88	3.21	85	600	109	724	18	52
Specified Requirements	36 (Min)	0.88 (Min)	2.00 (Min)	90 (Min)	600 (Min)	80 (Min)	600 (Min)	14 (Min)	45 (Min)

NOTES:

1. MD = Machine (Roll) Direction; TD = Transverse (Cross-Machine) Direction.

Comparing the results of the tests conducted on the four samples cut from the Cell 2 PPE liner to the original construction specification requirements and the above conformance test results shows that the PPE has aged well. Out of the seven different parameters being tested, there was only one result that fell below the original specification requirements. The machine direction tensile strength for the exposed liner on the south side was slightly below the specification requirement for the liner (88 lb/in vs. specified 90 lb/in).

Testing and Evaluation of Proposed Patching Method

As discussed above, URS had GSI prepare two additional “welded” test samples in the field to test and evaluate a patching method proposed for the sample areas and the numerous holes in the exposed liner portions. As previously described, one sample was a new PPE material sheet welded to another new PPE material sheet, and the other sample was a new PPE material sheet welded to a cut sheet of the older in-place PPE liner material. URS sent the two weld samples to an independent laboratory for peel strength and shear strength testing, and the laboratory test results were compared to the original 1997 construction specification minimum requirements. The minimum weld specification requirements were obtained from the “Halifax County Public Utilities Department, Cell 2 – Coal Ash Monocell, Construction Record, Documentation Report”, dated April 2000. The test results for the two different weld samples are summarized below:

	Peel Strength (ppi)	Shear Strength (ppi)
Specification Requirements	20	30
New to New Extrusion Weld	50	79
Old to New Extrusion Weld	18	51

See the Attachments for the detailed laboratory test results.



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The laboratory test results indicate that weld seam strengths for the new to new materials are higher [or greater] than the weld seam strengths for the old to new material. This is most likely due to the oxidation that has taken place in the older material as a result of the UV exposure, even though extensive preparation was done prior to the welding process. Even with oxidation of the older liner material, welding of the new PPE material to the older PPE material resulted in a shear strength above the original specified minimum requirement and a peel strength only slightly less than the original specified strength.

URS did additional research to determine if there is different specification requirements for a wedge weld versus an extrusion weld because no field testing of extrusion welds were documented in the Cell 2 construction report. The Cell 2 construction records only show destructive seam test results for wedge welds. URS obtained three different PPE specification guides to determine currently accepted standard specifications for PPE weld seam strengths. The three different specifications are attached. These current welded seam strength standards show similar requirements for extruded and wedge welded seams, and they match the 1997 welded seam strength requirements.

CONCLUSIONS AND RECOMMENDATIONS

The laboratory test results for the four cut samples show that the Cell 2 40-mil PPE liner still meets the minimum physical parameters specified for new material, except for only the machine direction tensile strength for one of the samples being 2.2% below the minimum specified tensile strength. The test results also show that there is only a slight difference in physical parameters between the exposed and unexposed PPE liner materials. The laboratory test results for the additional “welded” liner samples indicate that the welding capability/effectiveness of the PPE liner and the welding seam strengths are affected by oxidation resulting from UV exposure.

Our primary conclusions and recommendations are summarized below:

1. The laboratory physical parameter test results show that the Cell 2 PPE liner has not significantly suffered UV degradation.
2. It is recommended that liner damage holes observed on the three exposed Cell 2 sidewalls (east, west, and south slopes) be repaired as soon as possible. The holes consisted primarily of deer hoove punctures, and some damage from mowing operations at the edge of the anchor trench, atop the perimeter berms.
3. Extrusion welding methods can be used to successfully repair the damage holes and sample replacement areas; however, seam peel strengths on repair patches may not always meet the original minimum construction specification requirements (or 2010 industry standards).



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4. The exposed liner areas should be covered with 2 feet of ash materials within two weeks after completing all repairs, in the presence of a qualified engineer, to reduce the possibility of any further external stresses on the liner.

From an economic perspective, it doesn't seem reasonable for ROVA to replace the liner when the berms are constructed out of ash material and the surface water within the cell is discharged into a stream without treatment. Photographs of the discharge water in the sedimentation basin, and of the stream show no visible impact to surface water. The groundwater and surface water monitoring program confirms there is no impact to the environment.

URS recommends that ROVA (or Halifax County) make the necessary liner repairs, and immediately start placing ash material on the side slopes as discussed above. The repairs should be done in the same fashion that they were performed in the field on March 1, 2010. The repair work should be properly documented by an engineer experienced in geomembrane liner installation, and supported by written documentation sent to NCDENR after completion.

Prior to initiating liner repair work, ROVA (or Halifax County) should submit this report and its attachments to NCDENR to obtain confirmation of their agreement with our recommendations. URS can make this submittal on your behalf, if you prefer.

Should you have any questions or concerns, please feel free to contact us.

Sincerely,

Lenore Gaier
Environmental Consultant

Douglas W. Carr, P.E.
Geotechnical Engineer

Cc: Mr. Don Keisling
President Westmoreland – North Carolina Power, LLC

Mr. Glenn W. Outland
Environmental and Fuels Manager

Client Name:
ROVA

Site Location:
Halifax County Monocell

Project No.
31827096

Photo No. 1

Date:
11/02/09

Description:

Deer hoof damage on the exposed liner on west side slope of Cell 2.



Photo No. 2

Date:
11/02/09

Description:

Mower damage at the anchor trench on the west side of Cell 2.



Client Name:
ROVA

Site Location:
Halifax County Monocell

Project No.
31827096

Photo No. 3

Date:
03/01/10

Description:

Exposing the liner at the anchor trench on the south side of Cell 2.



Photo No. 4

Date:
03/01/10

Description:

Cutting the liner at the anchor trench on the south side of Cell 2. This is one of the unexposed samples sent to the lab.



Client Name:
ROVA

Site Location:
Halifax County Monocell

Project No.
31827096

Photo No. 5

Date:
03/01/10

Description:

Cutting the patch for the samples obtained on the south side of Cell 2.



Photo No. 6

Date:
03/01/10

Description:

Denatured Alcohol used to clean the liner surface prior to welding.



Client Name:
ROVA

Site Location:
Halifax County Monocell

Project No.
31827096

Photo No. 7

Date:
03/01/10

Description:

A GSI field technician cleaning the liner with the denatured alcohol prior to making the weld.



Photo No. 8

Date:
03/01/10

Description:

A GSI field technician using a lyster heat gun to fasten the patch to the existing liner.



Client Name:
ROVA

Site Location:
Halifax County Monocell

Project No.
31827096

Photo No. 9

Date:
03/01/10

Description:

A GSI field technician extrusion welding on the patched area.



Photo No. 10

Date:
03/01/10

Description:

Completed repair on the south side of Cell 2.



Client Name:
ROVA

Site Location:
Halifax County Monocell

Project No.
31827096

Photo No. 11

Date:
03/01/10

Description:

Completed repair on the west side of Cell 2.



Photo No. 12

Date:
11/02/09

Description:

Looking north at the sedimentation basin.



Client Name:
ROVA

Site Location:
Halifax County Monocell

Project No.
31827096

Photo No. 13

Date:
11/02/09

Description:

Contact water transmission pipe entering the sedimentation basin. Visually there is no sign that the discharge water is impacting the environment.



Photo No. 14

Date:
11/02/09

Description:

Discharge from the sedimentation basin being directly discharged into a stream.





FACILITY COMPLIANCE AUDIT REPORT
Division of Waste Management
Solid Waste Section

UNIT TYPE:											
Lined MSWLF	X	LCID		YW	X	Transfer		Compost		SLAS	COUNTY: HALIFAX PERMIT NO.: 42-04 FILE TYPE: COMPLIANCE
Closed MSWLF	X	HHW		White goods	X	Incin		T&P		FIRM	
CDFL	X	Tire T&P / Collection	X	Tire Monofill		Industrial Landfill	X	DEMO		SDTF	

Date of Audit: January 15, 2009

Date of Last Audit: January 25, 2008

FACILITY NAME AND ADDRESS:

Halifax County Industrial Coal Ash Landfill
 Liles Road
 Halifax, NC 27839

GPS COORDINATES: N: 36.38018

W: 077.80981

FACILITY CONTACT NAME AND PHONE NUMBER:

Larry Garriss, Operations and Maintenance Manager, Solid Waste Division, Halifax County Public Utilities, Tel- 252-586-7516, Cell- 252-308-3825, Fax- 252-593-5014.

FACILITY CONTACT ADDRESS:

Halifax County Industrial Coal Ash Landfill
 PO Box 70
 Halifax, NC 27839

AUDIT PARTICIPANTS:

Mary Whaley, NCDENR, Solid Waste Section
 Larry Garriss, Operations and Maintenance Manager

STATUS OF PERMIT:

Permit # 42-04 is the same permit number for the closed MSWLF, the active C&DLF and the Industrial Coal Ash Landfill. Permit # 42-04 was issued December 22, 2006 for Permit to Operate Phase 1 of the Construction and Demolition Debris Landfill Unit. Permit would have expired on July 1, 2008 due to amendments or modifications to the facility needed for continued operation in accordance with 15A NCAC 13B .0547. Paperwork has been submitted to the Section.

PURPOSE OF AUDIT:

To conduct a partial audit of an Industrial Coal Ash Landfill.

NOTICE OF VIOLATION(S):

NONE

You are hereby advised that, pursuant to N.C.G.S. 130A-22, an administrative penalty of up to \$15,000 per day may be assessed for each violation of the Solid Waste Statute or Regulations. For the violation(s) noted here, you may be subject to enforcement actions including penalties, injunction from operation of a solid waste management facility or a solid waste collection service and any such further relief as may be necessary to achieve compliance with the North Carolina Solid Waste Management Act and Rules.

STATUS OF PAST NOTED VIOLATIONS:

NONE

FACILITY COMPLIANCE AUDIT REPORT
Division of Waste Management
Solid Waste Section

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AREAS OF CONCERN AND COMMENTS:

1. The C&D and the Industrial landfills are open Monday through Friday, 8 AM to 4 PM.
2. The industrial coal ash landfill is a lined landfill. The loads that come to the site are sludge from the sediment ponds and the debris from the clean out of the storage silos at Cogentrics in Weldon, NC. Cogentrics was originally named Westmoreland Energy and is a coal fired power plant. The majority of the ash from Cogentrics goes to sites for beneficial use of coal combustion by-products. The last time ash was brought to the Halifax County Industrial Coal Ash Landfill was October of 2007. At that time 2034.84 tons of the material was brought to the site. Cell 1 of the coal ash landfill is approximately 12 acres in size and was constructed in 1993, and began to receive ash in May, 1994. Cell 2 was constructed in 1999 and is approximately 9 acres in size.
3. Coal ash was spread out over the base of the liner of Cell 2 in 2003. Until then the liner was exposed. The liner was guaranteed for 5 years against ultra violet damage. At the time of this audit, there is 10 to 12 feet of exposed liner on the sidewalls around the cell, still exposed to the weather. **It is strongly recommended that if ash is going to be put in Cell 2, where the liner has been exposed, an engineer should certify the integrity of the liner that has been exposed to the weather, prior to the disposal of the ash.**
4. Ground and surface water monitoring is done two times a year.
5. The sediment basin below the two cells needs to have the trees and shrubs removed.

Please contact me if you have any questions or concerns regarding this audit report.

 Mary Whaley
 Environmental Senior Specialist
Regional Representative

Phone: 919-693-5023.

Delivered on : <u>January 22, 2009</u> by		Hand delivery	<input checked="" type="checkbox"/>	US Mail		Certified No. []
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cc: Mark Poindexter, Field Operations Branch Supervisor
 Dennis Shackelford, Eastern District Supervisor
 Donald Herndon, Compliance Officer
 Donna Wilson, Permitting Environmental Engineer II
 Ed Mussler, Permitting Branch Head



HALIFAX COUNTY SOLID WASTE DEPARTMENT

**P. O. BOX 327
HALIFAX, N. C. 27839
919-586-4748**

**JERRY N. WILLIAMS
DIRECTOR**

State of North Carolina
Department of Environment, Health, and
Natural Resources
Division of Solid Waste Management
P. O. Box 27687
Raleigh, NC 27611



Please find enclosed the Solid Waste Permit, #42-04,
to construct a Coal Ash Monofill for Halifax County Sanitary
Landfill.

CERTIFIED COPY OF SOLID WASTE PERMIT



I do hereby certify that the attached PERMIT is an exact and true copy of Permit No. 42-04.

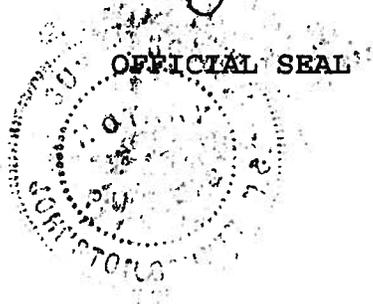
James C. Coffey
James C. Coffey, Supervisor
Permitting Branch
Solid Waste Section

North Carolina

Johnston County

I, Sue S. Hodge, a Notary Public for said County and State, do hereby certify that James C. Coffey, Solid Waste Section personally appeared before me this day and acknowledged the due execution of the foregoing instrument.

Witness my hand and official seal, this the 12th day of May, 1993.



Sue S. Hodge
NOTARY PUBLIC

My commission expires October 21, 1995.

North Carolina, Halifax County
The foregoing certificate of Sue S. Hodge
a Notary Public of Johnston
County is certified to be correct. This 17 day of September
1993 Recorded 3:35 P.M.
Book 1581 Page 374
Travis S. Uzzell By: Judy H. Evans, Asst.
Register of Deeds Halifax Co.

AMENDMENT TO PERMIT NO. 42-04
PART 1: PERMIT TO CONSTRUCT
DATE ISSUED 05-12-93

STATE OF NORTH CAROLINA
DEPARTMENT OF ENVIRONMENT, HEALTH, AND NATURAL RESOURCES
DIVISION OF SOLID WASTE MANAGEMENT
P.O. BOX 27687 RALEIGH, NC 27611

SOLID WASTE PERMIT

Halifax County

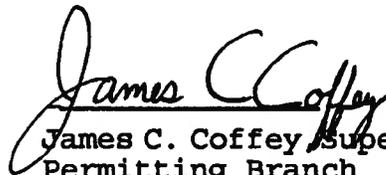
is hereby issued a permit to construct a
Coal Ash Monofill
located at the

HALIFAX COUNTY SANITARY LANDFILL

accessed

via SR 1417,
approximately 2 miles North of Aurelian Springs, Halifax County,
North Carolina

in accordance with Article 9, Chapter 130A, of the General Statutes
of North Carolina and all rules promulgated thereunder and subject
to the conditions set forth in this permit. The facility is
located and described by the legal description of the site on the
attached sheet.


James C. Coffey Supervisor
Permitting Branch
Solid Waste Section

SOLID WASTE PERMIT
Part 1: Permit to Construct
Coal Ash Monofill
Halifax County Sanitary Landfill

CONDITIONS OF PERMIT:

GENERAL

1. This permit shall not be effective unless the certified copy is filed in the Register of Deeds Office, in the grantor index under the name of the owner of the land in the county or counties in which the land is located. After recordation, the certified copy shall be returned to the Solid Waste Section and shall have indicated on it the page and book number, date of recordation, and Register's seal.
2. When this property is sold, leased, conveyed or transferred, the deed or other instrument of transfer shall contain in the description section in no smaller type than that used in the body of the deed or instrument a statement that the property has been used as a sanitary landfill.
3. This permit will be subject to review every five years as per 15A NCAC 13B .0201(c), according to the issuance date of the Permit to Operate. Modifications, where necessary, shall be required in accordance with rules in effect at the time of review.
4. The approved plan is described by Attachment 1, "List of Documents for Approved Plan". Where discrepancies may exist, the most recent submittal and the Conditions of Permit shall govern. Some components of the approved plan are reiterated in the Conditions of Permit.
5. Halifax County (the permittee) shall notify the Division of Solid Waste Management (DSWM), Solid Waste Section (SWS) and conduct a pre-construction meeting on-site prior to initiating construction activities. If construction does not commence within 18 months from the issuance date of this permit, then the permittee shall obtain written approval from the SWS prior to construction and comply with any conditions of said approval.
6. Prior to receiving waste at this facility, a Permit to Operate must be obtained. The requirements for this part of the Solid Waste Permit are described in the following section (Construction), Condition 3. The Conditions of Permit issued herein shall also be incorporated in the Permit to Operate.

7. This permit is not transferable.

BOOK 1581 PAGE 377

CONSTRUCTION

1. This construction permit is for development of Cell One of the Coal Ash Monofill located at Halifax County Sanitary Landfill and the on-site environmental management facilities, in accordance with the approved plan and as specified herein. Development of subsequent phases will require Halifax County to notify the DSWM 180 days prior to the scheduled date of construction, and receive written approval from DSWM regarding said notification.
 - a. The components of the engineered systems shall be specified and constructed to meet the performance requirements established by the facility design.
 - b. Relative to the established performance requirements, design revisions and/or requests for variance, will be reviewed by the agency and accepted or rejected.
 - c. Construction Quality Assurance (CQA) activities shall be documented and summarized in a CQA report and illustrated with as-built drawings. The CQA Report and Document Drawings shall bear an imprint of the registration seal of the engineer licensed to practice in the State of North Carolina.
 - d. The CQA report will include the following at a minimum:
 - (1) A summary of the methodology, modifications, and construction quality control measures necessary to demonstrate that the facilities were constructed in accordance with the approved plans and as specified herein;
 - (2) A summary of the actual materials and methodology implemented to construct and test any compacted soil liner; and
 - (3) Documentation of the thickness (using survey data) of any soil liner, drainage layer, and protective cover; constructed grades (for HDPE liner), and location and grades for all LCRS piping.
2. All sedimentation/erosion control activities will be conducted in accordance with the Sedimentation Control Act codified at 15 NCAC 4. Native vegetation shall be established on the completed landfill.
3. The following pre-operative requirements shall be met to obtain a PERMIT TO OPERATE this facility:
 - a. Site preparation shall be in accordance with the construction plan, and the conditions specified herein.
 - b. Site inspection shall be made by a representative of the Division of Solid Waste Management (DSWM).

- c. The permit number and the words "NO HAZARDOUS, OR LIQUID WASTE ACCEPTED" shall be posted on an entrance sign.
- d. Upon completion of construction, the permittee will submit the CQA report and document drawings to DSWM; the agency will review the submittal and issue its concurrence that the facility was constructed as specified herein.
- e. Surface water monitoring locations shall be established and groundwater monitoring wells shall be installed (see Monitoring and Reporting Requirements) and a baseline sampling performed.
- f. A Final Water Quality Monitoring Plan shall be submitted to the SWS Hydrogeologist for review and approval. The plan shall incorporate the Monitoring and Reporting Conditions described in this permit.
- g. Stream sediment sampling locations (see Monitoring and Reporting Requirements) shall be established and a baseline sampling(s) performed. A settlement basin effluent and stream sediment monitoring plan shall be prepared and submitted to the Solid Waste Section for review and approval. The plan shall incorporate the Monitoring and Reporting Conditions described in this permit, as well as contingency plans in the case of contamination in excess of the NC Groundwater Standards.

OPERATION

1. This Coal Ash Monofill Area is permitted to receive only coal combustion by-products in accordance with the approved plan. Municipal solid waste, construction/demolition wastes, land-clearing and inert debris, hazardous waste, special wastes, and liquid waste are prohibited from disposal in the coal ash monofill.
 - a. Acceptance of additional wastes are subject to prior written approval by the Division and subject to the Division's "Procedure and Criteria for Waste Determination" in accordance with 15A NCAC 13B .0103 (d).
2. The landfill unit shall conform to all operating procedures described in the approved plan, in accordance with Rule .0505 of 15A NCAC 13B, and as specified herein.
 - a. All pertinent landfill operating personnel will receive training and supervision necessary to properly operate this landfill. Specifically, training must be provided in operational procedures that will prevent damage to the liner and leachate collection and removal systems.
 - b. Ash which has been placed to final elevations around the perimeter of the facility shall be covered with a minimum of 12 inches of soil prior to the end of daily

- operations. Final cover and seeding shall be implemented within 30 days of reaching final grade.
- c. All operations shall be conducted in a manner sufficient to prevent releases of ash materials from the monofill unit or secondary settling basin.
3. Ground water quality at this facility is subject to the classification and remedial action provisions referenced in Rule .0503 (2) (d) of 15A NCAC 13B.
 4. A closure and post-closure plan must be submitted for approval at least 90 days prior to closure or partial closure of any landfill unit. The plan must include all steps and measures necessary to close and maintain the facility in accordance with all rules in effect at that time. At a minimum, the plan shall address the following:
 - a. Design of a final cover system which minimizes infiltration into the waste and supports vegetation;
 - b. Construction and maintenance/operation of the final cover system, erosion control structures, and leachate management system; and
 - c. Surface water, ground water, and effluent monitoring.

MONITORING AND REPORTING REQUIREMENTS

1. Ground water monitoring wells and monitoring requirements for the landfill unit:
 - a. Monitoring well design and construction shall conform to the specifications outlined in Attachment 2, "North Carolina Water Quality Monitoring Guidance Document for Solid Waste Facilities". The monitoring plan shall be modified as required by the SWS Hydrogeologist.
 - b. A total of five monitoring wells shall be established to monitor the landfill unit. In addition, two monitoring wells shall be established immediately downgradient of the active cell and relocated as necessary, during site development.
 - c. A geologist shall be in the field to supervise well installation. The exact locations, screened intervals, and nesting of the wells shall be established after consultation with the SWS Hydrogeologist at the time of well installation.
 - d. For each monitoring well constructed, a well completion record shall be submitted to DSWM within 30 days upon completion.
 - e. Prior to the acceptance of any waste at the facility, a baseline sampling event shall be completed. This event shall include all groundwater monitoring wells and shall

- be consistent with the above-referenced guidance document, (Attachment 2).
- f. Sampling parameters, equipment and procedures shall conform to specifications outlined in the above-referenced guidance document, (Attachment 2), or the current guidelines established by DSWM at the time of sampling.
 - g. The permittee shall sample the monitoring wells semi-annually or as directed by the SWS Hydrogeologist.
 - h. A readily accessible unobstructed path shall be initially cleared and maintained so that four-wheel drive vehicles may access the monitoring wells at all times.
2. The permittee shall establish two (2) locations for surface water sampling as described in the approved plan and as specified herein. Samples shall be collected from approved locations and analyzed semi-annually according to the protocol and parameters required by the SWS Hydrogeologist.
 3. The permittee shall monitor effluent from the secondary settlement basin in accordance with the following requirements:
 - a. Semi-annual sampling shall be performed to analyze effluent from the secondary settlement basin for the water quality monitoring parameters referenced in Condition 1.f. of this section.
 - b. If analyses indicate a statistically significant increase over background for one or more constituents, the permittee shall notify the Section within 14 days. Exceedances in excess of the North Carolina Groundwater Standards shall require the permittee to submit plans for adequate treatment of collected stormwater or to develop alternative stormwater management plans. Additional permits may be required.
 - c. Prior to the acceptance of any waste at the facility, a baseline sampling event shall be completed. This event shall include all water quality monitoring parameters referenced in Condition 1.f. of this Section.
 4. The permittee shall monitor stream sediments as follows:
 - a. Semi-annual sampling shall be performed to analyze sediments for the parameters (metals only) referenced in Condition 1.f. of this section, by the Toxicity Characteristics Leaching Procedure as specified in USEPA Manual SW-846. A visual inspection shall be made as well to evaluate potential ash migration.
 - b. If analyses indicate a statistically significant increase over background for one or more constituents, the permittee shall notify the Section within 14 days. Exceedances in excess of the North Carolina Groundwater

Standards shall require the permittee to submit plans for adequate treatment of collected stormwater or to develop alternative stormwater management plans. Additional permits may be required.

- c. Prior to the acceptance of any waste at the facility, a baseline sampling event shall be completed. This event shall include all water quality monitoring parameters referenced in Condition 1.f. of this Section.
5. The permittee shall maintain a record of all monitoring events and analytical data. Reports of the analytical data for baseline samplings and each water quality monitoring and sediment sampling events (1.g., 2., 3.a. & 4.a.) are to be submitted to DSWM in a timely manner.
6. The permittee shall maintain a record of the amount of solid waste received at the facility, compiled on a monthly basis. Scales shall be used to weigh the amount of waste received.
7. On or before 01 Dec 93, and each year thereafter, the permittee shall report the amount of waste received (in tons) at this facility and disposed of in the landfill to the Solid Waste Section, on forms prescribed by the Section. This report shall include the following information:
 - a. The reporting period shall be for the previous year, beginning 01 July and ending on 30 June;
 - b. The amount of waste received and landfilled in tons, compiled on a monthly basis, according to Condition 6 described above; and
 - c. The report shall be signed by the Halifax County Manager.
8. All records shall be maintained on-site and made available to the SWS upon request.

ATTACHMENT 1

List of Documents for the Approved Plan

The following documents are incorporated as the approved plan for Permit No. 42-04.

1. Site Suitability Study, submitted March 26, 1991.
2. Site Suitability for landfill expansion issued June 5, 1991.
3. Construction Plan incorporating the following components:
 - a. Operations Manual submitted April 27, 1992;
 - b. CQA Plan submitted April 27, 1992;
 - c. Contract Specifications submitted April 27, 1992;
 - d. Revised text for Design Report submitted May 11, 1993;
 - e. Appendices for Design Report submitted April 27, 1992;
and
 - f. Plan Drawings submitted April 27, 1992.



42-04
Halifax

State of North Carolina
Department of Environment, Health, and Natural Resources
512 North Salisbury Street • Raleigh, North Carolina 27604

James B. Hunt, Jr., Governor

DIVISION OF SOLID WASTE MANAGEMENT
TELEPHONE: (919) 733-0692

Jonathan B. Howes, Secretary

May 12, 1993

Mr. Neal C. Phillips, Manager
Halifax County
P. O. Box 38
Halifax, North Carolina 27839

RE: Amendment to Solid Waste Permit No. 42-04
Halifax County Sanitary Landfill
Part 1: Permit to Construct a Coal Ash Monofill

Dear Mr. Phillips:

The referenced permit is issued in accordance with N.C.G.S. 130A-294 and the NC Solid Waste Management Rules, 15A NCAC 13B. Please review the **GENERAL** Conditions of this permit which describes recordation procedures, definition of the approved plan, and general terms of the permit to construct. Also, please note the **CONSTRUCTION** Conditions which describe the pre-operational conditions which must be satisfied to qualify for a Permit to Operate.

Please review the Conditions of Permit thoroughly and contact me at (919) 733-0692, if you have any questions or if you require further clarification. Mr. Bob Harding is the Section's Waste Management Specialist for this area and can be contacted at DEHNR Raleigh Regional Office, 3800 Barrett Drive, Raleigh, NC 27609, or by phone at (919) 571-4700.

Sincerely,

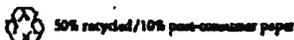
Sherri C. Hoyt
Environmental Engineer
Solid Waste Section

enclosure

cc: Bob Harding
Terry Dover
Jim Coffey
Greg Richardson, Hazen and Sawyer

P.O. Box 27687, Raleigh, North Carolina 27611-7687 Telephone 919-733-4984 Fax # 919-733-0513

An Equal Opportunity Affirmative Action Employer



AMENDMENT TO PERMIT NO. 42-04
PART 1: PERMIT TO CONSTRUCT
DATE ISSUED 05-12-93

STATE OF NORTH CAROLINA
DEPARTMENT OF ENVIRONMENT, HEALTH, AND NATURAL RESOURCES
DIVISION OF SOLID WASTE MANAGEMENT
P.O. BOX 27687 RALEIGH, NC 27611

SOLID WASTE PERMIT

Halifax County

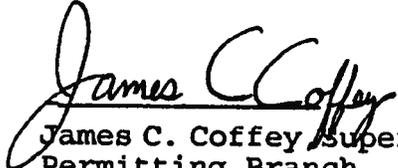
is hereby issued a permit to construct a
Coal Ash Monofill
located at the

HALIFAX COUNTY SANITARY LANDFILL

accessed

via SR 1417,
approximately 2 miles North of Aurelian Springs, Halifax County,
North Carolina

in accordance with Article 9, Chapter 130A, of the General Statutes
of North Carolina and all rules promulgated thereunder and subject
to the conditions set forth in this permit. The facility is
located and described by the legal description of the site on the
attached sheet.


James C. Coffey, Supervisor
Permitting Branch
Solid Waste Section

That certain tract or parcel of land lying and being situated in Butterwood Township, Halifax County, North Carolina, more particularly described as follows: Beginning at an iron rod located in the Southern right-of-way of N.C. State Road 1417; thence along the Ruth Warren property line S. 5° 55' E. 1037.52 feet to an existing iron pipe; thence N. 85° 31' E. 586.25 feet to an existing iron pipe; thence S. 6° 22' 46" W. 890.09 feet to an existing iron pipe; thence N. 86° 23' 37" W. 613.62 feet to an existing iron pipe; thence along an old wire fence S. 3° 37' 32" W. 595.29 feet to an iron pipe; thence S. 0° 31' 26" W. 316.13 feet to an existing iron pipe; thence N. 86° 00' W. 1031.8 feet to an existing iron pipe; thence S. 1° 30' W. 1725 feet to a concrete monument on the North side of a branch; thence running generally up the branch N. 75° 30' W. 205 feet to a point; thence N. 65° W. 165 feet to a point; thence N. 28° 30' W. 482 feet to a point; thence N. 55° 15' W. 415 feet to a point; thence S. 84° 20' W. 427 feet to a point; thence leaving said branch and running S. 74° 41' W. 195 feet to a point; thence N. 70° 18' W. 270 feet to a point; thence N. 74° 08' W. 144 feet to an iron axle; thence running along the Edward Butts property N. 6° 17' E. 202 feet to a point; thence N. 6° 33' E. 219 feet to a point; thence N. 6° 02' E. 178 feet to a point; thence N. 5° 38' E. 164 feet to a point; thence N. 6° 04' E. 232 feet to a point; thence N. 5° 36' E. 204 feet to a point; thence along a fence line N. 6° 17' E. 293 feet to a point; thence N. 6° 11' E. 685 feet to the centerline of N.C. State Road 1417; thence along said centerline the following courses and distances, N. 58° 50' E. 247.4 feet; N. 62° 50' E. 300 feet; N. 72° 05' E. 300 feet; N. 75° 45' E. 300 feet; N. 78° 40' E. 543 feet; thence S. 8° 38' W. approximately 30 feet to the Southern right-of-way of said State Road 1417; thence along said right-of-way in a Easterly direction approximately 510 feet to a point on an old road; thence N. 0° 53' 47" E. 1228.28 feet to a large rock; thence S. 32° 00' 18" E. 1280.76 feet to the point of beginning. This property is shown on that certain map entitled "Plat Showing Property Belonging to Halifax County 'Landfill Area'", prepared by Cyril C. Waters, Registered Surveyor, under date of April 11, 1992; reference to said map being hereby made for greater certainty of description.

State of North Carolina
Department of Environment,
Health and Natural Resources
Division of Solid Waste Management

James B. Hunt, Jr., Governor
Jonathan B. Howes, Secretary
William L. Meyer, Director



CF
13-04

May 17, 1996

Mr. Neal C. Phillips, Manager
Halifax County
P. O. Box 38
Halifax, North Carolina 27839

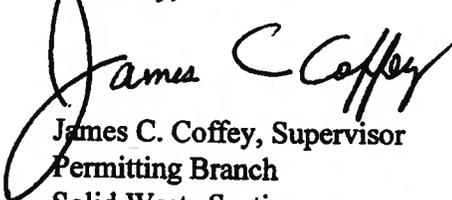
Re: Approval to Construct
Halifax County Ash Monofill - Cell 2
Permit No. 42-04

Dear Mr. Phillips:

The Solid Waste Section hereby approves the design modifications proposed by Hazen and Sawyer and issues approval to construct Cell 2 of the Halifax County Ash Monofill. Construction of Cell 2 shall be in accordance with the conditions of the Permit to Construct originally issued for the facility on 5/12/93. Construction Condition No. 3 describes the pre-operative requirements which must be met in order to obtain permission to operate Cell 2.

If you have any questions or comments regarding this approval, please contact me at (919) 733-0692, ext. 259.

Sincerely,


James C. Coffey, Supervisor
Permitting Branch
Solid Waste Section

cc: John Bove, Hazen and Sawyer
Terry Dover
Ben Barnes
Jim Barber

Preparation of the permit application will involve meetings with state regulatory staff to inform them of the proposed Cell 2 construction timetable and discuss, in general terms, any design modifications. This meeting, if held at the beginning of the design process, will allow the DEHNR to accommodate the project schedule in their reviews and will alert the design team of any potential regulatory concerns. Because of the type of residual to be disposed, and the degree that the facility exceeds regulatory requirements, we do not anticipate significant regulatory problems. Securing a prompt review may pose the greatest challenge in this regard. Hazen and Sawyer will closely follow the review process in order to expedite issuance of a permit.

Several design and operational improvements are being considered for Cell 2. Such modifications are intended to increase efficiency of operations, reduce construction costs or take advantage of improved materials. Improvements that have been discussed to date include the following:

- Use of Ash as Operational Cover. This will result in lower construction costs and reduce required volume of soil. Ash could be used by the Contractor to build the internal roadways needed to provide access. County forces could place the remainder of the ash operational cover as operations progress.
- Use of Ash in Berm Construction. Since ash will be delivered to the site on a daily basis during Cell 2 construction, the ash could be used in construction of the perimeter berms. It has been established that the ash is an excellent fill material and would not adversely impact the function of the cell. This will reduce the volume of soil needed to construct the berms, freeing up this material for other uses on the site, such as daily cover for the MSW landfill.
- Use Polypropylene Geomembrane. Polypropylene geomembrane is stronger than HDPE, is less prone to damage due to thermal expansion and requires less scrutiny during installation. For the exposed geomembrane in this application, Polypropylene is superior to HDPE. Polypropylene became available on an economical production scale only after the Cell 1 permit application was under active review by DEHNR. It was decided to keep the HDPE in Cell 1 to avoid delays associated with additional state review.
- Interior Drainage. Minor improvements will be considered to enhance flow of runoff out of the cell while still allowing the majority of the ash to settle out within the cell. Now that we have had an opportunity to evaluate the ash properties, such improvements can be designed.



March 10, 2010

Mail To:

Lenore Gaier
URS
1600 Perimeter Park Drive, Suite 400
Morrisville, North Carolina 27560

email: Lenore_Gaier@urscorp.com

Bill To:

<= Same

Dear Ms. Gaier:

Thank you for consulting TRI/Environmental, Inc. (TRI) for your geosynthetics testing needs. TRI is pleased to submit this final report for laboratory testing.

Project: ROVA-Halifax Monocell

TRI Job Reference Number: E2339-90-08

Material(s) Tested: 4 Smooth Polypropylene Geomembrane Panel(s)
2 Extrusion Weld Polypropylene Geomembrane Seam(s)

Test(s) Requested: Carbon Content (ASTM D 1603, mod.)
Tensile Properties (ASTM D 6693)
Puncture Strength (ASTM D 4833)
Tear Resistance (ASTM D 1004)
Peel and Shear (ASTM D 6392/GRI GM19/D 4437/NSF 54)

Codes

AD	Adhesion failure (100% Peel)
BRK	Break in sheeting away from Seam edge
SE	Break in sheeting at edge of seam
AD-BRK	Break in sheeting after some adhesion failure - partial peel
SIP	Separation in the plane of the sheet (leaving the bond intact)
FTB	Film tearing bond (all non "AD" failures)
NON-FTB	100% peel

If you have any questions or require any additional information, please call us at 1-800-880-8378.

Sincerely,

Sam R. Allen
Vice President
Geosynthetic Services Division
www.GeosyntheticTesting.com



GEOMEMBRANE TEST RESULTS

TRI Client: URS
Project: ROVA-Halifax Monocell

Material: Polypropylene Smooth Geomembrane Panel
Sample Identification: 1A-South Side Exposed
TRI Log #: E2339-90-08

PARAMETER	TEST REPLICATE NUMBER										MEAN	STD. DEV.	
	1	2	3	4	5	6	7	8	9	10			
Carbon Black Content (ASTM D 1603, mod.)													
% Carbon Black	3.22	3.26										3.24	0.03
Tensile Properties (ASTM D 6693, 2 lpm strain rate)													
MD Yield Strength (ppl)	39	40	38	39	38							39	1
TD Yield Strength (ppl)	33	34	35	35	34							34	1
MD Break Strength (ppl)	92	84	86	90	90							88	3
TD Break Strength (ppl)	90	92	87	95	86							90	4
MD Yield Elongation (%)	50	65	48	46	49							52	8
TD Yield Elongation (%)	61	61	65	61	58							61	2
MD Break Elongation (%)	675	619	641	661	664							652	22
TD Break Elongation (%)	726	749	698	769	689							726	34
Puncture Resistance (ASTM D 4833)													
Puncture Strength (lbs)	53	53	52	51	50							52	1
Tear Resistance (ASTM D 1004)													
MD Tear Strength (lbs)	17	18	17	19	19	18	16	17	16	20		18	1
TD Tear Strength (lbs)	19	16	17	20	16	17	16	16	18	17		17	1
MD Machine Direction	TD Transverse Direction					NA Not Available							

The testing is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested. TRI neither accepts responsibility for nor makes claim as to the final use and purpose of the material. TRI observes and maintains client confidentiality. TRI limits reproduction of this report, except in full, without prior approval of TRI.



GEOMEMBRANE TEST RESULTS

TRI Client: URS
Project: ROVA-Halfax Monocell

Material: Polypropylene Smooth Geomembrane Panel
Sample Identification: 1B-South Side Unexposed
TRI Log #: E2339-90-08

PARAMETER	TEST REPLICATE NUMBER										MEAN	STD. DEV.	
	1	2	3	4	5	6	7	8	9	10			
Carbon Black Content (ASTM D 1603, mod.)													
% Carbon Black	2.91	2.92										2.92	0.01
Tensile Properties (ASTM D 6693, 2 lpm strain rate)													
MD Yield Strength (ppi)	37	40	39	41	40							39	2
TD Yield Strength (ppi)	36	36	36	36	35							36	0
MD Break Strength (ppi)	111	82	90	105	90							96	12
TD Break Strength (ppi)	113	121	117	121	106							116	6
MD Yield Elongation (%)	52	44	54	54	56							52	5
TD Yield Elongation (%)	57	49	60	61	65							58	6
MD Break Elongation (%)	869	600	659	794	664							717	110
TD Break Elongation (%)	950	1046	1006	1038	881							984	69
Puncture Resistance (ASTM D 4833)													
Puncture Strength (lbs)	48	47	48	49	49							48	1
Tear Resistance (ASTM D 1004)													
MD Tear Strength (lbs)	20	19	20	19	19	18	19	18	18	21		19	1
TD Tear Strength (lbs)	19	19	19	19	20	20	18	19	20	19		19	1
MD Machine Direction	TD Transverse Direction					NA Not Available							

The testing is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested. TRI neither accepts responsibility for nor makes claim as to the final use and purpose of the material. TRI observes and maintains client confidentiality. TRI limits reproduction of this report, except in full, without prior approval of TRI.



GEOMEMBRANE TEST RESULTS

TRI Client: URS
Project: ROVA-Halifax Monocell

Material: Polypropylene Smooth Geomembrane Panel
Sample Identification: 2A-West Side Exposed
TRI Log #: E2339-90-08

PARAMETER	TEST REPLICATE NUMBER										MEAN	STD. DEV.	
	1	2	3	4	5	6	7	8	9	10			
Carbon Black Content (ASTM D 1603, mod.)													
% Carbon Black	3.25	3.27										3.26	0.01
Tensile Properties (ASTM D 6693, 2 ipm strain rate)													
MD Yield Strength (ppi)	45	45	45	47	45							45	1
TD Yield Strength (ppi)	33	34	35	36	35							35	1
MD Break Strength (ppi)	115	116	112	115	114							114	2
TD Break Strength (ppi)	101	102	102	99	106							102	3
MD Yield Elongation (%)	70	65	65	64	62							65	3
TD Yield Elongation (%)	52	56	59	54	55							55	3
MD Break Elongation (%)	783	783	754	781	766							773	13
TD Break Elongation (%)	851	864	846	821	929							862	40
Puncture Resistance (ASTM D 4833)													
Puncture Strength (lbs)	55	54	54	54	53							54	1
Tear Resistance (ASTM D 1004)													
MD Tear Strength (lbs)	20	18	17	18	19	17	17	17	18	20		18	1
TD Tear Strength (lbs)	18	18	18	19	19	16	17	17	19	19		18	1
MD Machine Direction	TD Transverse Direction					NA Not Available							

The testing is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested. TRI neither accepts responsibility for nor makes claim as to the final use and purpose of the material. TRI observes and maintains client confidentiality. TRI limits reproduction of this report, except in full, without prior approval of TRI.



GEOMEMBRANE TEST RESULTS

TRI Client: URS
Project: ROVA-Halfax Monocell

Material: Polypropylene Smooth Geomembrane Panel
Sample Identification: 2B-West Side Unexposed
TRI Log #: E2339-90-08

PARAMETER	TEST REPLICATE NUMBER										MEAN	STD. DEV.	
	1	2	3	4	5	6	7	8	9	10			
Carbon Black Content (ASTM D 1603, mod.)													
% Carbon Black	3.05	3.04										3.05	0.01
Tensile Properties (ASTM D 6693, 2 ipm strain rate)													
MD Yield Strength (ppi)	38	37	38	38	38							38	0
TD Yield Strength (ppi)	36	36	37	37	36							36	1
MD Break Strength (ppi)	117	96	112	118	121							113	10
TD Break Strength (ppi)	116	116	119	111	119							116	3
MD Yield Elongation (%)	57	38	38	38	40							42	8
TD Yield Elongation (%)	66	67	61	83	74							70	9
MD Break Elongation (%)	939	728	870	950	1026							903	112
TD Break Elongation (%)	1060	1054	1095	998	1081							1058	37
Puncture Resistance (ASTM D 4833)													
Puncture Strength (lbs)	48	45	46	44	46							46	2
Tear Resistance (ASTM D 1004)													
MD Tear Strength (lbs)	19	22	20	21	17	20	19	16	21	18		19	2
TD Tear Strength (lbs)	21	17	19	20	20	19	20	19	20	21		20	1
MD Machine Direction	TD Transverse Direction					NA Not Available							

The testing is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested. TRI neither accepts responsibility for nor makes claim as to the final use and purpose of the material. TRI observes and maintains client confidentiality. TRI limits reproduction of this report, except in full, without prior approval of TRI.



DESTRUCTIVE SEAM QUALITY ASSURANCE TEST RESULTS

TRI Client: URS

Project: ROVA-Halfax Monocell

Material: Polypropylene Smooth Geomembrane Seam

Test: Peel and Shear (ASTM D 6392/GRI GM19/D 4437/NSF 54)

TRI Log #: E2339-90-08

PARAMETER	TEST REPLICATE NUMBER					MEAN
	1	2	3	4	5	
Sample ID:	DS-1 , New to New					
Weid:	Extrusion Weid					
Peel Strength (ppi)	55	47	42	55	52	Peel 50
Peel Incursion (%)	<10	<10	<10	<10	<10	
Peel Locus of Failure Code	SE	SE	SE	SE	SE	
Peel NSF Failure Code	FTB	FTB	FTB	FTB	FTB	
Shear Strength (ppi)	76	80	79	77	81	Shear 79
Shear Elongation @ Break (%)	>50	>50	>50	>50	>50	
Sample ID:	DS-2 , Old to New					
Weid:	Extrusion Weid					
Peel Strength (ppi)	16	30	10	20	16	Peel 18
Peel Incursion (%)	100	100	100	100	100	
Peel Locus of Failure Code	AD	AD	AD	AD	AD	
Peel NSF Failure Code	NON-FTB	NON-FTB	NON-FTB	NON-FTB	NON-FTB	
Shear Strength (ppi)	56	50	48	51	51	Shear 51
Shear Elongation @ Break (%)	>50	>50	>50	>50	>50	

The testing is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested. TRI neither accepts responsibility for nor makes claim as to the final use and purpose of the material. TRI observes and maintains client confidentiality. TRI limits reproduction of this report, except in full, without prior approval of TRI.

Smooth FPP Geomembrane Sample Specification

A typical physical and mechanical property specification for smooth unreinforced geomembrane made from Astryn flexible polypropylene resins is in Figure 33.

Figure 33
Minimum Value for Black Smooth Unreinforced FPP Geomembranes

<i>Property</i>	<i>Test Method</i>		
Nominal Thickness [mil]		40	60
Minimum Thickness [mil]	ASTM D 751, D 1593 or D 5199	36	54
Carbon Black Content [%]	ASTM D 1603, modified or D4218	2.75 ± 0.5	2.75 ± 0.5
Tensile Properties: (Avg. MD & TD)	ASTM D 638 Type IV, 20 IPM NSF 54 modified		
Strength at Break [lb./in.]		65	95
Elongation at Break [%]	(2.5" gauge length)	>500	>500
Tear Resistance [lb.]	ASTM D 1004	12	18
Puncture Resistance [lb.]	FTMS 101, Method 2065 or D4833	38	45
Dimensional Stability [% change]	ASTM D 1204 (1 hr. at 100 °C)	± 2	± 2

A suggested wedge weld strength specification for smooth unreinforced flexible polypropylene geomembrane is in Figure 34.

Figure 34
Minimum Weld Values for Smooth Unreinforced FPP Geomembranes

<i>Property</i>	<i>Test Method</i>	
Thickness, mil	ASTM D751	40
Peel strength, ppi	ASTM D 4437	20
Shear strength, ppi	ASTM D 4437	30

The elongation of unreinforced flexible polypropylene is so high that field tensometers can not take the material to break without reclamping the specimen. Reclamping is not recommended, rather the shear strength should be recorded at the maximum travel of the field tensometer.

It is suggested you contact flexible polypropylene geomembrane producers to review any proposed sheet specification. Test methods change and test values vary from lab to lab.



PHYSICAL PROPERTIES – POLYPROPYLENE GEOMEMBRANES

PROPERTY	TEST METHOD	SPECIFICATION		
		Certified Value	Certified Value	Certified Value
Gauge (nominal) mils (mm)	--	.036 (0.90)	.045 (1.14)	.060 (1.52)
Plies, reinforcing	--	1	1	1
Thickness, min. 1) Overall - mil (mm) 2) Over Scrim - mil (mm)	ASTM D-751 Optical Method	34 (0.86) 11 (0.28)	41 (1.04) 11 (0.28)	54 (1.37) 11 (0.28)
Breaking Strength-fabric min. lbf (kN)	ASTM D-751 Method A	225 (1.0)	225 (1.0)	250 (1.11)
Low Temp. Flex. °F (°C)	ASTM D-2136 1/8-in. mandrel, 4 hr. pass	-40 (-40)	-40 (-40)	-40 (-40)
Puncture Resistance, min. lbs. (kN)	FTMS 101C Method 2031	300 (1.34)	350 (1.56)	375 (1.67)
Tear Strength, min. lbf (kN)	ASTM D-5884	55 (0.24)	55 (0.24)	55 (0.24)
Dim. Stability (% chg. max.)	ASTM D-1204 180°F/82°C 1 hr.	1.0 (1.0)	1.0 (1.0)	1.0 (1.0)
Hydrostatic resist. min psi (MPa)	ASTM D-751 Method A, Procedure 1	325 (2.2)	350 (2.4)	375 (2.58)
Ply Adhesion, min. lbs/in (kN/m)	ASTM D-413 Machine method modified	20 (3.5)	20 (3.5)	20 (3.5)
Water Absorption max, % wt. chg.	ASTM D-471, 30 days @70°F (21°C)	<1%	<1%	<1%
ESCR (Env. Stress Crack Resist) min. hrs w/o failure	ASTM D-1693 3000 hours	Not affected by ESC	Not affected by ESC	Not affected by ESC
UV Resistance	ASTM G26 Xenon Arc 80°C/4000 hrs	Pass	Pass	Pass
TYPICAL FABRICATED SEAM PROPERTIES**				
Bonded seam strength, min.	ASTM D-751, modified	175 (0.78)	200 (0.89)	220 (0.98)
Peel Adhesion, min.	ASTM D-413, modified	20 (3.5) or FTB	20 (3.5) or FTB	20 (3.5) or FTB



PP (S)

Supported Polypropylene styles have excellent cold temperature flexibility, long term UV resistance, and substantial tensile strength.

Material Properties

29 Oct 2009	PP (S) Minimum Material Properties		
Style	ASTM	PP 36 (S)	PP 45 (S)
Thickness (nominal)	D1593	36 mil 0.91 mm	45 mil 1.14 mm
Tensile Strength @ Break (MD/CD)	D751	200 lbs 890 N	250 lbs 1,100 N
Tear Resistance (MD/CD)	D5884	55 lbs 245 N	55 lbs 245 N
Puncture Resistance	D4833	85 lbs 380 N	85 lbs 380 N
Low Temperature	D2136	-40°F -40°C	-40°F -40°C
Hydrostatic Resistance	D751 Method A	350 psi 2.4 mPa	350 psi 2.4 mPa

Shop Seam Strengths

29 Oct 2009	PP (S) Minimum Shop Seam Strengths		
Style	ASTM	PP 36 (S)	PP 45 (S)
Heat Bonded Seam Strength	D6392 25.4 mm (1") Strip	75 ppi 13.1 N/mm	75 ppi 13.1 N/mm
Heat Bonded Peel Adhesion Strength	D6392 25.4 mm (1") Strip	FTB 22 ppi 3.9 N/mm	FTB 25 ppi 4.4 N/mm

Field Seam Strengths

27 Oct 2009	PP (S) Minimum Field Seam Strengths		
Style	ASTM	PP 36 (S)	PP 45 (S)
Heat Bonded Seam Strength	D6392 25.4 mm (1") Strip	60 ppi 10.5 N/mm	60 ppi 10.5 N/mm
Heat Bonded Peel Adhesion Strength	D6392 25.4 mm (1") Strip	FTB 20 ppi 3.5 N/mm	FTB 20 ppi 3.5 N/mm

Disclaimer - Please Note

Please Note

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**GEOMEMBRANE LINER
ENGINEERING SPECIFICATION GUIDE**



POLYPROPYLENE Reinforced Geomembrane

Physical Property	Test Method	Property of Unaged Sheet	Property After Aging 30 days @ 185°F
Tolerance on nominal thickness, %	ASTM D 751	± 10	
Thickness over scrim, in (mm)			
36-mil	ASTM D 4637	0.010 (0.254) min	
45-mil	Optical Method	0.013 (0.330) min	
60-mil		0.018 (0.457) min	
Mass per unit area, lb/ft ² (g/ft ²) (kg/m ²)			
36-mil	ASTM D 5261	0.17 (77) (0.83) typical	
45-mil		0.21 (95) (1.03) typical	
60-mil		0.29 (132) (1.42) typical	
Breaking strength, lbf (kN) (grab tensile at strain rate of 12 in./min.)	ASTM D 751 Grab Method A	200 (0.9) min. 260 typ. 250 (1.1) min. 300 typ.	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	ASTM D 5884 (max. load)	80 (356) min 130 (578) typ	
45 & 60-mil		100 (445) min. 160 (712) typ	
Low temperature flexibility, °F (°C)	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 122°F (50°C) 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	ASTM D 751 Procedure A	350 (2.4) min 400 (2.8) typical	350 (2.4) min 400 (2.8) typical
45-mil		450 (3.1) typical	450 (3.1) typical
60-mil		500 (3.4) typical	500 (3.4) typical
Field seam strength, lbf (N) Seam tested in peel after weld	ASTM D 4437 1 in. wide	30 (5.3) min. 60 (10.5) typical	
Water vapor permeance, Perms	ASTM E 96	0.10 max. 0.05 typical	
Puncture resistance, lbs (N)			
36-mil & 45-mil	ASTM D 4883 (index puncture)	85 (378) min. 110 (489) typical	
60-mil		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 80°C 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/m² irradiance

² Factory bonded seam strength is the responsibility of the fabricator.

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