Presented at IECA 2014,
Nashville, TN

EVALUATING SEDIMENT BARRIERS

C. Joel Sprague, P.E.
TRI/Environmental, Inc.
PO Box 9192, Greenville, SC 29604
Phone: 864/242-2220; Fax: 864/242-3107; jsprague@tri-env.com

Benton Ruzowicz, CPESC, CESSWI
Georgia Soil and Water Conservation Commission
PO Box 1665, Athens, GA 30603
Phone: 706-542-4475; bruzowicz@gaswcc.org

James E. (Jay) Sprague, Laboratory Director,
TRI/Environmental - Denver Downs Research Facility
4915 Clemson Blvd., Anderson, SC 29621
Phone: 864/569-6888; jesprague@tri-env.com

Biography

C. Joel Sprague, Sr. Engineer - Mr. Sprague is a Senior Engineer for TRI/Environmental, Inc., Austin, TX. Mr. Sprague is based in Greenville, South Carolina where he also consults for Sprague & Sprague Consulting Engineers. He is a registered professional engineer in North and South Carolina, Georgia, and Texas. He has authored numerous articles and technical papers on the development, testing, and application of erosion and sediment control materials.

Benton Ruzowicz, Technical Specialist – Mr. Ruzowicz provides technical assistance to land disturbers, local governments, and erosion and sediment control professionals around the State on erosion and sedimentation control issues and the appropriate use of urban BMP's. He also provides technical plan reviews on behalf of the Districts in the Metro Atlanta area as well as technical support to all plan reviewers throughout the State. Ben also helps oversee the State's education and certification program for people involved in land disturbing activities in which there have been over 75.000 people certified.

Jay Sprague, Lab Director – Mr. Sprague supervises a staff of technicians, directs all site operations and testing, and is responsible for implementation of TRI's Quality Systems throughout all lab operations. Mr. Sprague's background includes developing markets and technologies associated with agricultural and erosion and sediment control products.

Abstract

In 2010, the Georgia Soil and Water Conservation Commission (GSWCC) received funding to revise the Manual for Erosion and Sediment Control in Georgia. One of the parameters was to incorporate new BMP's into the Manual. This was done by characterizing full-scale, installed performance of commonly used best management practices (BMPs) for sediment control. Some of the specific BMPs tested included what the GSWCC refers to as sediment barriers. Sediment barriers have traditionally been constructed of two rows of silt fence or one row of silt fence backed by straw bales for sensitive areas and one row of silt fence for non-sensitive areas, with the silt fence being categorized into three different types. More recently "wattles", "socks" and other alternative BMP's have been used. These sediment barriers are used as so-called "perimeter control devices" around construction and building sites to intercept sheet flows when no obvious low point or ponding capacity exists on-site.

Since there is relatively little performance data available for most BMPs, including sediment barriers, and the limited data that is available has generally been developed using widely differing protocols, the testing protocol chosen should, as much as possible, conform to an existing standardized procedure so that future sediment barriers could be subjected to the same protocols and easily and reliably be compared to the results of this program.

Recognizing that the actual performance of many sediment barriers is system or installation dependent, the GSWCC determined that a large-scale test that could incorporate full-scale "as installed" conditions would be the best evaluation procedure. To this end, the GSWCC selected a large-scale standard test method that is being developed within ASTM for the evaluations. This proposed test method uses test plots having a slope of 3:1 and a 27 ft slope length. The test soil was classified as a Sandy Clay as shown on the USDA soil triangle. The sediment laden flow is generated by simulated rainfall falling on the slope, eroding the bare soil plots, and collecting against the sediment barrier at the toe of the slope. The rainfall sequence was run according to ASTM D 6459 - 2 in/hr, 4 in/hr, and 6 in/hr each for 20 minutes. All runoff seepage and associated sediment passing the sediment barrier was collected, dried, and measured. The measured soil loss value is used to calculate the P-Factor.

The Practice Management Factor, or P-Factor, from the Revised Universal Soil Loss Equation (RUSLE) of the USDA-ARS Agricultural handbook 703 is the reported performance measure from this testing. Total sediment loss and the associated rainfall depth measured during the testing are the principle data used to determine the P-Factor. The P-Factor thus calculated is the reported performance value. This facilitates product-to-product comparison of test results at a common point of the storm event. Additionally, using the regression equations for the protected and the control (or unprotected) conditions, the users of the test report can evaluate performance at other points in the model storm by selecting the R factor (and the corresponding A-Factor) that may fit local conditions and calculating the ratio.

In general, lower system seepage rates correlate with lower system sediment loss rates. Related to this, lower fabric permittivity rates parallel lower system seepage rates and thus lower sediment loss, and higher fabric percent open area (for woven fabrics) correlates with maintaining higher system seepage rates along with associated higher sediment loss rates.

It was not possible to make similar comparisons for non-fabric (i.e. non-silt fence) systems, since there are no standardized index tests for these 3-dimensional (3-D) materials. Still, it would be likely that these 3-D systems have lower open area and size (i.e. straight-thru open spaces) but as high or higher flow (similar to permittivity). This suggests that 3-D structures may be able to provide superior balance of properties (greater filtration and greater flow) as long as there is no piping, undermining, or overtopping. The data suggests that products fall into one of two categories: "High Retention" or "High Flow". A lower P-Factor is generally associated with the High Retention systems, while High Flow systems typically have higher seepage rates. Straw bales are not recommended as sediment barriers for slopes greater than or equal to 3:1 and, perhaps, not even for lower slopes.

Keywords: sediment barriers, perimeter sediment control, BMP, slope testing, GSWCC, Method 11340

1 Background

The Georgia Soil and Water Conservation Commission (GSWCC) testing program described herein was intended to characterize full-scale, installed performance of commonly used best management practices (BMPs) for sediment control. These BMPs are commonly referred to as sediment retention devices, or sediment barriers. The sediment barriers tested include what the GSWCC refers to as sediment barriers and were exposed to conditions relevant to typical installations. This testing served as a "baseline" for qualification of future sediment barriers. Additionally, the "index properties" of the tested materials were verified and documented to go along with their associated performance properties. Together the index and performance data facilitates the correlation of performance to certain easily measured properties of the sediment barrier components, and it "bench-marks" the performance of a given product to specific index properties.

The testing protocols were either existing standard test methods or fully documented for potential standardization, so that future sediment barriers can be subjected to the same protocols and be easily and reliably compared to the results of this program.

2 Overview of Test Procedures for sediment barriers

2.1 Basic Index Tests for QC and "Bench-marking" of Tested Products

All product manufacturers must perform a few tests frequently so that they can prove that they are keeping their manufacturing processes within preset limits and thereby producing a consistent product.

2.1.1 Basic Index Properties for 2-Dimensional (Geotextile-based) Sediment Barriers

In the manufacturing of sediment barriers with geotextile components, a few basic mechanical and hydraulic properties are routinely measured in the manufacturer's own QC lab. These include:

- Mass per Unit Area via ASTM D 5261, "Standard Test Method for Measuring Mass per Unit Area of Geosynthetics."

- Thickness via ASTM D 5199, "Standard Test Method for Measuring Thickness of Geosynthetics."

- Tensile Strength via ASTM D 4632, "Standard Test Method for Grab Breaking Load and Elongation of Geosynthetics."

- Permittivity – Permittivity relates to the vertical water flow capacity of the material. It is often reported as gallons per minute per square foot of material and uses clear water and is measured via ASTM D 4491, "Standard Test Methods for Water Permeability of Geotextiles by Permittivity".

- Apparent Opening Size (AOS) – The approximate largest (O_{95}) size opening in the fabric is called the apparent opening size (AOS). The standard test method is ASTM D 4751, "Standard Test Method for Measuring the Apparent Opening Size of Geosynthetics".

- Percent Open Area (POA) – While the AOS is a good indicator of a geotextile's ability to retain sediments when the geotextile has lots of varying sized openings – such as with a nonwoven geotextile – a woven geotextile can have a few larger openings and a lot of very small ones making it prone to clogging even though the AOS test may indicate that it has relatively large openings. To make sure it has enough openings, the overall percent of open area can be determined using light projection. Though the test is not standardized, a light projection technique is commonly used.

2.1.2 Basic Index Properties for 3-Dimensional Sediment Barriers

Many sediment barriers are 3-dimensional products (i.e. wattles, bales, etc.), thus non-standard procedures are currently used to measure such things as density (or unit weight per length) and circumference.

2.2 Full-scale Performance Testing of *Sediment Barriers in Perimeter Control Applications*

The most common sediment barriers, including silt fences and wattles, are used as so-called "perimeter devices" around building sites to intercept modest sheet flows when no obvious low point or ponding capacity exists on-site. Characterization testing associated with this application is described in GSWCC Method 11340.

3 Products Tested and Associated Index Properties

3.1 Test Matrix

Table 1 presents the testing matrix, including the sediment barrier type tested and the number of tests. Products were randomly chosen from approved product listings of the GADOT QPL 36.

Sediment Barrier Type	# Tested	Installation
Silt Fence – GADOT Type A	3	36” fabric; 1.5” x 1.5” x 4ft oak posts @ 6ft spacing
Silt Fence – GADOT Type B	2	24” fabric; 1.0” x 1.0” x 3ft oak posts @ 6ft spacing
Silt Fence – GADOT Type C	3	36” fabric; wire backing; steel posts @ 4ft spacing
Silt Fence – GADOT C-System	2 Prefab Systems	Install according to manufacturer’s specifications
GSWCC Type B Silt Fence Alternative	Compost Sock	Install according to manufacturer’s specifications
GSWCC Type C Silt Fence Alternative	Scrim-Reinforced Silt Fence	Install according to manufacturer’s specifications
GSWCC-USDA “Traditional”	Straw Bales	Installed per the Manual / Installed per USDA

Table 1. Test Matrix

3.2 Index Testing Results

Table 2 presents a summary of index testing results for the products used in testing.

Type A Silt Fence					Products Tested		
Property	Units	Spec	Test	Spec	A-1	A-2	A-3
Tensile	lb	min	D4632	120 x 100	175 x 157	167 x 127	173 x 119
Elong	%	max	D4632	40	31 x 20	25 x 22	26 x 23
AOS	mm	max size	D4751	0.6	0.539	0.579	0.607
Flow	gpm/ft^2	min	GDT 87	25	22.9	111	85
POA	%	-	-	-	3	16	8
Type B Silt Fence					Products Tested		
Property	Units	Spec	Test	Spec	B-1	B-2	
Tensile	lb	min	D4632	120 x 100	175 x 157	232 x 171	
Elong	%	max	D4632	40	31 x 20	21 x 16	
AOS	mm	max size	D4751	0.6	0.539	0.465	
Flow	gpm/ft^2	min	GDT 87	25	23	169	
POA	%	-	-	-	3	7	
Type C Silt Fence					Products Tested		
Property	Units	Spec	Test	Spec	C-1	C-2	C-3
Tensile	lb	min	D4632	260 x 180	451 x 256	351 x 259	458 x 262
Elong	%	max	D4632	40	42 x 76	20 x 12	45 x 21
AOS	mm	max size	D4751	0.6	0.49	0.416	0.505
Flow	gpm/ft^2	min	GDT 87	70	394	131	585
POA	%	-	-	-	28	18	21
C-System Silt Fence					Products Tested		
Property	Units	Spec	Test	Spec	CSys-1	CSys-2	
Tensile	lb	min	D4632	260 x 180	364 x 201	296 x 181	
Elong	%	max	D4632	40	21 x 15	19 x 14	
AOS	mm	max size	D4751	0.6	0.416	0.417	
Flow	gpm/ft^2	min	GDT 87	70	171	114	
POA	%	-	-	-	30	14	
GSWCC Alt Silt Fence					Products Tested		
Property	Units	Spec	Test	Spec	CAlt-1		
Tensile	lb	min	D4632	120 x 100	105 x 90		
Elong	%	max	D4632	40	96 x 117		
AOS	mm	max size	D4751	0.6	0.164		
Flow	gpm/ft^2	min	GDT 87	25	112		
POA	%	-	-	-	n/a		

Table 2. Specifications and Index Testing Results

4 Sediment Barrier Performance Testing in accordance with Method 11340

4.1 Testing Overview

The large-scale sediment barrier testing reported herein was performed in accordance with GSWCC Method 11340 modified as necessary to accommodate the selected products, on 3:1 slopes using sandy clay test plots measuring 27 ft long x 8 ft wide. The simulated rainfall was produced by "rain trees" arranged around the perimeter of each test slope. Each rain tree has four sprinkler heads atop a 15 ft riser pipe. The rainfall system has been calibrated prior to testing to determine the number of sprinkler heads and associated pressure settings necessary to achieve target rainfall intensities and drop sizes. The target rainfall intensities are 2, 4, and 6 in/hr and are applied in sequence for 20 minutes each. Three replicate test slopes with the sediment barrier installed at the bottom were tested. The sediment retention provided by the product tested is obtained by comparing the protected slope results to control (bare soil) results. Rainfall versus soil loss relationships are generated from the accumulated data.

Figure 1. Test Slopes (Control Setup)

Figure 2. "Rain Trees" around Test Slopes

4.2 Preparation of the Test Slopes

The initial slope soil veneer (12-inch thick minimum) is placed and compacted. Compaction is verified to be 90% (± 3%) of Proctor Standard density using ASTM D2937 (drive cylinder method). Subsequently, the test slopes undergo a "standard" preparation procedure prior to each slope test. First, any rills or depressions resulting from previous testing are filled in with test soil and subject to heavy compaction. The entire test plot is then tilled to a depth not less than four inches. The test slope is then raked to create a slope that is smooth both side-to-side and top-to-bottom. Finally, a steel drum roller is rolled down-and-up the slope 3 times proceeding from one side of the plot to the other. The submitted erosion control product is then installed using the technique acceptable to / recommended by the client. For this testing, TRI technicians installed the product to be tested.

4.3 Installation of a Sediment Barrier at the End of the Test Slopes

Each sediment barrier was installed as directed by the client. For the tests reported herein, the sediment barrier installations were in accordance with the GSWCC's Manual for Erosion and Sediment Control in Georgia (the "Green Book") or manufacturer's specifications. The products chosen for testing by the laboratory are listed in Table 1. The specific installations included:

4.4 Specific Test Procedure

Immediately prior to testing, rain gauges are placed at the quarter points (i.e. 10, 20, 30 ft) on the slope. The slope is then exposed to sequential 20-minute rainfalls having target intensities of 2, 4, and 6 inches

per hour. All runoff is collected during the testing. Additionally, periodic sediment concentration grab samples are taken and runoff rate measurements are made. Between rainfall intensities, the rainfall is stopped and rainfall depth is read in the six rain gauges, valves are adjusted to facilitate the subsequent rainfall intensity, and empty collection vessels are positioned to collect subsequent runoff. After allowing for sediments to settle, water is decanted from the collected runoff. The remaining sediments are collected and dried to determine total soil loss.

5 Test Results

5.1 Calculations

The Practice Management (P) Factor from the Revised Universal Soil Loss Equation (RUSLE) of the USDA-ARS Agricultural handbook 703 is the reported performance measure for slopes determined from this testing. The A-Factor, R-Factor, and P-Factor reported herein are related through RUSLE by the following relationship:

$$A = R \times K \times LS \times C \times P$$

where: A = the computed soil loss in tons per acre (measured/calculated from test);
R = the rainfall erosion index (measured/calculated from test);
K = the erodibility of the soil (calculated from control tests);
LS = the topographic factor (2.02 for 8 x 27 ft slope);
C = the cover factor = (1.0 for all test slopes); and
P = the practice factor = ratio of protected slope sediment loss (via seepage through a sediment barrier) to control slope sediment loss (via runoff without sediment barrier). Note: P = 1.0 for the control slope.

Total sediment loss and the associated rainfall depth measured during the testing are the principle data used to determine the P-Factor. Based on the RUSLE equation, the following steps are followed to derive the P-Factor for the tested product:

1. Using the control test results, the K-Factor is derived by fitting a linear regression to the plot of cumulative “A” to cumulative “R” (see Figure 3). The slope of the regression line is used to calculate the “K”, or characteristic erodibility, of the test soil. The regression equation is used to calculate the “A”, or soil loss, at R = 231. This is the normalized cumulative R-Factor calculated for the target test events: 2 in/hr for 20 minutes + 4 in/hr for 20 minutes + 6 in/hr for 20 minutes based on the equation:

   R-Factor = [total kinetic energy of the storm (E)] x [the max 30-minute Intensity (I)]

2. Using the protected test results, a “best fit” regression line is fitted to a plot of cumulative “A” and cumulative “R”. The “A”, or soil loss, is calculated for R = 231 using the best fit regression equation.

3. The P-Factor at R = 231 is then calculated for the protected condition using the following equation:

   P-Factor = [“A” protected at R = 231] / [“A” control at R = 231]

The P-Factor thus calculated is the reported performance value. This facilitates product-to-product comparison of test results at a common point of the storm event. Additionally, using the regression equations for the protected and the control conditions, the users of the test report can evaluate performance at other points in the model storm by selecting the R factor (and the corresponding A-Factor) that may fit local conditions and calculating the ratio.

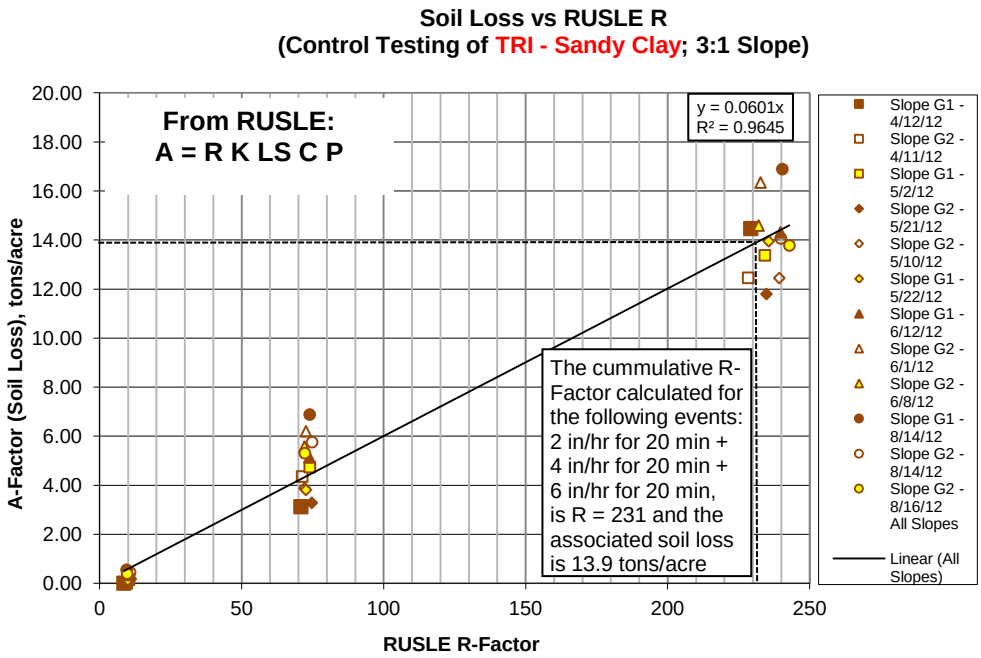

Figure 3. Cumulative Plot of A-Factor vs. R-Factor for Control Tests

5.2 Discussion

Pictures of prepared and end-of-test slopes are shown in Figures 4 through 11.

Figure 4. Prepared Slope & Installed Product

Figure 5. Control End-of-Test

Figure 6. Type A End-of-Test

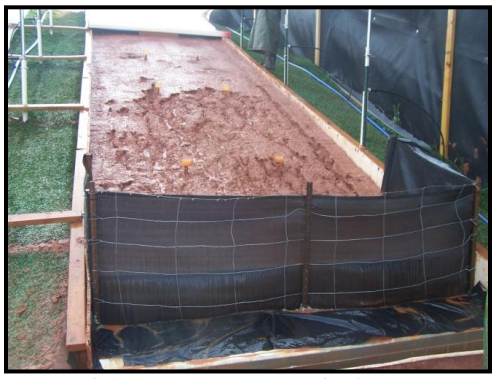

Figure 7. Type C End-of-Test

Figure 8. C-System End-of-Test

Figure 9. Type B Compost Sock End-of-Test

Figure 10. Type B Silt Fence End-of-Test

Figure 11. Type B Straw Bales End-of-Test

Tables 3a and 3b summarize the test data and calculations for all the tests performed. When the data is presented graphically, as shown in Figures 12 through 14, some relationships are suggested. Figures 12 and 13 summarize the performance results of all sediment barrier testing. Figure 12 presents seepage and sediment loss through/over/under the sediment barrier, and the calculated P-Factor for each tested product. The P-Factor is the sediment loss for the protected condition divided by the sediment loss from the control condition. This is the recognized performance value for sediment barriers with lower values indicating better performance. Three of the thirteen tested products had relatively lower P-Factors.

Figure 13 presents a plot of the seepage versus sediment loss for each product. In general, lower system seepage rates correspond with lower system sediment loss rates. As shown, there is a linear relationship for woven geotextile silt fences between seepage and sediment loss, while other product types seem to demonstrate unique performance.

Relating index properties to performance, an examination of Figure 14 indicates that lower system seepage rates correlate with lower system sediment loss rates. Related to this, lower fabric permittivity rates parallel lower system seepage rates and thus lower sediment loss, and higher fabric percent open area (for woven fabrics) correlates with maintaining higher system seepage rates along with associated higher sediment loss rates.

It is not possible to make similar comparisons for non-fabric systems, since there are no standardized index tests for these 3-dimensional (3-D) materials. Still, it would be likely that these 3-D systems have lower open area and size (i.e. straight-thru open spaces) but as high or higher flow (similar to permittivity). This suggests that 3-D structures may be able to provide superior balance of properties (greater filtration and greater flow) as long as there is no piping, undermining, or overtopping. Testing of the Type B (shorter) systems suggests that these systems are more susceptible to piping, undermining, and/or overtopping.

Product	Rainfall Event	Test Slope 1		Test Slope 2		Test Slope 3		Avg Seepage, gal	A-Factor at $_{R=231}$	P-Factor
		Sed. Loss, lbs	Runoff, gal	Sed. Loss, lbs	Runoff, gal	Sed. Loss, lbs	Runoff, gal			
C Alt	2	0.025	7	0.043	7	0.044	4			
	4	0.489	51	0.597	56	0.709	68			
	6	1.185	102	1.194	115	1.379	126			
Cumulative Data:		2	160	2	178	2	198	179	0.126	0.009
Csys-1	2	0.13	4	0.21	9	0.26	5			
	4	2.38	79	2.48	74	2.89	78			
	6	4.53	140	4.89	146	4.63	145			
Cumulative Data:		7	223	8	229	8	228	227	0.501	0.036
C-2	2	0.1	7	0.02	6	0.07	5			
	4	2.18	72	2	67	2.05	71			
	6	4.97	133	4.38	128	5.4	133			
Cumulative Data:		7	212	6	201	8	209	207	0.478	0.034
A-1	2	0.09	4	0.01	2	0.25	7			
	4	1	57	0.96	60	1.48	63			
	6	1.5	97	2.5	94	1.88	98			
Cumulative Data:		3	158	3	156	4	168	161	0.215	0.015
C-1	2	0.3	8	0.6	14	0.41	12			
	4	2.7	76	3.8	83	2.7	76			
	6	4.8	150	5.2	155	5.2	157			
Cumulative Data:		8	234	10	252	8	245	244	0.569	0.041
A-2	2	0.4	15	0.4	11	0.4	10			
	4	2.2	66	2.3	67	2.1	66			
	6	4.1	126	4.05	125	4.25	128			
Cumulative Data:		7	207	7	203	7	204	205	0.443	0.032
A-3	2	0.11	6	0.15	7	0.21	8			
	4	1.45	65	1.75	70	2.1	72			
	6	3.75	120	3.85	120	4.3	125			
Cumulative Data:		5	191	6	197	7	205	198	0.393	0.028
CSys-2	2	0.04	9	0.03	11	0.05	8			
	4	1.9	70	1.95	71	2.2	69			
	6	4.76	135	4.96	138	4.2	130			
Cumulative Data:		7	214	7	220	6	207	214	0.441	0.032
C-3	2	0.02	7	0.18	11	0.27	9			
	4	2.44	80	2.9	75	2.84	82			
	6	5.2	151	5.4	148	5.81	152			
Cumulative Data:		8	238	8	234	9	243	238	0.565	0.041
B-2	2	0.2	6	0.11	5	0.1	6			
	4	5.52	55	1.21	61	1.8	62			
	6	3.7	153	2.98	149	2.5	144			
Cumulative Data:		9	214	4	215	4	212	214	0.372	0.027
B-1	2	0.18	6	0.2	6	0.14	4			
	4	0.99	60	0.8	62	1.1	57			
	6	1.6	178	1.9	187	2.35	172			
Cumulative Data:		3	244	3	255	4	233	244	0.207	0.015
Alt	2	0.06	5	0.04	4	0.08	9			
	4	1.8	80	2.7	81	2.42	87			
	6	6.9	173	8.3	166	6.23	173			
Cumulative Data:		9	258	11	251	9	269	259	0.721	0.052
B-Alt	2	0.03	6	0.1	10	0.26	14			
	4	0.76	74	0.83	76	1.65	110			
	6	3.6	176	4.3	164	5.72	176			
Cumulative Data:		4	256	5	250	8	300	269	0.375	0.027

Table 3a. Data for Product Tests

Product	Rainfall Event	Test Slope 1		Test Slope 2		Test Slope 3		Avg Seepage, gal	A-Factor at $_{R=231}$	P-Factor
		Sed. Loss, lbs	Runoff, gal	Sed. Loss, lbs	Runoff, gal	Sed. Loss, lbs	Runoff, gal			
Control	2	0.1	5	0.0	1	2.2	7			
	4	45.8	110	64.0	110	67.5	114			
	6	166.6	223	119.0	207	126.8	211			
Cumulative Data:		213	338	183	318	197	332	329		
Control	2	2.6	15	3.1	22	2	23			
	4	45.6	101	53.9	96	54	115			
	6	125.1	213	125.9	226	148.9	207			
Cumulative Data:		173	329	183	344	205	345	339		
Control	2	5.04	21	6.3	19	5.5	25			
	4	70.4	140	84.8	150	76.4	131			
	6	134.8	213	149	218	132.4	209			
Cumulative Data:		210	374	240	387	214	365	375		
Control	2	8.12	28	6.6	23	5.8	20			
	4	93	123	78	119	72.2	129		Cumulative Factors	
	6	147	217	122	188	124.4	224			
Cumulative Data:		248	368	207	330	202	373	357	13.880	1

Table 3b. Data for Control Runs

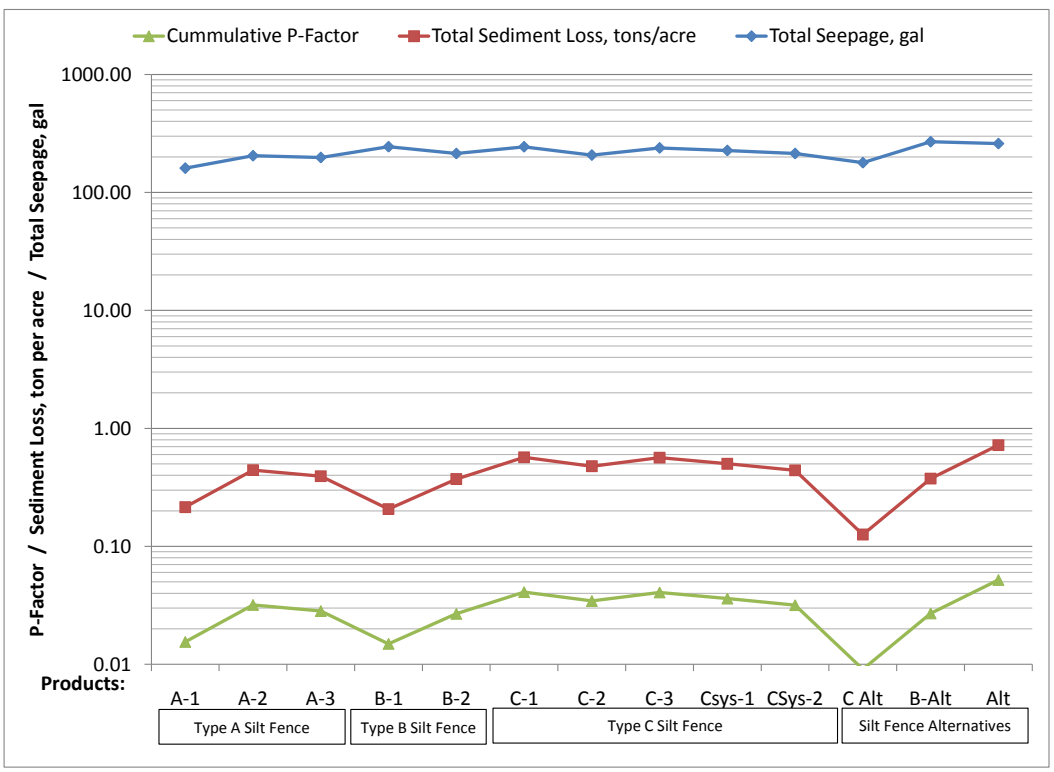

Figure 12. Seepage, Sediment Loss, and P-Factor for the Products Tested

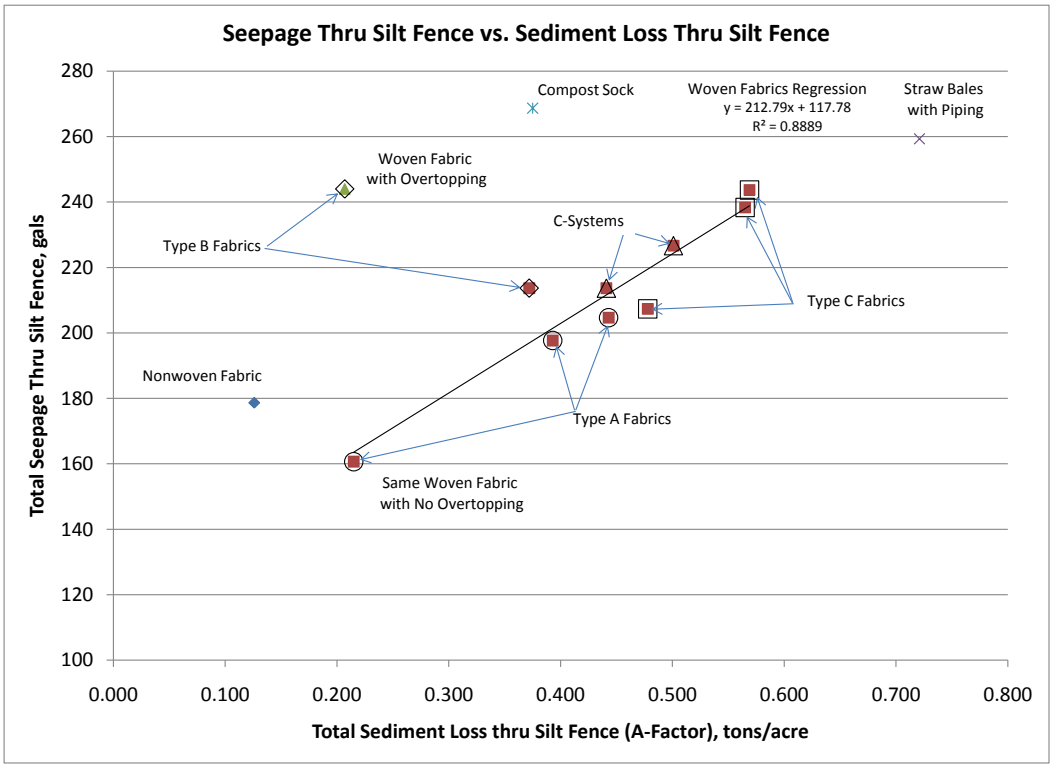

Figure 13. Seepage vs. Sediment Loss for All Tested Products

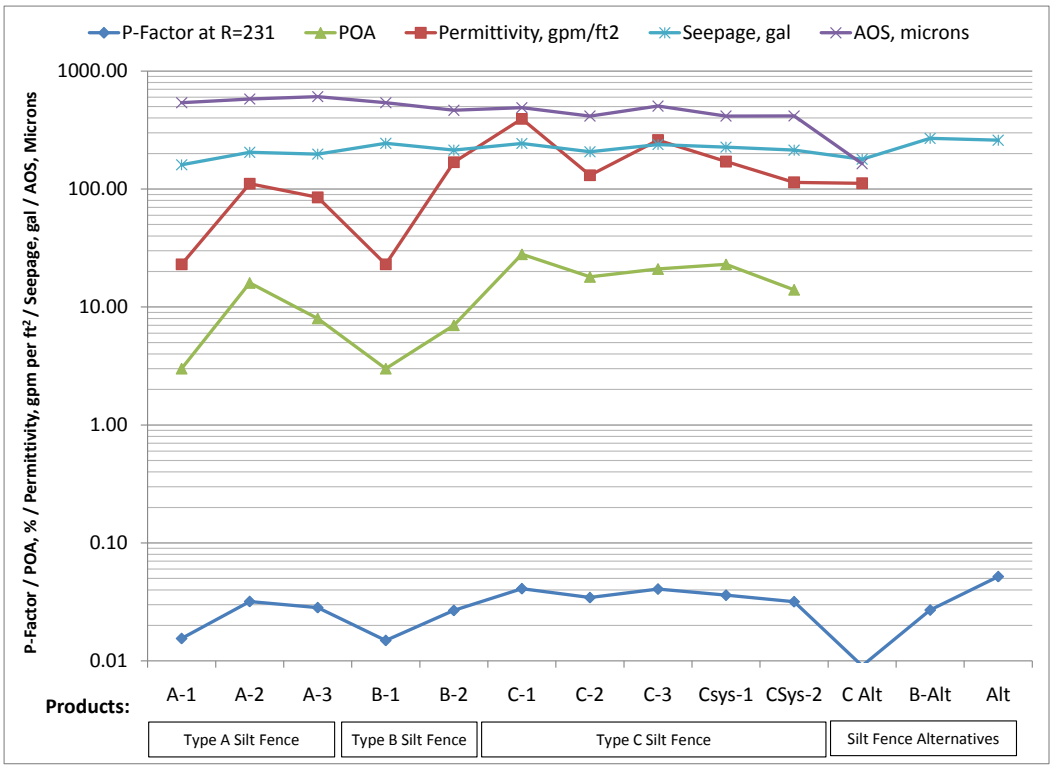

Figure 14. Seepage and Related Index Properties for the Tested Products

6 Conclusions and Recommendations

Figure 15 summarizes the results of all sediment barrier testing. The figure is similar to Figure 13, but instead of plotting system seepage vs. sediment loss, it relates seepage to P-Factor which is the sediment loss for the protected condition divided by the sediment loss from the control condition. This is the reported performance value. Figure 15 also shows suggested performance envelopes for "High Retention" and "High Flow" systems, respectively. Clearly, a lower P-Factor is generally associated with the High Retention systems, while High Flow systems typically have higher seepage rates. Table 4 shows how these performance limits could be incorporated into the existing GADOT specifications for silt fence fabrics. Straw bales are not recommended as sediment barriers for slopes greater than or equal to 3:1. Generally, the test results suggest that it is possible to specify high retention systems for applications that can accommodate the associated ponding and high flow systems where ponding would create a hazard or exceed the available area.

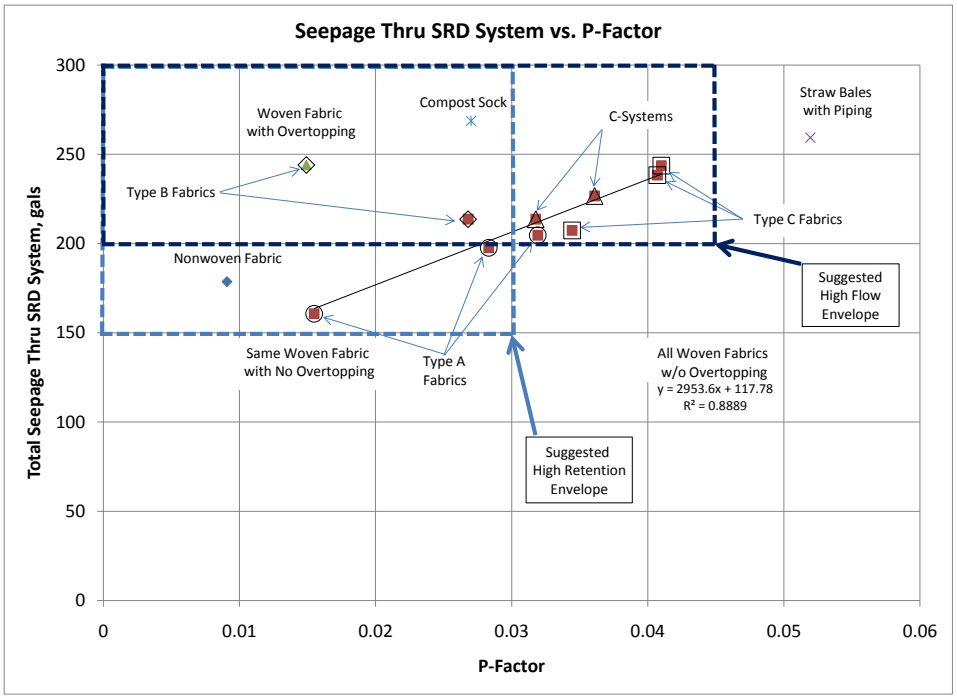

Figure 15. Seepage vs. P-Factor for All Tested Products

Property	Units	Spec	Test	Type A & B	Type C	Alt. Systems
Tensile	lb	min	D4632	120 x 100	260 x 180	Properties and Installation Guidelines To Be Provided By Manufacturer
Elongation	%	max	D4632	40	40	
AOS	mm	max size	D4751	0.6	0.6	
Flow	gpm/ft^2	min	D4491	25	70	
POA	%	min	Light Projection	-	10	
Large-scale Performance	P-Factor	max	Method 11340	0.03	0.045	TBD
	gals	min		150	200	TBD

Table 4. Recommended Revised Material Specifications

7 Acknowledgement

The authors would like to recognize the Georgia Soil and Water Conservation Commission for making this testing/research possible through a 319 grant.