TxDOT/TTI Hydraulics and Erosion Control Laboratory
Field Performance Testing of
Selected Erosion Control Products

Final Performance Analysis - 1995 Evaluation Cycle
Class 1 - "Slope Protection"
Class 2 - "Flexible Channel Liners"

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ERRATA
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The following corrections have been made to the report dated February, 1996:

Page 15: The address and telephone number for BonTerra America, Inc., was revised

The address and telephone number for American Excelsior Company was revised.

Page 16: The "Name of Product Tested" was revised **from** *LANDLOK® ECRM 450* **to** *LANDLOK® TRM 450*.

By letter dated January 29, 1996, Synthetic Industries announced the name change for the subject product. The trade name *LANDLOK® TRM 450* should be substituted for the trade name *LANDLOK® ECRM 450* whenever found within the report.

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THE TxDOT/TTI HYDRAULICS AND EROSION CONTROL LABORATORY

INTRODUCTION:

The Texas Department of Transportation (TxDOT) has shifted from a material-type specification for hydraulic mulches (termed "cellulose fiber mulches" within Standard Specification Item 164 *Seeding For Erosion Control*), and for roll-type erosion control mats (termed "soil retention blankets" within Standard Specification Item 169 *Soil Retention Blanket*,) into an "approved product"-type specification. The approved product list (APL) is based upon the demonstrated field performance of products tested through TxDOT's formal evaluation program.

TxDOT's current specifications for cellulose fiber mulches (See Appendix A), and for soil retention blankets (See Appendix B), do not include any of the typical ASTM-type material requirements, such as weight, tensile strength, elongation, water-holding capacity, pH, etc.

TxDOT has defined critical performance measures and has established minimum performance standards for selected erosion control and revegetation products which are promoted by industry for use within TxDOT's construction and/or maintenance activities. In cooperation with the Texas Transportation Institute (TTI) Environmental Management Program, TxDOT has funded the construction and annual operation of an extensive, outdoor, field-testing facility designed to collect performance data which may be used by TxDOT to produce and maintain a defensible APL.

With respect to soil retention blankets, TxDOT felt that the critical performance factors were:

(a) how well does the product protect the seedbed or the geometry of a channel from the loss of sediment; and

(b) how well does the product promote the establishment of a warm-season, perennial vegetative cover over a single March - December growing season.

Further, TxDOT recognized that soil retention blankets should be divided into two distinct types:

(a) products designed for normal overland flows associated with typical embankment protection; and

(b) products designed for concentrated water flows associated with drainage channels.

With respect to cellulose fiber mulches, TxDOT felt that sediment loss was not a critical performance factor, in that TxDOT recommends limiting the use of these products to slopes of 1:3 or flatter. The single performance factor adopted is the amount of warm-season, perennial vegetation produced within a single March - December growing season.

INTRODUCTION (Continued)

Through formal, field performance testing at the TxDOT/TTI Hydraulics and Erosion Control Laboratory (HECL,) TxDOT has adopted minimum performance standards for each application. In order for a product to be placed upon TxDOT's APL, it must meet (or exceed) the currently adopted performance standards associated with that application.

In the case of soil retention blankets, products must meet the minimum performance standards for both of the critical performance measures. Failure within either of the measures will automatically reject the product from being placed upon the APL.

THE TESTING FACILITY

The facility was constructed by TTI on Texas A&M University's Riverside Campus, 6.5 km (4 mi) west of Bryan, Texas. The facility encompasses 8.5 ha (21 acres) and includes an L-shaped embankment, a series of 10, at-grade channels, water reservoirs, pumping stations and various instrumentation.

The facility is located on what was once a military airport, and is bounded on the north, east and west sides by runways. Because the site is located on a ridge just above the Brazos River, it is exposed to harsh climatic conditions. Existing soils are generally low in organic content and the site is influenced by heat energy stored in, or reflected from the surrounding pavement. These unique physical conditions were deliberately selected by TTI to provide the most realistic conditions possible for conducting controlled experiments related to the roadside environment.

The L-shaped embankment is approximately 300 linear meters by 6.7 meters in vertical height (984 linear feet by 22 feet high). The embankment was constructed to strict TxDOT standards with respect to compaction in order to simulate a typical highway embankment as closely as possible. In order to test the significance of steepness of slope, one side of the embankment was constructed to a 1:2 (2:1) slope, while the other side was constructed to a 1:3 (3:1) slope. To test the significance of soil texture, one-half of the embankment is plated with 98 cm (6 inches) of an erosive, sandy loam soil, while the remaining one-half of the embankment is plated with 98 cm (6 inches) of a tight, clay soil.

Individual embankment treatment plots are 6 meters (20 feet) across and either 15 meters (50 feet) or 21 meters (70 feet) in length depending upon the slope conditions. The embankment provides the capability of establishing a total of seventy-six (76) individual plots.

Sediment collection troughs are constructed at the base of each treatment plot. The troughs are of precast concrete and permit the collection of sediment from each plot as produced within each of the six, simulated rainfall events.

THE TESTING FACILITY (Continued)

The facility contains two reservoirs to provide necessary water to provide rainfall simulations, channel flows, and supplemental water during drought periods. The upper reservoir surface area is 2.43 ha (6.5 acres) which is the primary water source for all experimental work.

A ten-horsepower centrifugal pump supplies the rainfall simulation machines stationed on the embankment. Each rainfall simulator unit consists of a series of tubular steel arms, piping and irrigation nozzles. The nozzles were selected so as to create a droplet size which is generally representative of natural rainfall.

The flexible channel liner testing facility consists of ten, at-grade channels (six with a 7% centerline grade, and four with a 3% centerline grade.) Each open channel has a trapezoidal cross section that includes a 0.30 meter (1 foot) bottom, 1:1 side slopes, and a typical 0.91 meter (3 feet) depth beginning 4.5 meters (15 feet) downstream of the channel release gate. The total length of each test channel is 26 meters (85 feet.) Water for channel flows is supplied by an industrial grade, high-volume, low-head, axial-flow pump which is capable of producing over 136,260 liters per minute (36,000 gallons per minute.)

INDUSTRY ADVISORY COUNCIL

TxDOT and TTI have created the Industry Advisory Council (IAC) to encourage dialogue and communication between industry, participants, associations and TxDOT. Each participant is automatically a member of the council.

Members call meetings to discuss matters appropriate to the evaluation facility at their convenience. TxDOT/TTI personnel will be available to meet with IAC personnel to discuss and provide answers to any question or concern raised by the IAC.

Although TxDOT will remain sensitive to all matters voiced by the IAC, the final decision and authority regarding the conduct of the evaluation facility remains with TxDOT.

EVALUATION FEES AND INSTALLATION OPTIONS

TxDOT or TTI do not charge a testing or evaluation fee. Participants are given the following installation options:

(1) Participant donates the product(s) for evaluation as well as all labor, equipment and incidentals necessary to install the product in strict accordance with the manufacturer's published literature. Installation is supervised by TTI; or

EVALUATION FEES AND INSTALLATION OPTIONS (Continued)

(2) Participant donates the product(s) for evaluation and reimburses TTI for all costs associated with labor, equipment and incidentals necessary to install the material in strict accordance with the manufacturer's published literature; or

(3) TTI purchases the product(s) and is reimbursed by the participant for all costs associated with the purchase, labor, equipment and incidentals necessary to install the product in strict accordance with the manufacturer's published literature.

TTI requires the participant to furnish certificates of insurance and necessary release agreement forms prior to performing any work at the facility.

EVALUATION WAITING LIST

The final decision regarding confirming that a product will be tested at the HECL rests with the TTI facility manager. The TTI facility manager will maintain a waiting list of products desiring to be tested at the facility during the next available evaluation cycle. The waiting list shall be maintained based upon the postmarked date on a completed "Request for Performance Evaluation" packet, as received within TTI. Personal memoranda or letters to the TTI facility manager will not be utilized to determine a product's position on the waiting list.

Based upon space availability, TTI will offer an evaluation slot to new participants in the order of the postmarked date shown on the completed "Request for Performance Evaluation" packet. In the event that a participant fails to commit to testing by the deadline established by TTI, the next product on the waiting list will be offered the evaluation slot.

TTI and TxDOT reserve the right to restrict the number of products any single company, manufacturer or distributor may evaluate during any given evaluation cycle.

INSTALLATION PROCEDURES

With respect to soil retention blankets tested for Class 1 "Slope Protection" applications, participants have the option of specifying the steepness of slope on which their product is to be evaluated. Participants may elect to have their product evaluated on the 1:2 slopes, 1:3 slopes, or both 1:2 and 1:3 slopes. Regardless of the slope selected, TTI will install the product on both a clay and a sand plot.

With respect to soil retention blankets tested for Class 2 "Flexible Channel Liner" applications, industry has the option of specifying the shear-stress range most appropriate for their product.

INSTALLATION PROCEDURES (Continued)

Generally, the 3% centerline-gradient channels are utilized to evaluate organic or biodegradable products which should withstand shear stresses of up to 96 Pascals (2 pounds per square foot), while the 7% centerline-gradient channels are designed to test the products which are designed for the higher shear stresses (> 96 Pascals.)

All soil retention blankets are installed in strict accordance with the manufacturer's published installation literature. Particular attention is paid to edge and junction overlaps, stapling patterns, check, transverse, top or slope or bottom of slope anchor slots, and installation beyond that recommended by the manufacturer's standard installation literature is not permitted.

All cellulose fiber mulches are applied at the following rates:
Sandy Soils - 2.3 Mg/ha (2000 pounds/acre);
Clay Soils - 2.8 Mg/ha (2500 pounds/acre) for clay soils.

Installation of all products for a given evaluation cycle occurs on or about March 15 of each year. All performance evaluations take place between March 15 and December 31 of each year.

Each plot, regardless of product, slope or soil type, receives the identical mixture and rate of the standard rural-area, warm-season, permanent, perennial seed mix for TxDOT's Bryan District 17. (See Table 2 of Appendix A.) Further, each plot receives the identical amounts of fertilizer during installation.

Prior to product installation, the embankment is cleared of all vegetation, repaired with stockpiled or excavated soil, and brought to a uniform grade and condition. Each plot is fumigated with a soil sterilant to remove any existing vegetation.

All channel treatment plots are cleared of vegetation, repaired with stockpiled or excavated soil, brought to a uniform grade, and final-graded with a trapezoidal-shaped tool. Each treatment plot is fumigated with a soil sterilant to remove any existing vegetation.

EVALUATION PROCEDURES

Cellulose Fiber Mulch Products:

Currently, two separate methods of application are repeated for each product: (1) A one-step process where seed, fertilizer and mulch are applied to the plot in a single application; and (2) a two-step process where a seed-fertilizer slurry is applied to the plot, followed by a separate application of the mulch slurry.

EVALUATION PROCEDURES (Continued)

Cellulose Fiber Mulch (Continued)

TxDOT is testing the significance of vegetative density production between these two application techniques.

Cellulose fiber mulch products are not subjected to simulated rainfall events, as TxDOT feels they should not be used to protect a slope to the degree capable by a soil retention blanket. Each treatment, however, is sprinkle irrigated to provide sufficient moisture for vegetative growth. For the first three months, water is applied evenly to each plot to provide a minimum of 25.4 mm (1 inch) of water per month per plot. After the initial three month period, no supplemental water is provided except in the event of a drought in excess of 30 days. Vegetation density data is recorded throughout the duration of the March - December growing season. The vegetation density achieved by the final measurement round is compared to the adopted minimum vegetation density standard to determine acceptance or rejection.

Class 1 "Slope Protection" Products:

Starting within two weeks after installation, each product is subjected to a series of six (6) simulated rainfall events. Each product receives two each, ten-minute duration repetitions of the following design storms:

1-Year = 30.2 mm/hr (1.19 in/hr);
2-Year = 145.5 mm/hr (5.73 in/hr); and
5-Year = 183.6 mm/hr (7.23 in/hr.)

Sediment is collected, dried and weighed after each individual rainfall event. The average sediment loss, expressed in kilograms per 10 square meters, collected in the six individual rainfall events is compared to the adopted maximum sediment loss standard to determine acceptance or rejection.

Each product is also sampled for vegetation density production over the March - December growing season. The initial sample is normally taken on or about the fourth week following product installation. The final sample is normally taken during December. The vegetative density production which has been achieved by the final sampling round only, is compared to the adopted minimum vegetative density standard to determine acceptance or rejection.

EVALUATION PROCEDURES (Continued)

Class 2 "Flexible Channel Liner" Products

Prior to actual installation within the outdoor channels, TTI determines Manning's *n* for all products through the use of an indoor flume facility located at the College of Ocean Engineering, Texas A&M University.

Following installation, each product experiences a 90-day resting period to promote the initial growth of vegetation prior to initiating a series of increasing, shear-stress flows.

After the 90-day resting period, a series of simulated flows begin. Prior to each flow, channels are pre-wetted to moisten the channel surface. Based upon the determined Manning's *n*, and the known geometry of the channel, the depth of water is controlled to initiate a series of increasing flows, starting at 96 Pascal (2 lb/sq ft), and continuing on a 48 Pascal (1 lb/sq ft) increment. Each flow is repeated twice and continues for twenty (20) minutes after a stable flow has been achieved.

During the test flows, measurements are taken approximately every two minutes to determine the amount of soil displaced by the flow. Further, data is collected regarding product movement (loss of intimate soil contact.) The average soil displacement exhibited within the channel is compared to the adopted maximum soil displacement standard to determine acceptance or rejection.

All channels are also sampled to determine the growth of vegetation over a single, March-December growing season. Similar to the embankment, channels are initially sampled at the end of the 90-day resting period for vegetation production. The final density sample is normally taken during December. The vegetation density achieved within the channel by the final sampling is compared to the adopted minimum vegetation density standard to determine acceptance or rejection.

APPROVAL BY EXTENSION

For Class 1 "Slope Protection Products", if a product is evaluated on the severe-slope conditions only (Types C and D), and successfully meets the current minimum performance standards established by TxDOT for the particular application, the product will also be included as an approved product (by extension) on the associated, less-severe conditions as well. For example, if a product is evaluated on both Types C and D slopes (Slopes Steeper than 1:3 - Clay and Sand soils, respectively), and successfully meets the performance standards for Type C (Slopes Steeper than 1:3 - Clay Soils), the product will be added by extension to the approved product list for Type A (Slopes 1:3 or Flatter - Clay Soils).

APPROVAL BY EXTENSION (Continued)

Conversely, if a product is evaluated on the less-severe slope conditions only (Types A and B), the product will not be added to the severe-slope conditions as an approved equal regardless of the performance of the material.

If a product elects to test on each of the four available Class 1 applications, the product's performance, as documented within each individual application shall determine placement on the approved product list, and approval by extension shall not apply.

RELEASE OF PERFORMANCE DATA

With the exception of the final research report as published by TTI, all performance data will be released by TxDOT only. Data will only be released at the end of a complete evaluation cycle. As the annual operation of the HECL is funded with state funds, all performance data will be released regardless of the performance of any individual product.

Performance data for all products evaluated to date are available from TxDOT without charge to any interested party. Final research reports, as published by TTI are available for a fee through the Texas Transportation Institute Information and Technology Exchange Center.

RETEST PROCEDURES

Class 1 "Slope Protection" and Cellulose Fiber Mulch Products

If, after the initial test at the HECL, a product fails to meet the established minimum performance standards for any application, as established by TxDOT, TTI will reserve an evaluation slot within the next available evaluation cycle for that product. The participant must commit to retesting the identical product by the deadline established by TTI. In the event the participant fails to confirm retesting by the deadline established by TTI, the evaluation slot will be offered to the next product on the waiting list.

In the event a product is retested at the HECL and again fails to meet the established minimum performance standards for any application as established by TxDOT, an evaluation plot will not be guaranteed the product during the next available evaluation cycle. The product representative must complete a new "Request for Performance Evaluation" packet and the product will be scheduled for retesting according to the postmark date on the completed "Request for Performance Evaluation" and the procedures established within the normal waiting list process.

RETEST PROCEDURES (Continued)

Class 2 "Flexible Channel Liner" Products

Due to the limited number of evaluation channels available at the HECL and the number of individual products currently requesting Class 2 applications evaluation, a product cannot be guaranteed an evaluation slot within the next available evaluation cycle in the event that product fails to meet any of the established minimum performance standards established by TxDOT.

The product representative must complete and forward to TTI, a new "Request for Performance Evaluation" packet if they desire to retest the identical product. The product will be scheduled for retesting according to the postmark date on the completed "Request for Performance Evaluation" packet, and the procedures established within the normal waiting list process.

REVISION OF MINIMUM PERFORMANCE STANDARDS

TxDOT reserves the right to revise the minimum performance standards for the Approved Product List (APL) as produced through the HECL.

In the event that a product's performance no longer meets the revised minimum performance standards, the product will be notified by TxDOT and provided the opportunity to retest the product within the next available evaluation cycle as determined by TxDOT.

The product will remain on the APL pending results of the next available evaluation cycle. In the event that the product fails to meet the revised standards at the end of the evaluation cycle retest, the product will be removed from the APL during the next scheduled revision. In the event that the product's performance meets the newly adopted minimum performance standards, the product will remain on the Approved Material List.

In the event that the participant fails to commit to retesting the product within the next available evaluation cycle by the deadline established by TTI, the product will be removed from the APL during the next scheduled revision.

CONTRACTOR'S OPTION

The APL will be maintained by TxDOT according to the Class and Type as may be appropriate for any given product. It is the Contractor's option to use any of the products provided that the product is listed by brand name on the current APL for the Class and Type specified, and provided the Contractor installs the product in strict accordance with TxDOT specifications and the manufacturer's installation literature.

PRIVATE LABELING

If the original manufacturer of a product tested and approved at the HECL will, to TxDOT's satisfaction, certify that the brand name tested is also distributed under other trade names (private labels), TxDOT will include those private label names on the APL for the appropriate Class and Type. Addition and/or revision of the APL due to private labels will only be made by TxDOT during the normally scheduled revision of the APL.

APPROVED PRODUCT LIST

Based upon the data collected through the HECL, TxDOT will establish and maintain a current approved product list. New products which are placed on the approved product list will become eligible for use by Contractors after statewide distribution of the official approved product list, normally issued in the form of a special provision to Item 169 "Soil Retention Blanket". This event typically occurs during the May or June following the close of the previous March - December evaluation cycle.

Copies of the current approved material list for soil retention blankets, may be requested through the Director, Construction and Maintenance Division , Attn: Mr. Paul Northcutt, 125 East 11th Street, Austin, TX 78701-2483.

SUMMARY

The TxDOT/TTI Hydraulics and Erosion Control Laboratory provides TxDOT the capability of using selected erosion control products which have demonstrated their capability to perform and protect the natural environment. The program also provides industry with a timely, fair and uniform testing program for products they feel are appropriate for use within TxDOT's construction and maintenance activities, and for new products as developed by industry. The program seeks to establish and maintain the greatest number of individual products on the APL as possible, provided those products have demonstrated their capability to meet established minimum performance standards.

Data as published by TxDOT for all of the products evaluated through the HECL are available to any interested party without charge. Final reports as published by TTI are available for a fee through the Information and Technology Exchange Center, Texas Transportation Institute. Specify Report Number 1914 when ordering.

CONTACTS

The following personnel should be contacted for more information regarding the evaluation program conducted at the TxDOT/TTI Hydraulics and Erosion Control Laboratory:

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707 Texas Avenue, Suite 100-E
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(409)847-8709
Fax: (409)862-1759

To order final research reports for Research Project 1914, for a fee, as published by Texas Transportation Institute, contact:

Texas Transportation Institute
Information & Technology Exchange Cntr
Texas A&M University System
College Station, TX 77843-3135
(409)845-4853
Fax: (409)8620-3703
Internet: dolores@ttiadmin.tamu.edu

MINIMUM PERFORMANCE STANDARDS

Texas Department of Transportation

Class 1 "Slope Protection
Class 2 "Flexible Channel Liners"

Texas Department of Transportation

Minimum Performance Standards

Item 169 "Soil Retention Blanket"

Effective Date: March 1, 1996

Spec Pay Item	Class	Type	Site Conditions	Maximum Sediment Loss[1]	Minimum Vegetation Density
169	1 - Slope Protection	A	Slopes 1:3 or Flatter - Clay Soils	0.34	80%
		B	Slopes 1:3 or Flatter - Sandy Soils	12.20	70%
		C	Slopes Steeper than 1:3 - Clay Soils	0.34	80%
		D	Slopes Steeper than 1:3 - Sandy Soils	26.84	70%
	Class	**Type**	**Site Conditions**	**Maximum Sediment Loss[2]**	**Minimum Vegetation Density**
	2 - Flexible Channel Liners	E	Shear Stress Range 0 to 96 Pa	1.15	70%
		F	Shear Stress Range 0 to 192 Pa	1.00	70%
		G	Shear Stress Range 0 to 287 Pa	1.00	70%
		H	Shear Stress Range 0 to 383 Pa	0.80	70%

All performance standards must be achieved through formal testing conducted at the TxDOT/TTI Hydraulics and Erosion Control Laboratory.

1. Kilograms per 10 Square Meters

2. Average Soil Deformation in Centimeters

Record of Product Evaluations and
Private Label Record

TxDOT/TTI Hydraulics and Erosion Control Laboratory
Record of Products Evaluated and
Private Label Record

Name of Product Tested	Contact	Private Label Name
Airtrol®	U.S. Gypsum Co., 700 North Highway 45, Libertyville, IL 60048-1296; (708)970-5138	None
Antiwash Geojute	Belton Industries, 8613 Roswell Road, Atlanta, GA 30350; (800)225-4099	Soil Saver
BonTerra® S1	BonTerra America, Inc., 355 West Chestnut Street, Genesee, ID 83832; (800)882-9489	None
BonTerra ®S2		None
Curlex® I	American Excelsior Co., 900 Avenue H East, P.O. Box 5624, Arlington, TX 76011; (800)777-2691	None
Curlex® II (Double Sided)		None
GEOCOIR®/DeKoWe® 700	Belton Industries, Inc., 8613 Roswell Road, Atlanta, GA 30350; (800)225-4099	None
Geojute Plus		None
Geojute® Plus-Regular High Velocity		None
Geojute Plus 1		None
ECS Straw Blanket Standard	Erosion Control Systems, Inc., 1800 McFarland Blvd., Suite 180, Tuscaloosa, AL 35406; (800)942-1986	None

TxDOT/TTI Hydraulics and Erosion Control Laboratory
Record of Products Evaluated and
Private Label Record

Name of Product Tested	Contact	Private Label Name
Enkamat® 7020	AKZO/NOBEL, P.O. Box 7249, Asheville, NC 28802; (704)665-5050	None
GREENSTREAK® PEC-MAT™	Greenstreak, Inc., 3400 Tree Court Ind. Blvd., St. Louis, MO 63122-6689; 800-325-9504	1. Webmat 280
LANDLOK® TRM 450	Synthetic Industries, Inc., 4019 Industry Drive, Chattanooga, TN 37416; (800)621-9444	Contech Construction Products "C-45"
LANDSTRAND® Natural		None
Miramat® TM8™	Nicolon Mirafi Group, 3500 Parkway Lane, Suite 500, Norcross, GA 30092; (404)447-6272	None
Miramat 1000		None
North American Green S75	North American Green, Inc., 14649 Highway 41 North, Evansville, Indiana 47711; (800)772-2040	None
North American Green S150		None
North American Green SC150		None
North American Green C350 Three-Phase		None
Permamat 200F	P.P.S. Packaging Company, P.O. Box 427, Fowler, CA 93625; (209)834-1641	None

TxDOT/TTI Hydraulics and Erosion Control Laboratory
Record of Products Evaluated and
Private Label Record

Name of Product Tested	Contact	Private Label Name
POZ-O-CAP®	Chemical Lime Company, P.O. Box 121874, Fort Worth, TX 76107; (800)365-6724	None
Polyjute 407GT	Synthetic Industries, Inc., 4019 Industry Drive, Chattanooga, TN 75230; 800-621-0444	1. C-JUTE 2. TerraJute
Soil Guard	Weyerhaeuser, P.O. Box 434, Montclair, New Jersey 07042; (201)744-2625	None
SuperGro™	AMOCO Fabrics and Fibers, 260 The Bluffs, Austell, GA 30001; (770)944-4419	None
Tensar® Erosion Blanket TB 1000	The Tensar Corporation, 1210 Citizens Parkway, Morrow, GA 30260; (404)250-1290	BonTerra SFB12 (orig manuf)
Tensar® Erosion Mat TM 3000		None
verdyol®ERO-MAT™	Verdyol Alabama, Inc, P.O. Box 605, Pell City, AL 35125; (205)338-4411	None
verdyol® EXCELSIOR Standard		Winters Excelsior, Inc. POPLAR EXCELSIOR BLANKET
verdyol® Excelsior High-Velocity		None

TxDOT/TTI Hydraulics and Erosion Control Laboratory
Record of Products Evaluated and
Private Label Record

Name of Product Tested	Contact	Private Label Name
Xcel Regular	P.P.S. Packaging Co., 204 N. Seventh Street P.O. Box 56 Fowler, CA 93625 209-834-2011	1. Contech Standard 2. Green Triangle Regular
Xcel Superior		1. Contech Standard Plus 2. Green Triangle Superior
Permamat 200F		None

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CLASS 1 "SLOPE PROTECTION"
Final Performance Analysis

(Analysis by Steepness of Slope and Type of Soil)

ANALYSIS LEVEL USED BY TxDOT TO DETERMINE APPROVED PRODUCT LIST

This analysis level seeks to determine what the sediment-loss and vegetation-density performance of each product was *based upon both the steepness of slope and type of soil.*

Sediment-loss figures shown represent the average sediment loss from the six, simulated rainfall events given each plot, and are expressed in terms of Kilograms of Sediment Loss per 10 Square Meters.

Vegetation-density figures shown represent the average percent of vegetative cover achieved within the plot by the final measurement cycle only.

TABULAR DATA
Class 1 "Slope Protection"

1:2 Clay

Texas Department of Transportation
Final Performance Analysis

Class 1 "Slope Protection"
Analysis by Steepness of Slope and Type of Soil)
(Level Used by TxDOT to Produce Approved Product List)

Final Product Performance Analysis						
No	**Product Evaluated**	**Year**	**Slope**	**Soil**	**Sediment Loss (0.34 kg/10 m²)**	**Vegetation Density (80%)**
1	*LANDSTRAND®*	1995	1:2	Clay	0.2835	96.513
2	*Miramat® TM8™*	1995	1:2	Clay	0.3175	91.236
3	*BonTerra ®S2*	1995	1:2	Clay	0.3177	96.584
4	*Geojute Plus* 1	1995	1:2	Clay	0.3885	83.351
5	verdyol EXCELSIOR High Velocity	1995	1:2	Clay	0.3892	88.837
Product Performance: 1991 - 1995 Evaluation Cycles						
1	*Curlex®* I	1991	1:2	Clay	0.1917	97.834
2	*North American Green SC150*	1991	1:2	Clay	0.2130	89.979
3	*Polyfelt* TS22	1991	1:2	Clay	0.2174	35.909
4	*GEOCOIR®/DeKoWe®* 700	1992	1:2	Clay	0.2201	73.717
5	*North American Green S150*	1991	1:2	Clay	0.2258	92.014
6	*Polyjute* 407GT	1991	1:2	Clay	0.2380	96.151
7	*Airtrol®*	1992	1:2	Clay	0.2432	86.094
8	*GREENSTREAK® PEC-MAT™*	1991	1:2	Clay	0.2499	87.580
9	*Soil* Guard	1994	1:2	Clay	0.2712	83.987
10	*Antiwash* Geojute	1991	1:2	Clay	0.2727	90.058
11	*LANDSTRAND®*	1995	1:2	Clay	0.2835	96.513
12	*Miramat® TM8™*	1995	1:2	Clay	0.3175	91.236
13	*BonTerra ®S2*	1995	1:2	Clay	0.3177	96.584
14	*Xcel Superior*	1991	1:2	Clay	0.3212	98.814
15	*SuperGro™*	1994	1:2	Clay	0.3342	96.353

(Continued)

Texas Department of Transportation
Final Performance Analysis

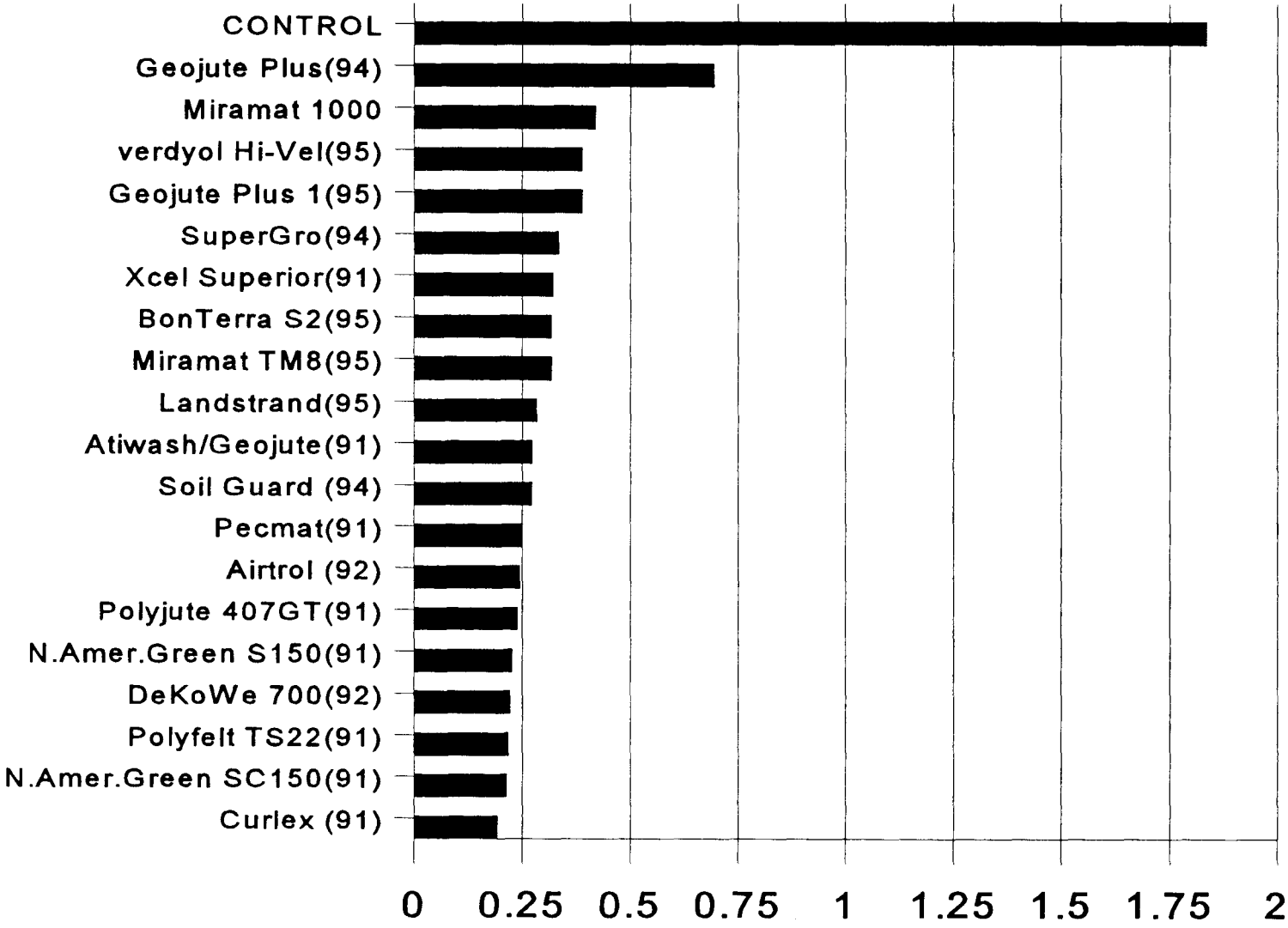
Class 1 "Slope Protection"
Analysis by Steepness of Slope and Type of Soil)
(Level Used by TxDOT to Produce Approved Product List)

Final Product Performance Analysis						
No	**Product Evaluated**	**Year**	**Slope**	**Soil**	**Sediment Loss (0.34 kg/10 m^2)**	**Vegetation Density (80%)**
16	*Geojute Plus 1*	1995	1:2	Clay	0.3885	83.351
17	verdyol EXCELSIOR High Velocity	1995	1:2	Clay	0.3892	88.837
18	*Miramat* 1000	1994	1:2	Clay	0.4199	65.814
19	*Geojute Plus*	1994	1:2	Clay	0.6942	72.647
20	CONTROL	91-95	1:2	Clay	1.8339	81.467

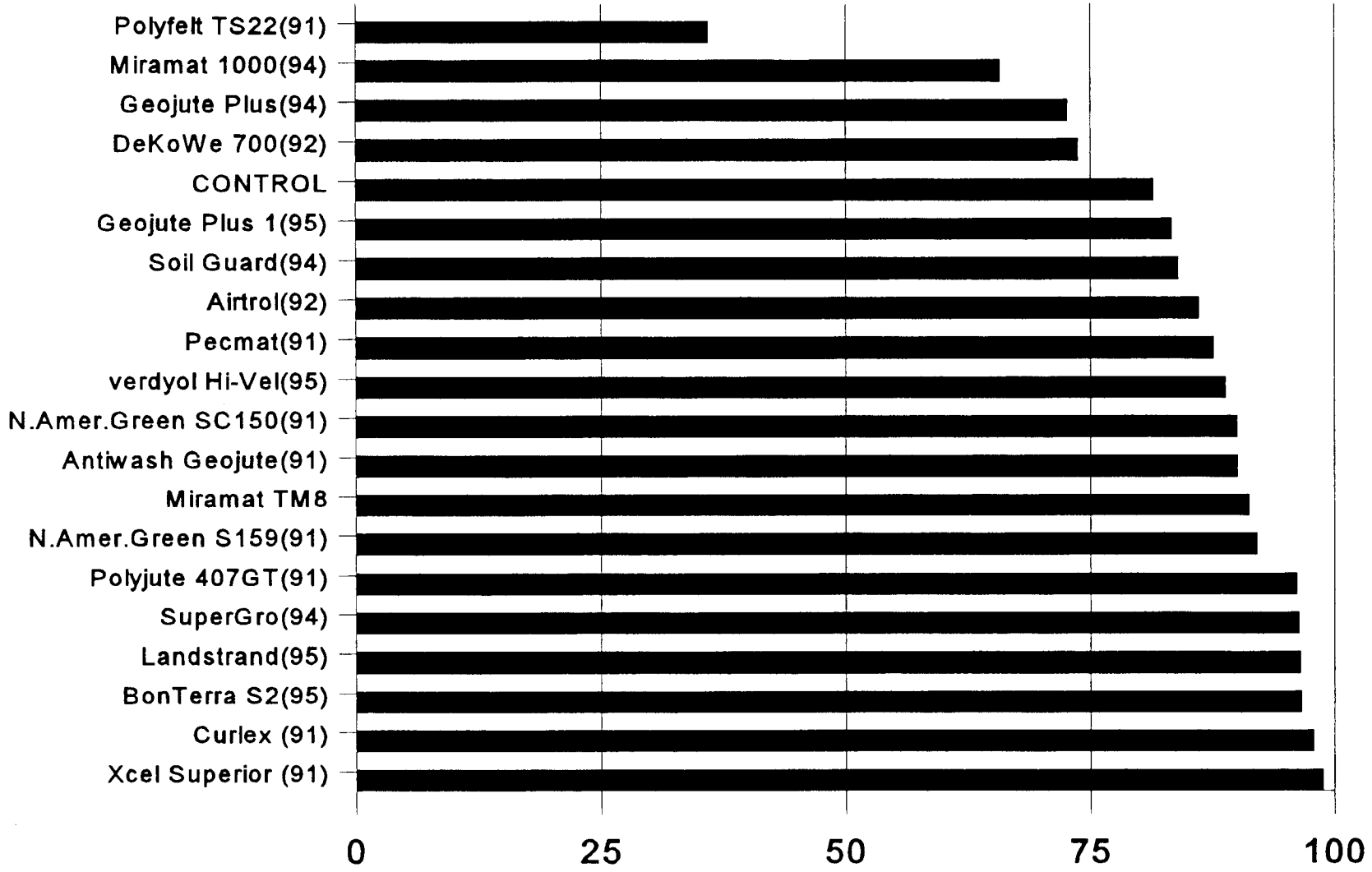
NOTE:

Shaded cells (if any) indicate performance which failed to meet currently established minimum performance standards.

1:2 Clay Soils
Sediment Loss (Kilograms per 10 Square Meters)



1:2 Clay Soils
Final Percent Vegetative Cover Achieved



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TABULAR DATA
Class 1 "Slope Protection"

1:2 Sand

Texas Department of Transportation
Final Performance Analysis

Class 1 "Slope Protection"
Analysis by Steepness of Slope and Type of Soil
(Level Used by TxDOT to Produce Approved Product List)

Final Product Performance Analysis						
No	**Product Evaluated**	**Year**	**Slope**	**Soil**	**Sediment Loss (26.84 kg/10 m^2)**	**Vegetation Density (70%)**
1	*LANDSTRAND®*	1995	1:2	Sand	14.253	64.758
2	*BonTerra ®S2*	1995	1:2	Sand	15.299	68.348
3	*verdyol EXCELSIOR High Velocity*	1995	1:2	Sand	16.728	63.538
4	*Miramat® TM8™*	1995	1:2	Sand	22.731	85.597
5	*SuperGro™*	1995	1:2	Sand	23.170	51.092
6	*GEOCOIR®/DeKoWe® 700*	1995	1:2	Sand	24.587	49.192
7	*Geojute Plus 1*	1995	1:2	Sand	27.032	80.797
8	*Airtrol®*	1995	1:2	Sand	[1]	[1]
Product Performance: 1991 - 1995 Evaluation Cycles						
1	*Soil Guard*	1994	1:2	Sand	8.042	86.735
2	*Geojute Plus*	1994	1:2	Sand	8.157	3.883
3	*SuperGro™*	1994	1:2	Sand	8.967	69.570
4	*Curlex® I*	1994	1:2	Sand	9.124	89.461
5	*GEOCOIR®/DeKoWe® 700*	1994	1:2	Sand	10.389	49.623
6	*Miramat® 1000*	1994	1:2	Sand	11.824	81.466
7	*Airtrol®*	1994	1:2	Sand	13.417	17.614
8	*LANDSTRAND®*	1995	1:2	Sand	14.253	64.758
9	*BonTerra ®S2*	1995	1:2	Sand	15.299	68.348
10	*Xcel Superior*	1991	1:2	Sand	15.676	85.805
11	*verdyol EXCELSIOR High Velocity*	1995	1:2	Sand	16.728	63.538
12	*Polyjute 407GT*	1991	1:2	Sand	18.769	74.302
13	*North American Green SC150*	1991	1:2	Sand	20.819	76.409

(Continued)

Texas Department of Transportation
Final Performance Analysis

Class 1 "Slope Protection"
Analysis by Steepness of Slope and Type of Soil
(Level Used by TxDOT to Produce Approved Product List)

Final Product Performance Analysis						
No	**Product Evaluated**	**Year**	**Slope**	**Soil**	**Sediment Loss (26.84 kg/10 m^2)**	**Vegetation Density (70%)**
14	*Curlex® I*	1992	1:2	Sand	21.806	47.335
15	Miramat® TM8™	1995	1:2	Sand	22.731	85.597
16	SuperGro™	1995	1:2	Sand	23.170	51.092
17	*North American Green S150*	1991	1:2	Sand	23.916	84.746
18	GEOCOIR®/DeKoWe® 700	1995	1:2	Sand	24.587	49.192
19	*Polyfelt TS22*	1991	1:2	Sand	25.123	46.051
20	*Geojute Plus 1*	1995	1:2	Sand	27.032	80.797
21	Curlex® I	1991	1:2	Sand	29.795	52.674
22	*Antiwash Geojute*	1991	1:2	Sand	30.295	51.372
23	*GREENSTREAK® PEC-MAT™*	1991	1:2	Sand	31.143	38.863
24	Airtrol®	1992	1:2	Sand	37.888	41.882
26	CONTROL	91-95	1:2	Sand	56.412	26.770
27	*Airtrol®*	1995	1:2	Sand	[1]	[1]
25	*GEOCOIR®/DeKoWe® 700*	1992	1:2	Sand	[2]	[2]

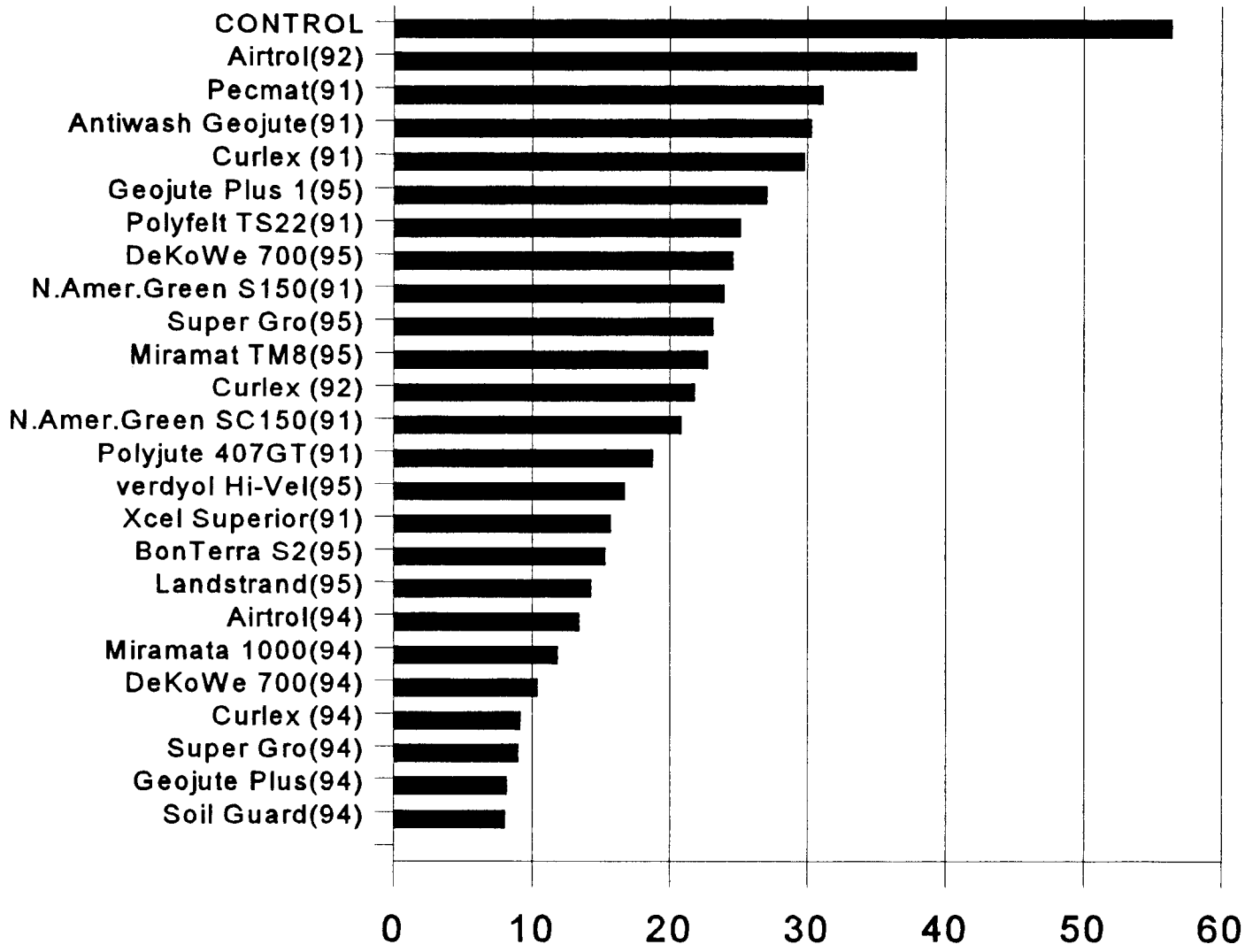
NOTE:

Shaded cells (if any) indicate performance which failed to meet currently established minimum performance standards.

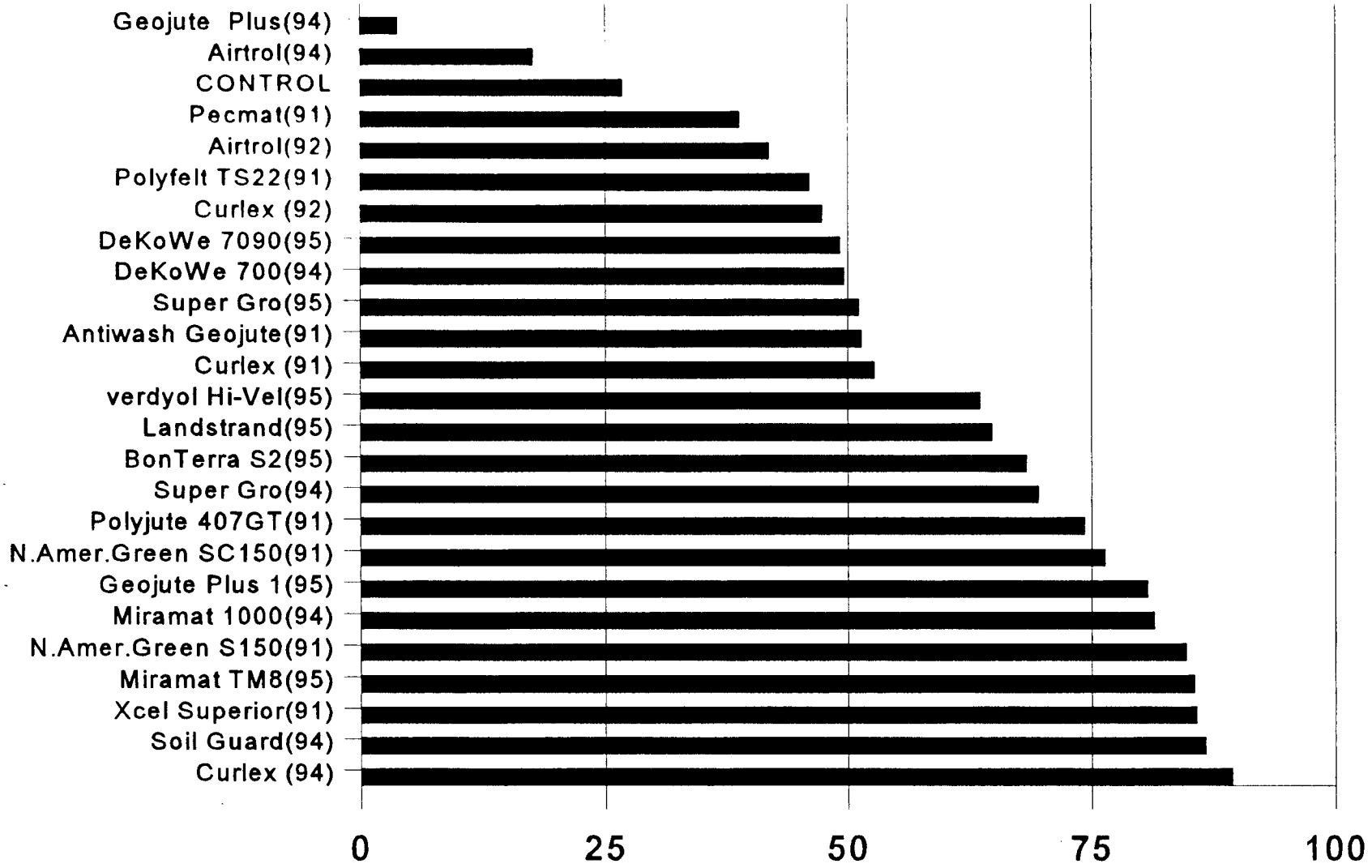
[1] 1:2 Sand Plot Destroyed by Natural Rainfall Event, shortly after installation. Product was reinstalled and was subsequently destroyed by another natural rainfall event. TxDOT elected to stop performance testing.

[2] 1992, 1:2 Sand Plot Inadvertently Destroyed. Retested during 1994.

1:2 Sand Soils
Sediment Loss (Kilograms per 10 Square Meters)



1:2 Sand Soils
Final Percent Vegetative Cover Achieved



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TABULAR DATA
Class 1 "Slope Protection"

1:3 Clay

Texas Department of Transportation
Final Perrformance Analysis

Class 1 "Slope Protection"
Analysis by Steepness of Slope and Type of Soil
(Analysis Level Used by TxDOT to Produce Approved Product List)

Final Product Performance Analysis						
No	**Product Evaluated**	**Year**	**Slope**	**Soil**	**Sediment Loss (0.34 kg/10 m^2)**	**Vegetation Density (80%)**
1	*BonTerra® S1*	1995	1:3	Clay	0.2516	93.424
2	*Erosion Control Straw Blanket* Standard	1995	1:3	Clay	0.2879	90.708
3	*SuperGro™*	1995	1:3	Clay	0.3062	89.418
4	*verdyol EXCELSIOR* Standard	1995	1:3	Clay	0.3197	91.212
5	*POZ-O-CAP®*	1995	1:3	Clay	0.3576	83.479
Product Performance: 1991 - 1995 Evaluation Cycles						
1	*SuperGro™*	1994	1:3	Clay	0.0819	70.378
2	*Curlex®* I	1992	1:3	Clay	0.1153	98.125
3	*Curlex®* I	1991	1:3	Clay	0.1470	63.230
4	*verdyol®ERO-MAT™*	1991	1:3	Clay	0.1525	87.809
5	*GREENSTREAK® PEC-MAT™*	1991	1:3	Clay	0.2001	90.525
6	*Airtrol®*	1992	1:3	Clay	0.2441	86.444
7	BonTerra® S1	1995	1:3	Clay	0.2516	93.424
8	*North American Green S75*	1991	1:3	Clay	0.2727	96.187
9	*Erosion Control Straw Blanket* Standard	1995	1:3	Clay	0.2879	90.708
10	*SuperGro™*	1995	1:3	Clay	0.3062	89.418
11	*Xcel Regular*	1991	1:3	Clay	0.3196	90.166
12	*verdyol EXCELSIOR Standard*	1995	1:3	Clay	0.3197	91.212
13	*POZ-O-CAP®*	1995	1:3	Clay	0.3576	83.479
14	CONTROL	91-95	1:3	Clay	1.3015	79.631

NOTE:
Shaded cells (if any) indicate performance which failed to meet currently established minimum performance standards.

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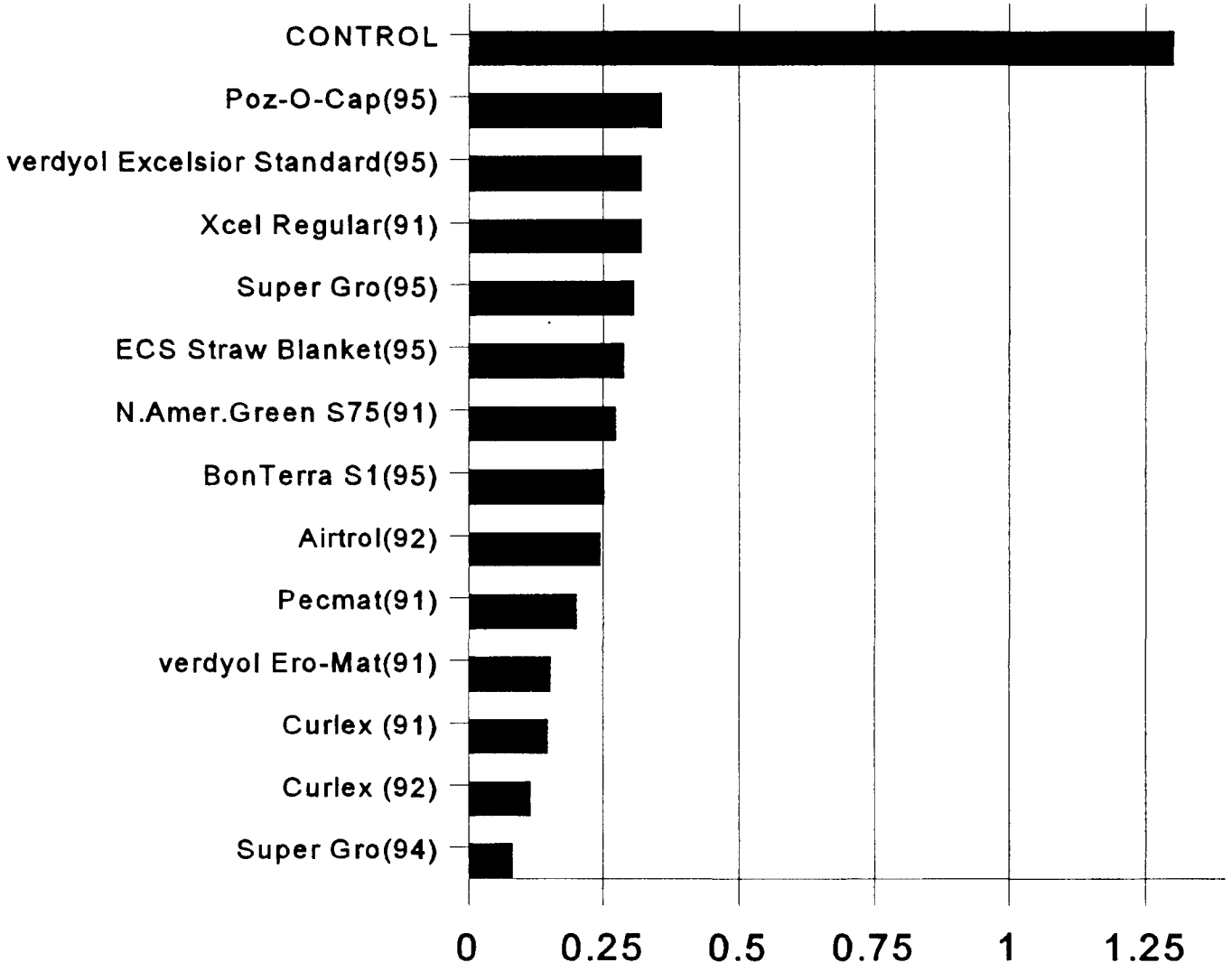
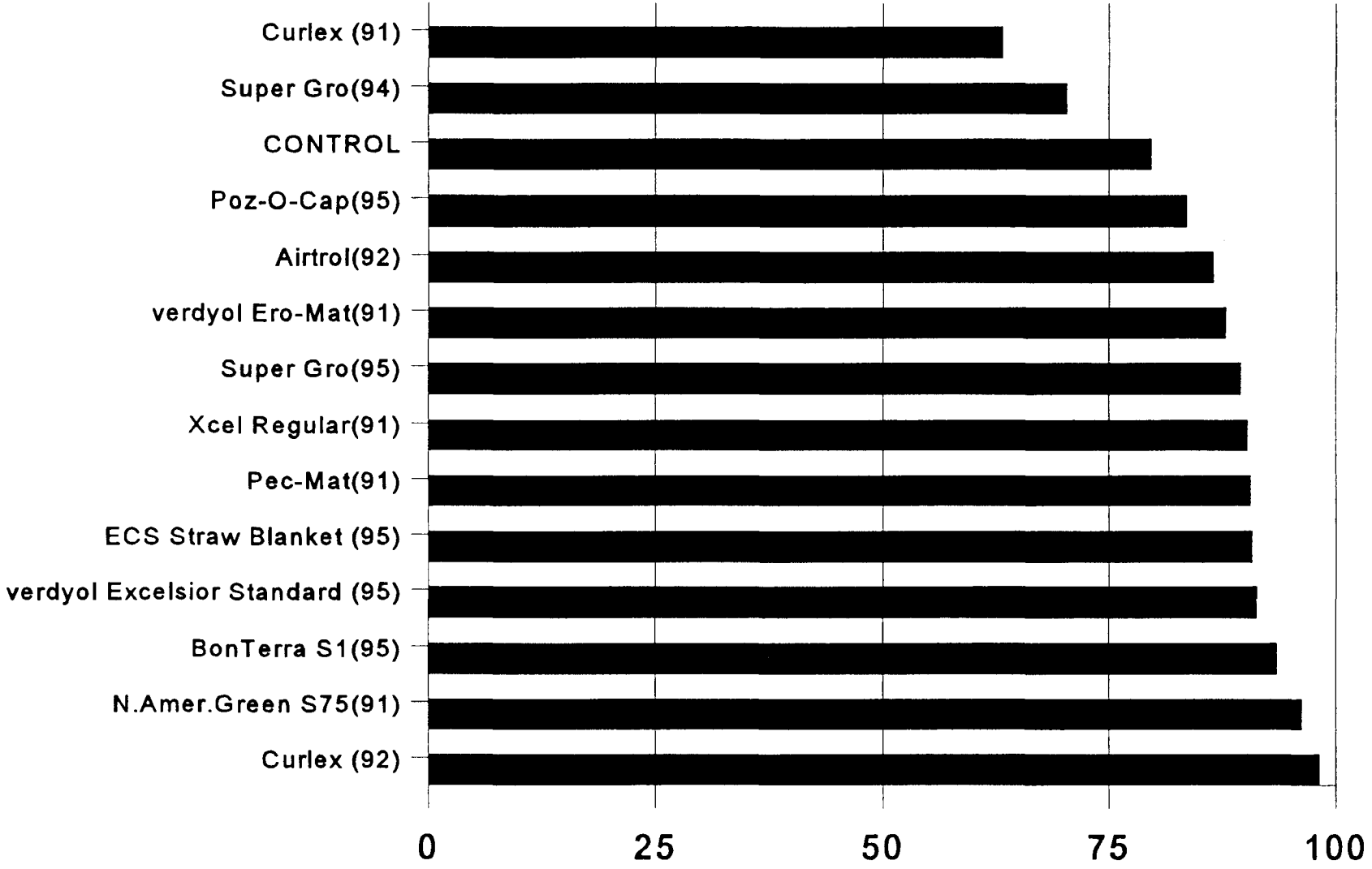
1:3 Clay Soils
Sediment Loss (Kilograms per 10 Square Meters)



1:3 Clay Soils
Final Percent Vegetative Cover Achieved



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TABULAR DATA
Class 1 "Slope Protection

1:3 Sand

Texas Department of Transportation
Final Performance Analysis

Class 1 "Slope Protection"
Analysis by Steepness of Slope and Type of Soil
(Analysis Level Used by TxDOT to Produce Approved Material List)

Final Product Performance Analysis						
No	**Product Evaluated**	**Year**	**Slope**	**Soil**	**Sediment Loss (12.20 Kg/10 $M^{2)}$**	**Vegetation Density (70%)**
1	*BonTerra® S1*	1995	1:3	Sand	6.289	77.089
2	*verdyol EXCELSIOR Standard*	1995	1:3	Sand	7.411	75.330
3	*Curlex® I*	1995	1:3	Sand	7.835	63.962
4	***Erosion Control Straw Blanket Standard***	1995	1:3	Sand	8.063	80.276
5	*SuperGro™*	1995	1:3	Sand	9.742	56.888
6	*Airtrol®*	1995	1:3	Sand	13.018	26.180
7	*POZ-O-CAP®*	1995	1:3	Sand	[1]	[1]
Product Performance: 1991 - 1995 Evaluation Cycles						
1	*Curlex® I*	1994	1:3	Sand	2.936	48.632
2	*SuperGro™*	1994	1:3	Sand	3.002	17.585
3	*Curlex® I*	1992	1:3	Sand	4.119	33.232
4	*Curlex® I*	1991	1:3	Sand	4.406	60.937
5	*Xcel Regular*	1991	1:3	Sand	4.712	72.263
6	*BonTerra® S1*	1995	1:3	Sand	6.289	77.089
7	*verdyol EXCELSIOR Standard*	1995	1:3	Sand	7.411	75.330
8	*Curlex® I*	1995	1:3	Sand	7.835	63.962
9	***Erosion Control Straw Blanket Standard***	1995	1:3	Sand	8.063	80.276
10	*North American Green S75*	1991	1:3	Sand	8.099	77.904
11	*verdyol®ERO-MAT™*	1991	1:3	Sand	9.078	73.202
12	*Airtrol®*	1994	1:3	Sand	9.261	33.638
13	*SuperGro™*	1995	1:3	Sand	9.742	56.888

(Continued)

Texas Department of Transportation
Final Performance Analysis

Class 1 "Slope Protection"
Analysis by Steepness of Slope and Type of Soil
(Analysis Level Used by TxDOT to Produce Approved Material List)

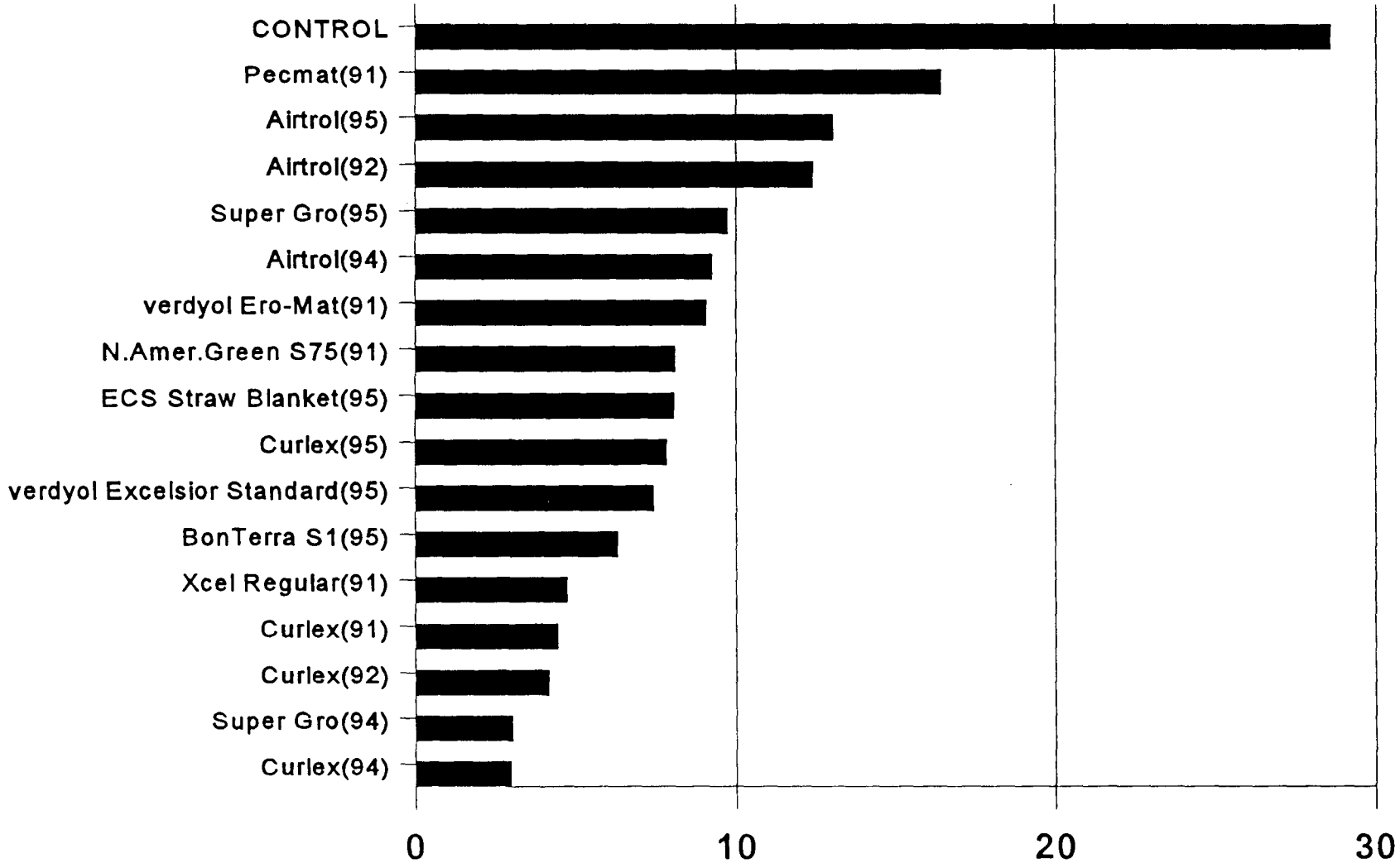
Final Product Performance Analysis						
No	**Product Evaluated**	**Year**	**Slope**	**Soil**	**Sediment Loss (12.20 Kg/10 M^2)**	**Vegetation Density (70%)**
14	*Airtrol®*	1992	1:3	Sand	12.389	68.749
15	*Airtrol®*	1995	1:3	Sand	13.018	26.180
16	*GREENSTREAK® PEC-MAT™*	1991	1:3	Sand	16.402	62.385
17	CONTROL	91-95	1:3	Sand	28.576	33.211
18	*POZ-O-CAP®*	1995	1:3	Sand	[1]	[1]

NOTES:

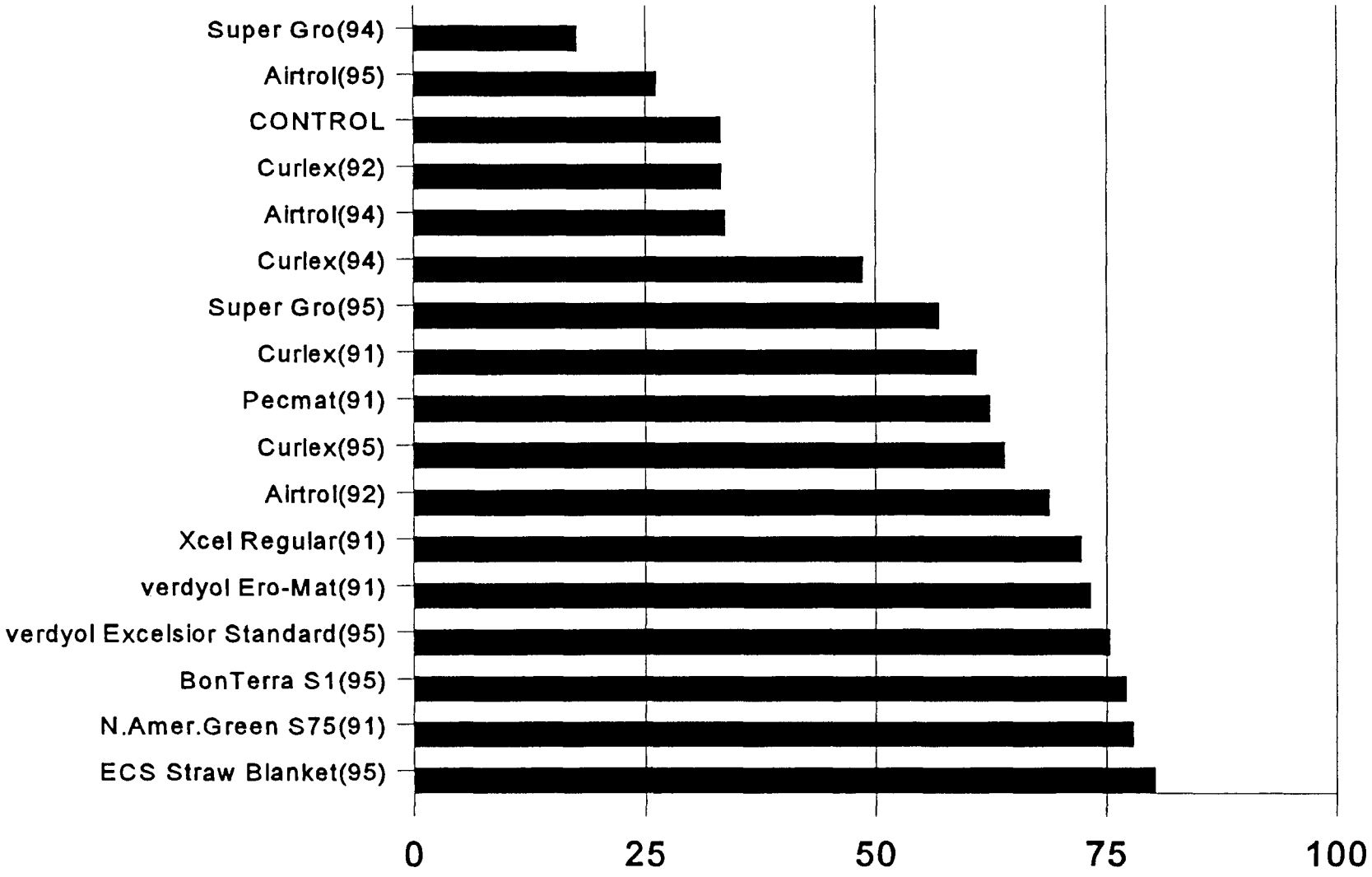
Shaded cells (if any) indicate performance which failed to meet currently established minimum performance standards.

[1] Product was destroyed by natural rainfall event shortly after installation. Product was reinstalled and was subsequently desroyed by another natural rainfall event. TxDOT elected to cease performance testing.

1:3 Sand Soils
Sediment Loss (Kilograms per 10 Square Meters)



1:3 Sand Soils
Final Percent Vegetative Cover Achieved



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STATISTICAL ANALYSIS
Class 1 "Slope Protection" Applications

1:2 Clay

Analysis of Variance
Duncan's Multiple Range Test
Confidence Level = 95%

---------- SLOPE=2:1 SOIL=CLAY ----------

ANALYSIS OF VARIANCE PROCEDURE

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: SDMT

NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE, NOT THE EXPERIMENTWISE ERROR RATE

ALPHA= 0.05 DF= 536 MSE= 0.409522
WARNING: CELL SIZES ARE NOT EQUAL.
HARMONIC MEAN OF CELL SIZES= 17.53603

NUMBER OF MEANS	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
CRITICAL RANGE	.4246	.4470	.4620	.4730	.4817	.4888	.4947	.4997	.5041	.5079	.5114	.5144	.5172	.5197	.5220	.5241	.5261	.5279	.5296

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING	MEAN	N	PLOT
A	-0.1917	10	CURLEX I(91)
A	-0.2130	10	N/A/G SC150(91)
A	-0.2174	10	POLYFLT TS22(91)
A	-0.2201	30	DEKOWE 700(92)
A	-0.2258	10	N/A/G S150(91)
A	-0.2380	10	POLYJUT407GT(91)
A	-0.2432	32	AIRTROL(92)
A	-0.2499	10	PECMAT(91)
A	-0.2712	30	SOIL GUARD(94)
A	-0.2727	10	GEOJUTE(91)
A	-0.2835	36	LANDSTRAND(95)
A	-0.3175	36	MIRAMAT TM8(95)
A	-0.3177	36	BONTERRA S2(95)
A	-0.3212	10	XCEL SUP(91)
A	-0.3342	30	SUPER GRO(94)
A	-0.3885	36	GEOJUTE PLS1(95)
A	-0.3892	36	VERDYOL HI-V(95)
A	-0.4199	30	MIRAMAT 1000(94)
A	-0.6942	36	GEOJUTE PLUS(94)

---------- SLOPE=2:1 SOIL=CLAY ----------

ANALYSIS OF VARIANCE PROCEDURE

DUNCAN GROUPING	MEAN	N	PLOT
B	-1.8339	108	CONTROL

FINAL VEGETATIVE DENSITY PRODUCTION (PERCENT)
ANALYSIS LEVEL 4 (STEEPNESS OF SLOPE AND TYPE OF SOIL)

---------- SLOPE=2:1 SOIL=CLAY ----------

ANALYSIS OF VARIANCE PROCEDURE

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: COVER

NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE, NOT THE EXPERIMENTWISE ERROR RATE

ALPHA= 0.05 DF= 390 MSE= 397.7118
WARNING: CELL SIZES ARE NOT EQUAL.
HARMONIC MEAN OF CELL SIZES= 18.36066

NUMBER OF MEANS	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
CRITICAL RANGE	12.94	13.62	14.08	14.42	14.68	14.90	15.07	15.23	15.36	15.48	15.58	15.67	15.76	15.83	15.90	15.97	16.02	16.08	16.13

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING				MEAN	N	PLOT
		A		98.814	16	XCEL SUP(91)
		A				
		A		97.834	16	CURLEX I(91)
		A				
B		A		96.584	20	BONTERRA S2(95)
B		A				
B		A		96.513	20	LANDSTRAND(95)
B		A				
B		A		96.353	20	SUPER GRO(94)
B		A				
B		A		96.151	16	POLYJUT407GT(91)
B		A				
B		A		92.014	16	N/A/G S150(91)
B		A				
B		A		91.236	20	MIRAMAT TM8(95)
B		A				
B		A		90.058	16	GEOJUTE(91)
B		A				
B		A		89.979	16	N/A/G SC150(91)
B		A				
B		A		88.837	20	VERDYOL HI-V(95)
B		A				
B		A	C	87.580	16	PECMAT(91)
B		A	C			
B	D	A	C	86.094	16	AIRTROL(92)
B	D	A	C			
B	D	A	C	83.987	20	SOIL GUARD(94)
B	D	A	C			
B	D	A	C	83.351	20	GEOJUTE PLS1(95)
B	D		C			
B	D		C	81.467	70	CONTROL
	D		C			
	D	E	C	73.717	16	DEKOWE 700(92)
	D	E				
	D	E		72.647	20	GEOJUTE PLUS(94)
		E				
		E		65.814	20	MIRAMAT 1000(94)

---------- SLOPE=2:1 SOIL=CLAY ----------

ANALYSIS OF VARIANCE PROCEDURE

DUNCAN GROUPING	MEAN	N	PLOT
F	35.909	16	POLYFLT TS22(91)

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STATISTICAL ANALYSIS
Class 1 "Slope Protection" Applications

1:2 Sand

Analysis of Variance
Duncan's Multiple Range Test
Confidence Level = 95%

---------- SLOPE=2:1 SOIL=SAND ----------

ANALYSIS OF VARIANCE PROCEDURE

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: SDMT

NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE, NOT THE EXPERIMENTWISE ERROR RATE

ALPHA= 0.05 DF= 842 MSE= 416.9439
WARNING: CELL SIZES ARE NOT EQUAL.
HARMONIC MEAN OF CELL SIZES= 28.50329

NUMBER OF MEANS	2	3	4	5	6	7	8	9	10	11	12	13	14
CRITICAL RANGE	11.02	11.18	11.55	11.83	12.05	12.23	12.37	12.50	12.61	12.71	12.79	12.87	12.94

NUMBER OF MEANS	15	16	17	18	19	20	21	22	23	24	25	26
CRITICAL RANGE	13.00	13.06	13.12	13.17	13.21	13.25	13.30	13.33	13.37	13.40	13.43	13.46

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING	MEAN	N	PLOT
A	-0.964	12	AIRTROL(95)
A			
B A	-8.042	30	SOIL GUARD(94)
B A			
B A	-8.157	30	GEOJUTE PLUS(94)
B A			
B A	-8.967	30	SUPER GRO(94)
B A			
B A C	-9.124	30	CURLEX I(94)
B A C			
B D A C	-10.389	30	DEKOWE 700(94)
B D A C			
E B D A C	-11.824	30	MIRAMAT 1000(94)
E B D C			
E B D F C	-13.417	30	AIRTROL(94)
E B D F C			
E B D F C G	-14.253	36	LANDSTRAND(95)
E B D F C G			
E B D F C G	-15.299	36	BONTERRA S2(95)
E B D F C G			
E B D F C G	-15.676	18	XCEL SUP(91)
E B D F C G			
E B D F C G	-16.728	36	VERDYOL HI-V(95)
E B D F C G			
E B D F H C G	-18.769	24	POLYJUT407GT(91)
E B D F H C G			
E B D F H C G	-20.819	21	N/A/G SC150(91)
E D F H C G			
E D F H C G	-21.806	34	CURLEX I(92)
E D F H G			
E D F H G	-22.731	36	MIRAMAT TM8(95)
E D F H G			
E D F H G	-23.170	36	SUPER GRO(95)

SLOPE=2:1 SOIL=SAND

ANALYSIS OF VARIANCE PROCEDURE

DUNCAN GROUPING	MEAN	N	PLOT
E F H G			
E F H G	-23.916	24	N/A/G S150(91)
E F H G			
E F H G	-24.587	36	DEKOWE 700(95)
F H G			
F H G	-25.123	26	POLYFLT TS22(91)
H G			
I H G	-27.032	36	GEOJUTE PLS1(95)
I H			
I H	-29.795	26	CURLEX I(91)
I H			
I H	-30.295	27	GEOJUTE(91)
I H			
I H	-31.143	28	PECMAT(91)
I			
I	-37.888	36	AIRTROL(92)
J	-56.412	130	CONTROL

---------- SLOPE=2:1 SOIL=SAND ----------

ANALYSIS OF VARIANCE PROCEDURE

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: COVER

NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE, NOT THE EXPERIMENTWISE ERROR RATE

ALPHA= 0.05 DF= 463 MSE= 630.0617
WARNING: CELL SIZES ARE NOT EQUAL.
HARMONIC MEAN OF CELL SIZES= 18.39732

NUMBER OF MEANS	2	3	4	5	6	7	8	9	10	11	12	13
CRITICAL RANGE	16.26	17.12	17.70	18.12	18.45	18.72	18.95	19.14	19.31	19.46	19.59	19.70

NUMBER OF MEANS	14	15	16	17	18	19	20	21	22	23	24	25
CRITICAL RANGE	19.81	19.90	19.99	20.07	20.15	20.22	20.28	20.34	20.40	20.45	20.50	20.55

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING			MEAN	N	PLOT
	A		89.461	20	CURLEX I(94)
	A				
B	A		86.735	20	SOIL GUARD(94)
B	A				
B	A		85.805	16	XCEL SUP(91)
B	A				
B	A		85.597	20	MIRAMAT TM8(95)
B	A				
B	A		84.746	16	N/A/G S150(91)
B	A				
B	A	C	81.466	20	MIRAMAT 1000(94)
B	A	C			
B	A	C	80.797	20	GEOJUTE PLS1(95)
B	A	C			
B	A	C	76.409	15	N/A/G SC150(91)
B	A	C			
B	A	C	74.302	16	POLYJUT407GT(91)
B		C			
B	D	C	69.570	20	SUPER GRO(94)
B	D	C			
B	D	C	68.348	20	BONTERRA S2(95)
	D	C			
E	D	C	64.758	20	LANDSTRAND(95)
E	D	C			
E	D	C	63.538	20	VERDYOL HI-V(95)
E	D				
E	D	F	52.674	16	CURLEX I(91)
E	D	F			
E	D	F	51.372	15	GEOJUTE(91)
E	D	F			
E	D	F	51.092	21	SUPER GRO(95)
E		F			
E		F	49.623	20	DEKOWE 700(94)

---------- SLOPE=2:1 SOIL=SAND ----------

ANALYSIS OF VARIANCE PROCEDURE

DUNCAN GROUPING			MEAN	N	PLOT
E		F			
E		F	49.192	20	DEKOWE 700(95)
E		F			
E		F	47.335	15	CURLEX I(92)
E		F			
E		F	46.051	16	POLYFLT TS22(91)
		F			
	G	F	41.882	16	AIRTROL(92)
	G	F			
	G	F	38.863	15	PECMAT(91)
	G				
H	G		26.770	51	CONTROL
H					
H	I		17.614	20	AIRTROL(94)
	I				
	I		3.883	20	GEOJUTE PLUS(94)

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STATISTICAL ANALYSIS
Class 1 "Slope Protection" Applications

1:3 Clay

Analysis of Variance
Duncan's Multiple Range Test
Confidence Level = 95%

---------- SLOPE=3:1 SOIL=CLAY ----------

ANALYSIS OF VARIANCE PROCEDURE

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: SDMT

NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE, NOT THE EXPERIMENTWISE ERROR RATE

ALPHA= 0.05 DF= 423 MSE= 0.305931
WARNING: CELL SIZES ARE NOT EQUAL.
HARMONIC MEAN OF CELL SIZES= 18.75229

NUMBER OF MEANS	2	3	4	5	6	7	8	9	10	11	12	13	14
CRITICAL RANGE	.3551	.3738	.3863	.3956	.4028	.4087	.4136	.4178	.4215	.4247	.4275	.4301	.4324

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING	MEAN	N	PLOT
A	-0.0819	30	SUPER GRO(94)
A			
A	-0.1153	29	CURLEX I(92)
A			
A	-0.1470	10	CURLEX I(91)
A			
A	-0.1525	10	EROMAT(91)
A			
A	-0.2001	10	PECMAT(91)
A			
A	-0.2441	32	AIRTROL(92)
A			
A	-0.2516	36	BONTERRA S1(95)
A			
A	-0.2727	10	N/A/G S75(91)
A			
A	-0.2879	36	ECS STRAW (95)
A			
A	-0.3062	36	SUPER GRO(95)
A			
A	-0.3196	10	XCEL REG(91)
A			
A	-0.3197	36	VERDYOL STD(95)
A			
A	-0.3576	36	POZ-O-CAP(95)
B	-1.3015	116	CONTROL

---------- SLOPE=3:1 SOIL=CLAY ----------

ANALYSIS OF VARIANCE PROCEDURE

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: COVER

NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE, NOT THE EXPERIMENTWISE ERROR RATE

ALPHA= 0.05 DF= 373 MSE= 292.4201
WARNING: CELL SIZES ARE NOT EQUAL.
HARMONIC MEAN OF CELL SIZES= 23.65831

NUMBER OF MEANS	2	3	4	5	6	7	8	9	10	11	12	13	14
CRITICAL RANGE	9.78	10.29	10.64	10.89	11.09	11.25	11.39	11.50	11.60	11.69	11.77	11.84	11.90

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING				MEAN	N	PLOT
		A		98.125	20	CURLEX I(92)
		A				
B		A		96.187	20	N/A/G S75(91)
B		A				
B		A	C	93.424	26	BONTERRA S1(95)
B		A	C			
B		A	C	91.212	26	VERDYOL STD(95)
B		A	C			
B	D	A	C	90.708	26	ECS STRAW (95)
B	D	A	C			
B	D	A	C	90.525	20	PECMAT(91)
B	D	A	C			
B	D	A	C	90.166	20	XCEL REG(91)
B	D	A	C			
B	D	A	C	89.418	26	SUPER GRO(95)
B	D	A	C			
B	D	A	C	87.809	20	EROMAT(91)
B	D		C			
B	D		C	86.444	20	AIRTROL(92)
	D		C			
	D		C	83.479	26	POZ-O-CAP(95)
	D					
	D	E		79.631	91	CONTROL
		E				
F		E		70.378	26	SUPER GRO(94)
F						
F				63.230	20	CURLEX I(91)

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STATISTICAL ANALYSIS
Class 1 "Slope Protection" Applications

1:3 Sand

Analysis of Variance
Duncan's Multiple Range Test
Confidence Level = 95%

SEDIMENT LOSS (KILOGRAMS PER 10 SQUARE METERS)
ANALYSIS LEVEL 4 (STEEPNESS OF SLOPE AND TYPE OF SOIL)

---------- SLOPE=3:1 SOIL=SAND ----------

ANALYSIS OF VARIANCE PROCEDURE

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: SDMT

NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE, NOT THE EXPERIMENTWISE ERROR RATE

ALPHA= 0.05 DF= 619 MSE= 86.10869
WARNING: CELL SIZES ARE NOT EQUAL.
HARMONIC MEAN OF CELL SIZES= 27.81442

NUMBER OF MEANS	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
CRITICAL RANGE	4.887	5.145	5.318	5.445	5.545	5.626	5.694	5.753	5.803	5.847	5.887	5.922	5.954	5.983	6.010	6.035	6.057

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING			MEAN	N	PLOT
	A		-0.503	12	POZ-O-CAP(95)
	A				
B	A		-2.936	30	CURLEX I(94)
B	A				
B	A		-3.002	36	SUPER GRO(94)
B	A				
B	A	C	-4.119	34	CURLEX I(92)
B	A	C			
B	A	C	-4.406	18	CURLEX I(91)
B	A	C			
B	A	C	-4.712	19	XCEL REG(91)
B		C			
B		C	-6.289	37	BONTERRA S1(95)
B		C			
B	D	C	-7.411	35	VERDYOL STD(95)
B	D	C			
B	D	C	-7.835	36	CURLEX I(95)
B	D	C			
B	D	C	-8.063	36	ECS STRAW (95)
B	D	C			
B	D	C	-8.099	25	N/A/G S75(91)
	D	C			
	D	C	-9.078	22	EROMAT(91)
	D	C			
	D	C	-9.261	24	AIRTROL(94)
	D	C			
	D	C	-9.742	36	SUPER GRO(95)
	D				
E	D		-12.389	42	AIRTROL(92)
E	D				
E	D		-13.018	36	AIRTROL(95)
E					
E			-16.402	25	PECMAT(91)
	F		-28.576	134	CONTROL

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FINAL VEGETATIVE DENSITY PRODUCTION (PERCENT)
ANALYSIS LEVEL 4 (STEEPNESS OF SLOPE AND TYPE OF SOIL)

---------- SLOPE=3:1 SOIL=SAND ----------

ANALYSIS OF VARIANCE PROCEDURE

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: COVER

NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE, NOT THE EXPERIMENTWISE ERROR RATE

ALPHA= 0.05 DF= 421 MSE= 419.1424
WARNING: CELL SIZES ARE NOT EQUAL.
HARMONIC MEAN OF CELL SIZES= 23.72418

NUMBER OF MEANS	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
CRITICAL RANGE	11.68	12.30	12.71	13.02	13.26	13.45	13.61	13.75	13.87	13.98	14.07	14.15	14.23	14.30	14.36	14.42

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING					MEAN	N	PLOT
			A		80.276	26	ECS STRAW (95)
			A				
			A		77.904	20	N/A/G S75(91)
			A				
	B		A		77.089	26	BONTERRA S1(95)
	B		A				
	B		A	C	75.330	26	VERDYOL STD(95)
	B		A	C			
	B	D	A	C	73.202	20	EROMAT(91)
	B	D	A	C			
	B	D	A	C	72.263	20	XCEL REG(91)
	B	D	A	C			
E	B	D	A	C	68.749	19	AIRTROL(92)
E	B	D		C			
E	B	D		C	63.962	26	CURLEX I(95)
E		D		C			
E		D		C	62.385	20	PECMAT(91)
E		D					
E		D			60.937	20	CURLEX I(91)
E							
E			F		56.888	26	SUPER GRO(95)
			F				
			F		48.632	26	CURLEX I(94)
			G		33.638	26	AIRTROL(94)
			G				
			G		33.232	19	CURLEX I(92)
			G				
			G		33.211	66	CONTROL
			G				
	H		G		26.180	26	AIRTROL(95)
	H						
	H				17.585	26	SUPER GRO(94)

CLASS 2 "FLEXIBLE CHANNEL LINER" APPLICATIONS
Final Performance Anslysis

ANALYSIS LEVEL USED BY TxDOT TO DETERMINE APPROVED PRODUCT LIST

This analysis level seeks to determine how well each product *resisted the erosive forces of concentrated water flows* by protecting the geometry of a channel, and how well each product *established warm-season, perennial vegetation within* a single March through December growing season.

Sediment-loss figures shown represent the average amount of soil displaced within either the particular shear-stress event shown, or within the shear-stress range of flows shown. Sediment loss is expressed in terms of Centimeters of Soil Displacement.

Vegetation-density figures shown represent the average percent of vegetative cover achieved within the channel by the final measurement cycle only.

TABULAR DATA
Class 2 "Flexible Channel Liner" Applications

96 Pascal Shear Stress Flow Only (2 Lb/Sq Ft)

(For Information Only)

Texas Department of Transportation
Final Performance Analysis

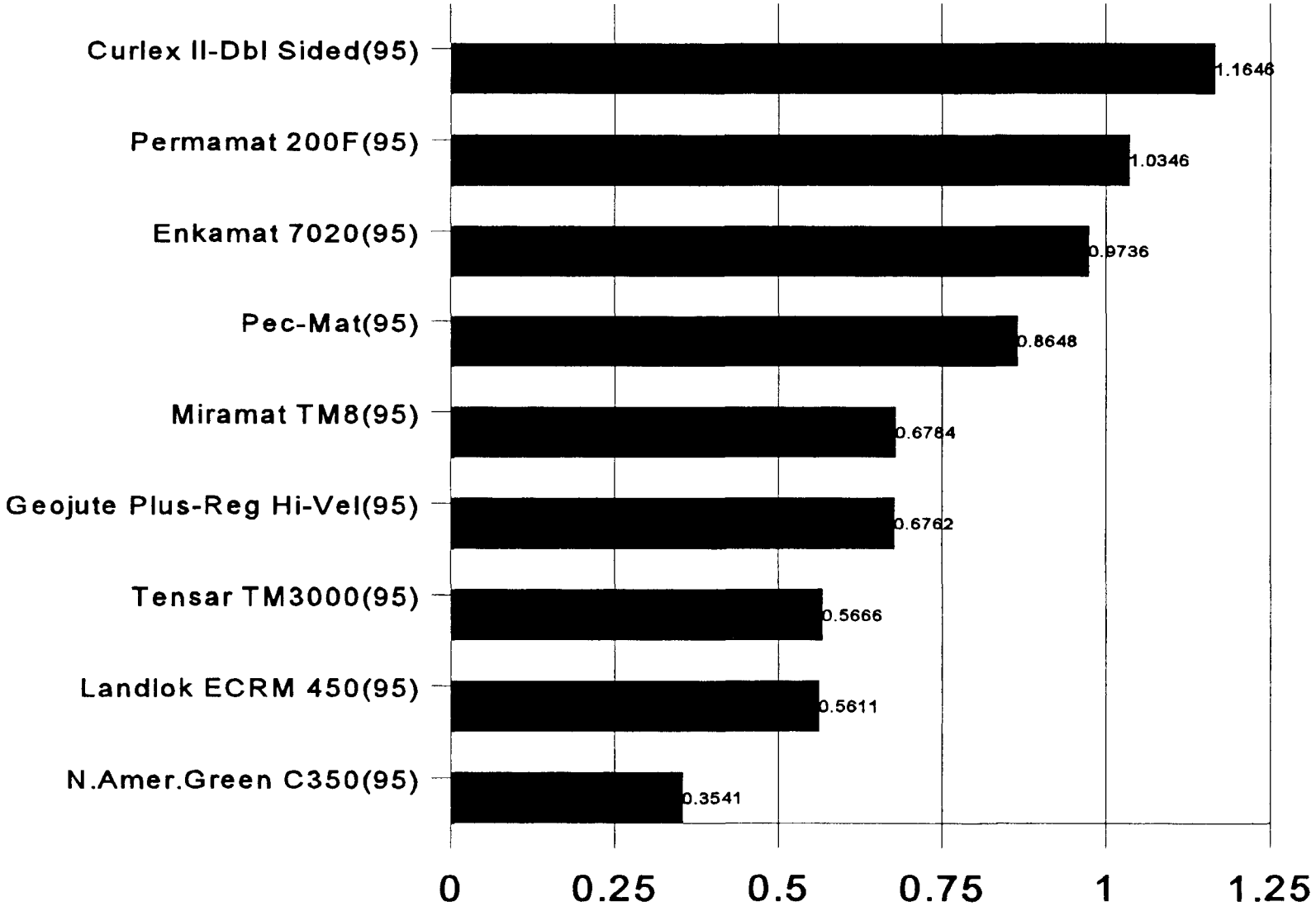
Class 2 "Flexible Channel Liner" Applications

Shear Stress = 96 Pascal (2 Lb/Sq Ft)
(For Information Only)

Final Performance Analysis								
No	**Product Evaluated**	**Year**	**Pct[1]**	**Depth of Flow[2]**	**Avg Flow Velocity[3]**	**Shear Stress[4]**	**Sediment Loss[5]**	**Vegetation Density[6]**
1	*North American Green C350™ Three Phase™*	1995	7	15.24	5.43	96	0.3541	79.982
2	*LANDLOK® ECRM 450*	1995	7	15.24	5.17	96	0.5611	78.116
3	*TENSAR® Erosion Mat TM3000*	1995	7	15.24	3.89	96	0.5666	92.853
4	*Geojute® Plus-Regular High Velocity*	1995	3	32.61	4.95	96	0.6762	59.490
5	*Miramat® TM8™*	1995	7	15.24	6.39	96	0.6784	86.574
6	*GREENSTREAK® PEC-MAT™*	1995	7	15.24	4.54	96	0.8648	71.830
7	*Enkamat® 7020*	1995	7	15.24	4.72	96	0.9736	82.394
8	*Permamat 200F*	1995	3	32.61	4.55	96	1.0346	56.954
9	*Curlex® II (Double Sided)*	1995	3	32.61	4.25	96	1.1646	54.664

1. Centerline Gradient of Channel - Expressed as Percent
2. Expressed in Centimeters (cm)
3. Expressed in Meters per Second
4. Expressed in Pascals (Pa)
5. Expressed as Centimeters (cm) of Channel Deformation
6. Expressed as Percent of Vegetative Cover Achieved by Final Measurement Round

Class 2 - "Flexible Channel Liner" Applications
Average Channel Deformation (Centimeters)
96 Pascal Shear Stress Flows Only (2 Lb/Sq Ft)



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TABULAR DATA
Class 2 "Flexible Channel Liner" Applications

144 Pascal Shear Stress Flows Only (3 Lb/Sq Ft)

(For Information Only)

Texas Department of Transportation
Final Performance Analysis

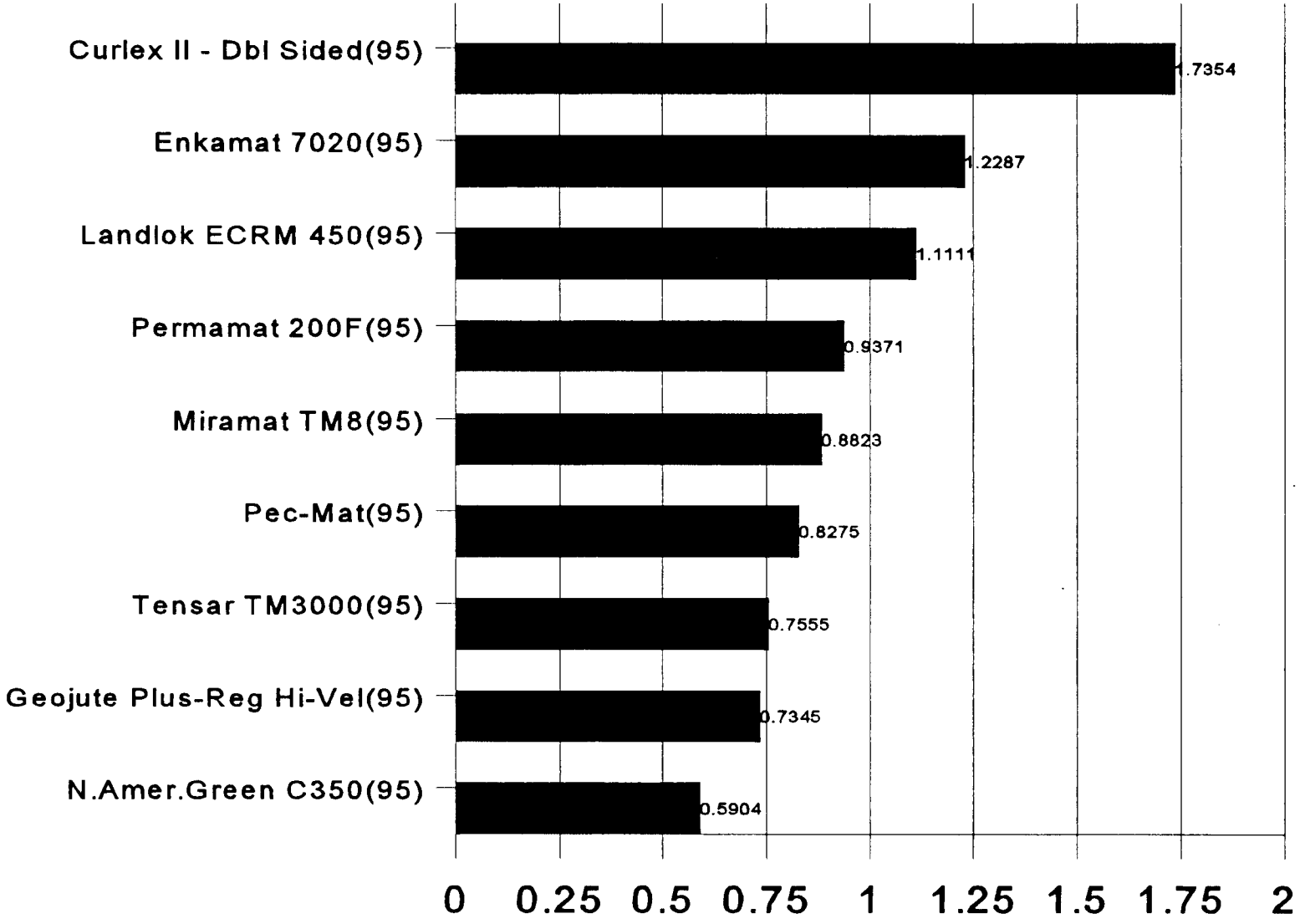
Class 2 "Flexible Channel Liner" Applications

Shear Stress = 144 Pascal (3 Lb/Sq Ft)
(For Information Only)

Final Performance Analysis								
No	**Product Evaluated**	**Year**	**Pct[1]**	**Depth of Flow[2]**	**Flow Velocity[3]**	**Shear Stress[4]**	**Sediment Loss[5]**	**Vegetation Density[6]**
1	*North American Green C350™ Three Phase™*	1995	7	21.34	7.54	144	0.5904	79.982
2	*Geojute® Plus-Regular High Velocity*	1995	3	48.77	5.44	144	0.7345	59.490
3	*TENSAR® Erosion Mat TM3000*	1995	7	21.34	4.89	144	0.7555	92.853
4	*GREENSTREAK® PEC-MAT™*	1995	7	21.34	7.47	144	0.8275	71.830
5	*Miramat® TM8™*	1995	7	21.34	5.97	144	0.8823	86.574
6	*Permamat 200F*	1995	3	48.77	4.94	144	0.9371	56.954
7	*LANDLOK® ECRM 450*	1995	7	21.34	4.15	144	1.1111	78.116
8	*Enkamat® 7020*	1995	7	21.34	4.41	144	1.2287	82.394
9	*Curlex® II (Double Sided)*	1995	3	48.77	4.98	144	1.7354	54.664

1. Centerline Gradient of Channel - Expressed as Percent
2. Expressed in Centimeters (cm)
3. Expressed in Meters per Second
4. Expressed in Pascals (Pa)
5. Expressed as Centimeters (cm) of Channel Deformation
6. Expressed as Percent of Vegetative Cover Achieved by Final Measurement Round

Class 2 - "Flexible Channel Liner" Applications
Average Channel Deformation (Centimeters)
144 Pascal Shear Stress Flows Only (3 Lb/Sq Ft)



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TABULAR DATA
Class 2 "Flexible Channel Liner" Applications

192 Pascal Shear Stress Flows Only (4 Lb/Sq Ft)

(For Information Only)

Texas Department of Transportation
Final Performance Analysis

Class 2 "Flexible Channel Liner" Applications

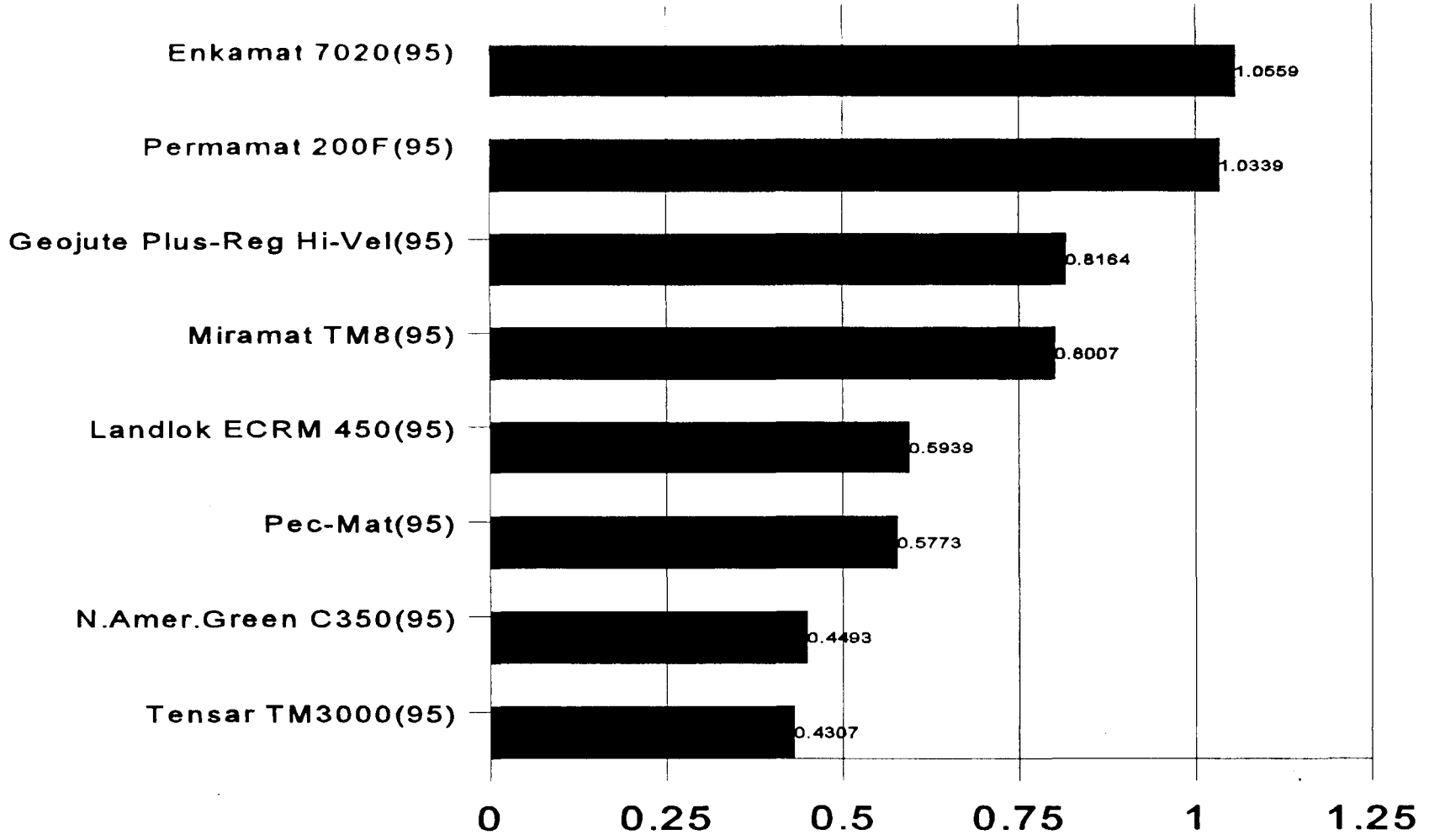
Shear Stress = 192 Pascal (4 Lb/Sq Ft)
(For Information Only)

Final Performance Analysis								
No	**Product Evaluated**	**Year**	**Pct[1]**	**Depth of Flow[2]**	**Flow Velocity[3]**	**Shear Stress[4]**	**Sediment Loss[5]**	**Vegetation Density[6]**
1	*TENSAR® Erosion Mat TM3000*	1995	7	27.43	5.22	192	0.4307	92.853
2	*North American Green C350™ Three Phase™*	1995	7	27.43	4.54	192	0.4493	79.982
3	*GREENSTREAK® PEC-MAT™*	1995	7	27.43	4.74	192	0.5773	71.830
4	*LANDLOK® ECRM 450*	1995	7	27.43	6.61	192	0.5939	78.116
5	*Miramat® TM8™*	1995	7	27.43	6.40	192	0.8007	86.574
6	*Geojute® Plus-Regular High Velocity*	1995	3	64.01	3.37	192	0.8164	59.490
7	*Permamat 200F*	1995	3	64.01	6.30	192	1.0339	56.954
8	*Enkamat® 7020*	1995	7	27.43	5.22	192	1.0559	82.394
9	*Curlex® II (Double Sided)*	1995	3	N/A	N/A	192	Not Tested	54.664

NOTES:

1. Centerline Gradient of Channel - Expressed as Percent
2. Expressed in Centimeters (cm)
3. Expressed in Meters per Second
4. Expressed in Pascals (Pa)
5. Expressed as Centimeters (cm) of Channel Deformation
6. Expressed as Percent of Vegetative Cover Achieved by Final Measurement Round

Class 2 - "Flexible Channel Liner" Applications
Average Channel Deformation (Centimeters)
192 Pascal Shear Stress Flows Only (4 Lb/Sq Ft)



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TABULAR DATA
Class 2 "Flexible Channel Liner" Applications

239 Pascal Shear Stress Flows Only (5 Lb/Sq Ft)

(For Information Only)

Texas Department of Transportation
Final Performance Analysis

Class 2 "Flexible Channel Liner" Applications

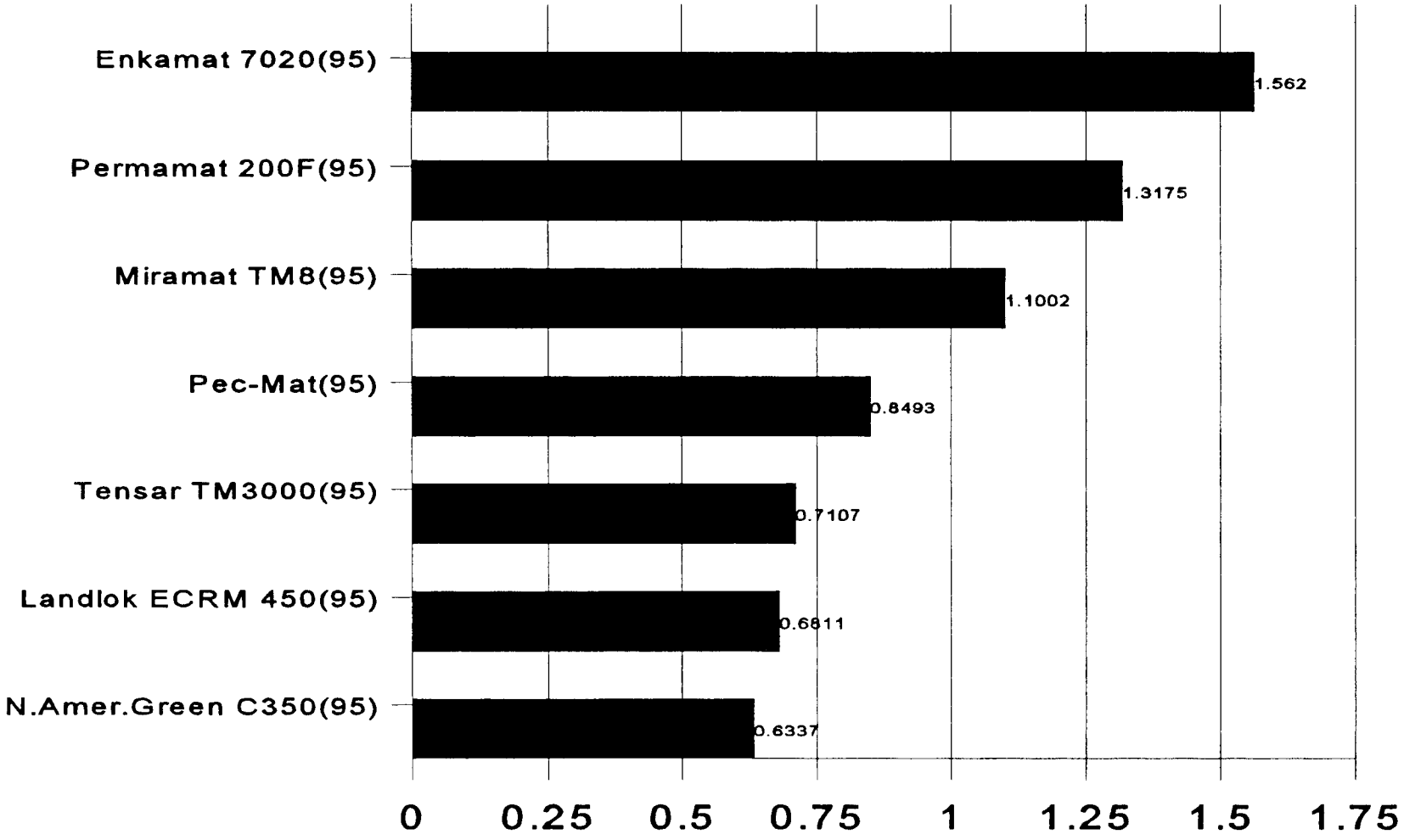
Shear Stress = 239 Pascal (5 Lb/Sq Ft)
(For Information Only)

Final Performance Analysis								
No	**Product Evaluated**	**Year**	**Pct[1]**	**Depth of Flow[2]**	**Flow Velocity[3]**	**Shear Stress[4]**	**Sediment Loss[5]**	**Vegetation Density[6]**
1	*North American Green C350™ Three Phase™*	1995	7	33.53	5.81	239	0.6337	79.982
2	*LANDLOK® ECRM 450*	1995	7	33.53	5.49	239	0.6811	78.116
3	*TENSAR® Erosion Mat TM3000*	1995	7	33.53	5.57	239	0.7107	92.853
4	*GREENSTREAK® PEC-MAT™*	1995	7	33.53	6.25	239	0.8493	71.830
5	*Miramat® TM8™*	1995	7	33.53	6.75	239	1.1002	86.574
6	*Permamat 200F*	1995	3	82.30	3.70	239	1.3175	56.954
7	*Enkamat® 7020*	1995	7	33.53	5.51	239	1.5620	82.394
8	*Geojute® Plus-Regular High Velocity*	1995	3	N/A	N/A	N/A	Not Tested	59.490
9	*Curlex® II (Double Sided)*	1995	3	N/A	N/A	N/A	Not Tested	54.664

NOTES:

1. Centerline Gradient of Channel - Expressed as Percent
2. Expressed in Centimeters (cm)
3. Expressed in Meters per Second
4. Expressed in Pascals (Pa)
5. Expressed as Centimeters (cm) of Channel Deformation
6. Expressed as Percent of Vegetative Cover Achieved by Final Measurement Round

Class 2 - "Flexible Channel Liner" Applications
Average Channel Deformation (Centimeters)
239 Pascal Shear Stress Flows Only (5 Lb/Sq Ft)



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TABULAR DATA
Class 2 "Flexible Channel Liner" Applications

287 Pascal Shear Stress Flows Only (6 Lb/Sq Ft)

(For Information Only)

Texas Department of Transportation
Final Performance Analysis

Class 2 "Flexible Channel Liner" Applications

Shear Stress = 287 Pascal (6 Lb/Sq Ft)
(For Information Only)

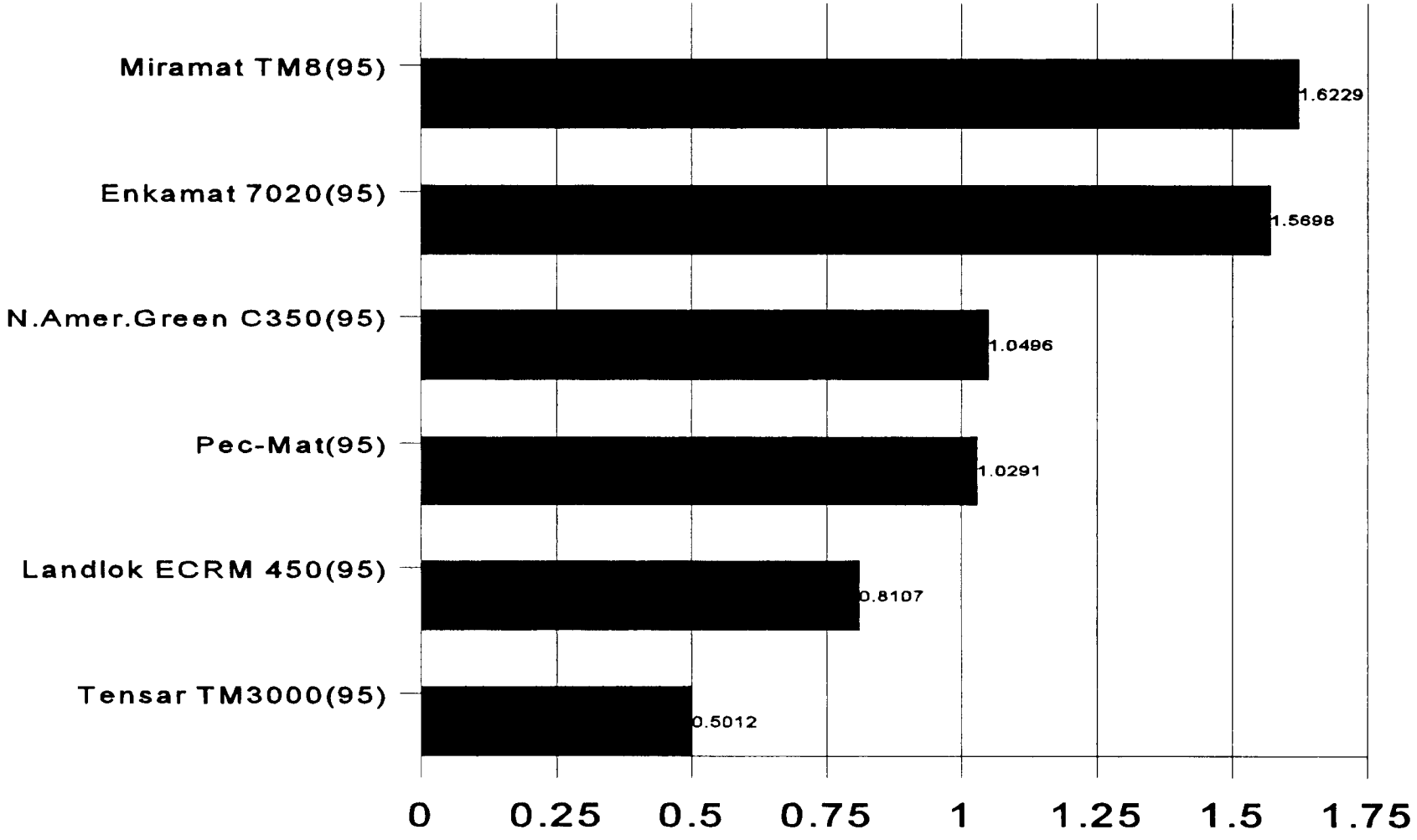
Final Performance Analysis								
No	**Product Evaluated**	**Year**	**Pct[1]**	**Depth of Flow[2]**	**Flow Velocity[3]**	**Shear Stress[4]**	**Sediment Loss[5]**	**Vegetation Density[6]**
1	*TENSAR® Erosion Mat TM3000*	1995	7	42.67	7.19	287	0.5012	92.853
2	*LANDLOK® ECRM 450*	1995	7	42.67	8.46	287	0.8107	78.116
3	*GREENSTREAK® PEC-MAT™*	1995	7	42.67	8.71	287	1.0291	71.830
4	*North American Green C350™ Three Phase™*	1995	7	42.67	8.21	287	1.0496	79.982
5	*Enkamat® 7020*	1995	7	42.67	7.75	287	1.5698	82.394
6	*Miramat® TM8™*	1995	7	42.67	7.81	287	1.6229	86.574
7	*Geojute® Plus-Regular High Velocity*	1995	3	N/A	N/A	287	Not Tested	59.490
8	*Curlex® II (Double Sided)*	1995	3	N/A	N/A	287	Not Tested	54.664
9	*Permamat 200F*	1995	3	N/A	N/A	287	Not Tested	56.954

NOTES:

[1] Flow at this level not performed. Product had been sufficiently damaged by previous flows to warrant canceling further flow events.

1. Centerline Gradient of Channel - Expressed as Percent
2. Expressed in Centimeters (cm)
3. Expressed in Meters per Second
4. Expressed in Pascals (Pa)
5. Expressed as Centimeters (cm) of Channel Deformation
6. Expressed as Percent of Vegetative Cover Achieved by Final Measurement Round

Class 2 - "Flexible Channel Liner" Applications
Average Channel Deformation (Centimeters)
287 Pascal Shear Stress Flows Only (6 Lb/Sq Ft)



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TABULAR DATA
Class 2 "Flexible Channel Liner" Applications

335 Pascal Shear Stress Flows Only (7 Lb/Sq Ft)

(For Information Only)

Texas Department of Transportation
Final Performance Analysis

Class 2 "Flexible Channel Liner" Applications

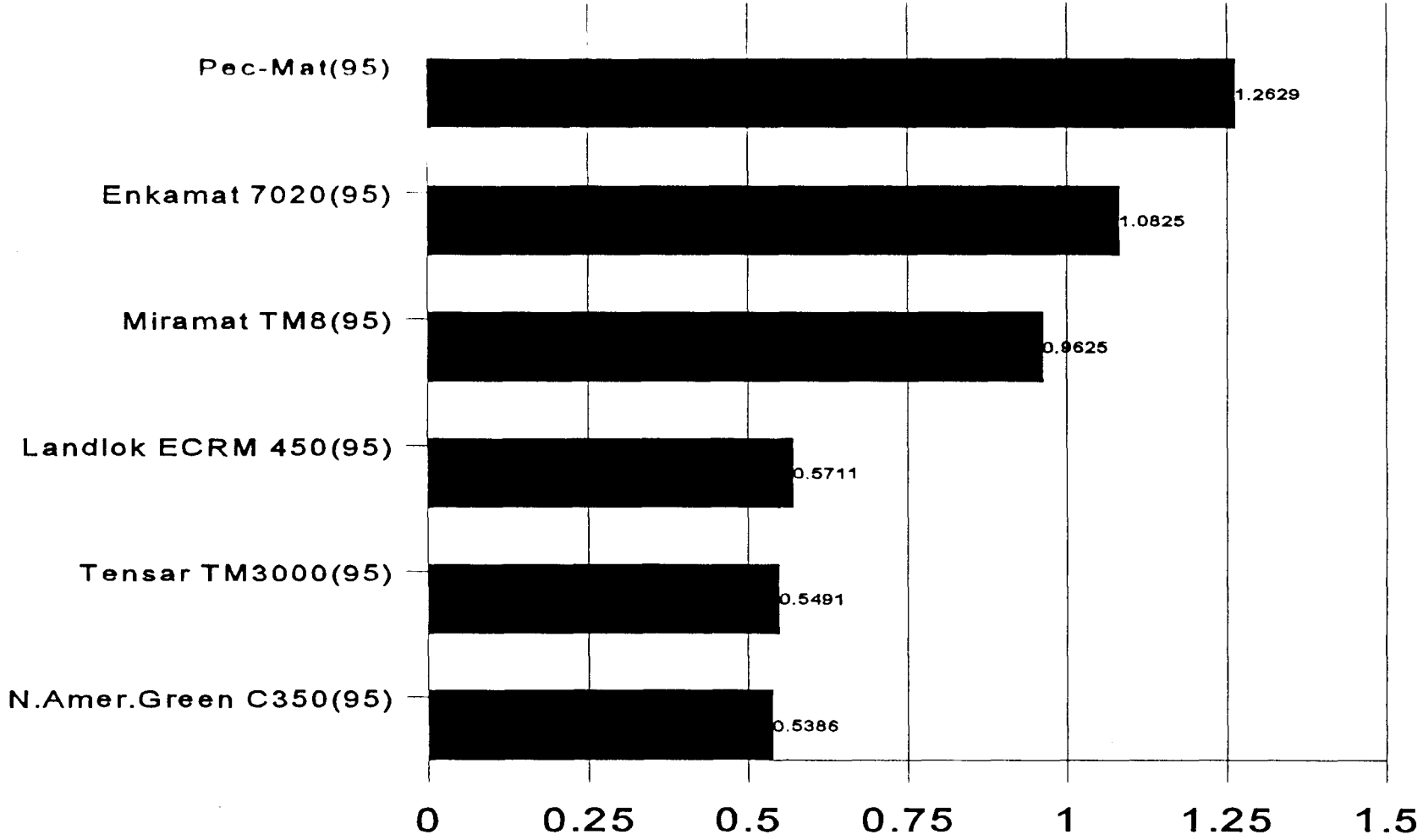
Shear Stress = 335 Pascal (7 Lb/Sq Ft)
(For Information Only)

Final Performance Analysis								
No	**Product Evaluated**	**Year**	**Pct[1]**	**Depth of Flow[2]**	**Flow Velocity[3]**	**Shear Stress[4]**	**Sediment Loss[5]**	**Vegetation Density[6]**
1	*North American Green C350™ Three Phase™*	1995	7	48.77	9.57	335	0.5386	79.982
2	*TENSAR® Erosion Mat TM3000*	1995	7	48.77	7.19	335	0.5491	92.853
3	*LANDLOK® ECRM 450*	1995	7	48.77	9.29	335	0.5711	78.116
4	*Miramat® TM8™*	1995	7	48.77	7.6	335	0.9625	86.574
5	*Enkamat® 7020*	1995	7	48.77	8.15	335	1.0825	82.394
6	*GREENSTREAK® PEC-MAT™*	1995	7	48.77	9.24	335	1.2629	71.830
7	*Geojute® Plus-Regular High Velocity*	1995	3	N/A	N/A	335	Not Tested	59.490
8	*Curlex® II (Double Sided)*	1995	3	N/A	N/A	335	Not Tested	54.664
9	*Permamat 200F*	1995	3	N/A	N/A	335	Not Tested	56.954

NOTES:

1. Centerline Gradient of Channel - Expressed as Percent
2. Expressed in Centimeters (cm)
3. Expressed in Meters per Second
4. Expressed in Pascals (Pa)
5. Expressed as Centimeters (cm) of Channel Deformation
6. Expressed as Percent of Vegetative Cover Achieved by Final Measurement Round

Class 2 - "Flexible Channel Liner" Applications
Average Channel Deformation (Centimeters)
335 Pascal Shear Stress Flows Only (7 Lb/Sq Ft)



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TABULAR DATA
Class 2 "Flexible Channel Liner" Applications

383 Pascal Shear Stress Flows Only (7 Lb/Sq Ft)

Texas Department of Transportation
Final Performance Analysis

Class 2 "Flexible Channel Liner" Applications

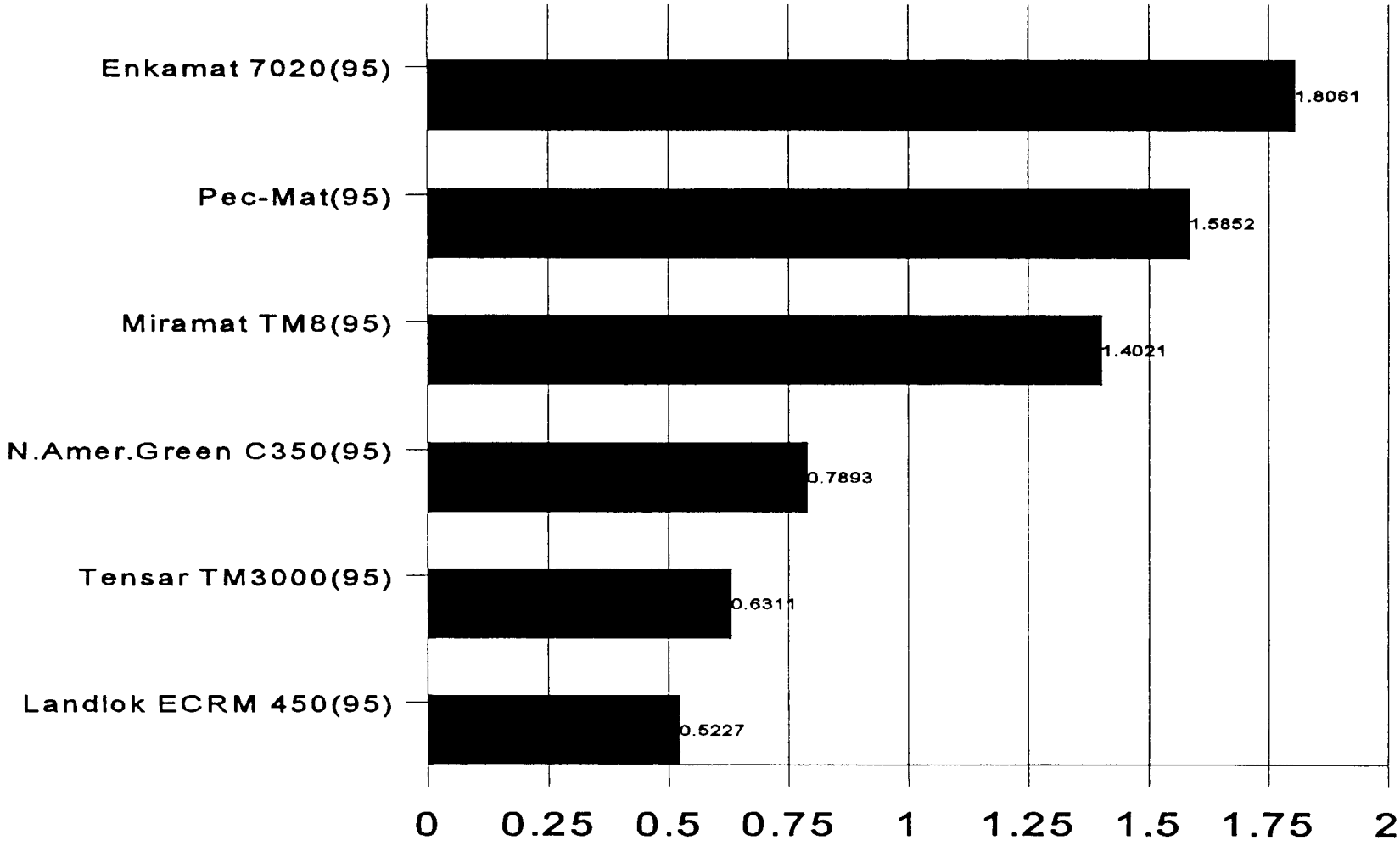
Shear Stress 383 Pascal (8 Lb/Sq Ft)
(For Information Only)

Final Performance Analysis								
No	**Product Evaluated**	**Year**	**Pct[1]**	**Depth of Flow[2]**	**Flow Velocity[3]**	**Shear Stress[4]**	**Sediment Loss[5]**	**Vegetation Density[6]**
1	*LANDLOK® ECRM 450*	1995	7	54.86	9.70	383	0.5227	78.116
2	*TENSAR® Erosion Mat TM3000*	1995	7	54.86	9.14	383	0.6311	92.853
3	*North American Green C350™ Three Phase™*	1995	7	54.86	10.00	383	0.7893	79.982
4	*Miramat® TM8™*	1995	7	54.86	7.21	383	1.4021	86.574
5	*GREENSTREAK® PEC-MAT™*	1995	7	54.86	9.93	383	1.5852	71.830
6	*Enkamat® 7020*	1995	7	54.86	8.58	383	1.8061	82.394
7	*Geojute® Plus-Regular High Velocity*	1995	3	N/A	N/A	383	Not Tested	59.490
8	*Curlex® II (Double Sided)*	1995	3	N/A	N/A	383	Not Tested	54.664
9	*Permamat 200F*	1995	3	N/A	N/A	383	Not Tested	56.954

NOTES:

1. Centerline Gradient of Channel - Expressed as Percent
2. Expressed in Centimeters (cm)
3. Expressed in Meters per Second
4. Expressed in Pascals (Pa)
5. Expressed as Centimeters (cm) of Channel Deformation
6. Expressed as Percent of Vegetative Cover Achieved by Final Measurement Round

Class 2 - "Flexible Channel Liner" Applications
Average Channel Deformation (Centimeters)
383 Pascal Shear Stress Flows Only (8 Lb/Sq Ft)



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TABULAR DATA
Class 2 "Flexible Channel Liner" Appltions

0 - 96 Pascal Shear Stress Flows

Texas Department of Transportation
Final Performance Analysis

Class 2 "Flexible Channel Liner" Applications

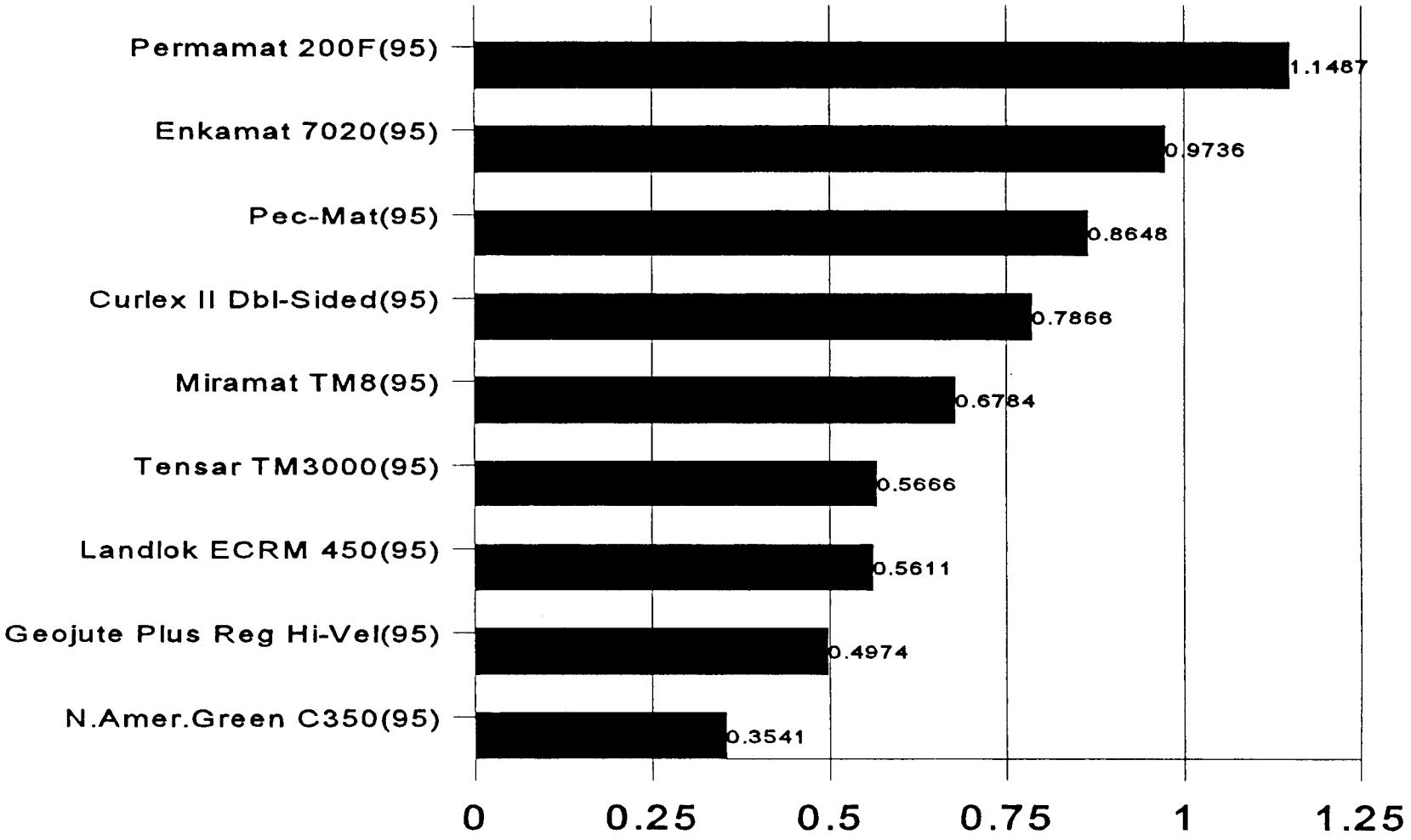
(Shear Stress Range 0 - 96 Pascal)
(0 - 2 Lb/Sq Ft)
(Level Used by TxDOT to Produce Approved Material List)

Final Performance Analysis						
No	**Product Evaluated**	**Year**	**Sediment Loss[1]**	**Sediment Standard[2]**	**Vegetation Density[3]**	**Density Standard**
1	*North American Green C350™ Three Phase™*	1995	0.3541	1.15	79.982%	70%
2	*Geojute® Plus-Regular High Velocity*	1995	0.4974	1.15	59.490%	70%
3	*LANDLOK® ECRM 450*	1995	0.5611	1.15	78.116%	70%
4	*TENSAR® Erosion Mat TM3000*	1995	0.5666	1.15	92.853%	70%
5	*Miramat® TM8™*	1995	0.6784	1.15	86.574%	70%
6	Curlex® II (Double Sided)	1995	0.7866	1.15	54.664%	70%
7	*GREENSTREAK® PEC-MAT™*	1995	0.8648	1.15	71.830%	70%
8	*Enkamat® 7020*	1995	0.9736	1.15	82.394%	70%
9	*Permamat 200F*	1995	1.1487	1.15	56.954%	70%

NOTE: Shaded cells (if any) indicate performance which failed to meet currently established minimum performance standards.

1. Expressed as Centimeters (cm) of Channel Deformation
2. Expressed as Centimeters (cm) of Channel Deformation
3. Expressed as Percent of Vegetative Cover Achieved by Final Measurement Round

Class 2 - "Flexible Channel Liner" Applications
Average Channel Deformation (Centimeters)
0 - 96 Pascal Shear Stress Flows (0 - 2 Lb/Sq Ft)



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TABULAR DATA
Class 2 "Flexble Channel Liner" Applications

0 - 192 Pascal Shear Stress Flows

Texas Department of Transportation
Final Performance Analysis

Class 2 "Flexible Channel Liner" Applications

(Shear Stress Range 0 - 192 Pascal)
(> 0 to 4 Lb/Sq Ft)
(Level Used by TxDOT to Produce Approved Material List)

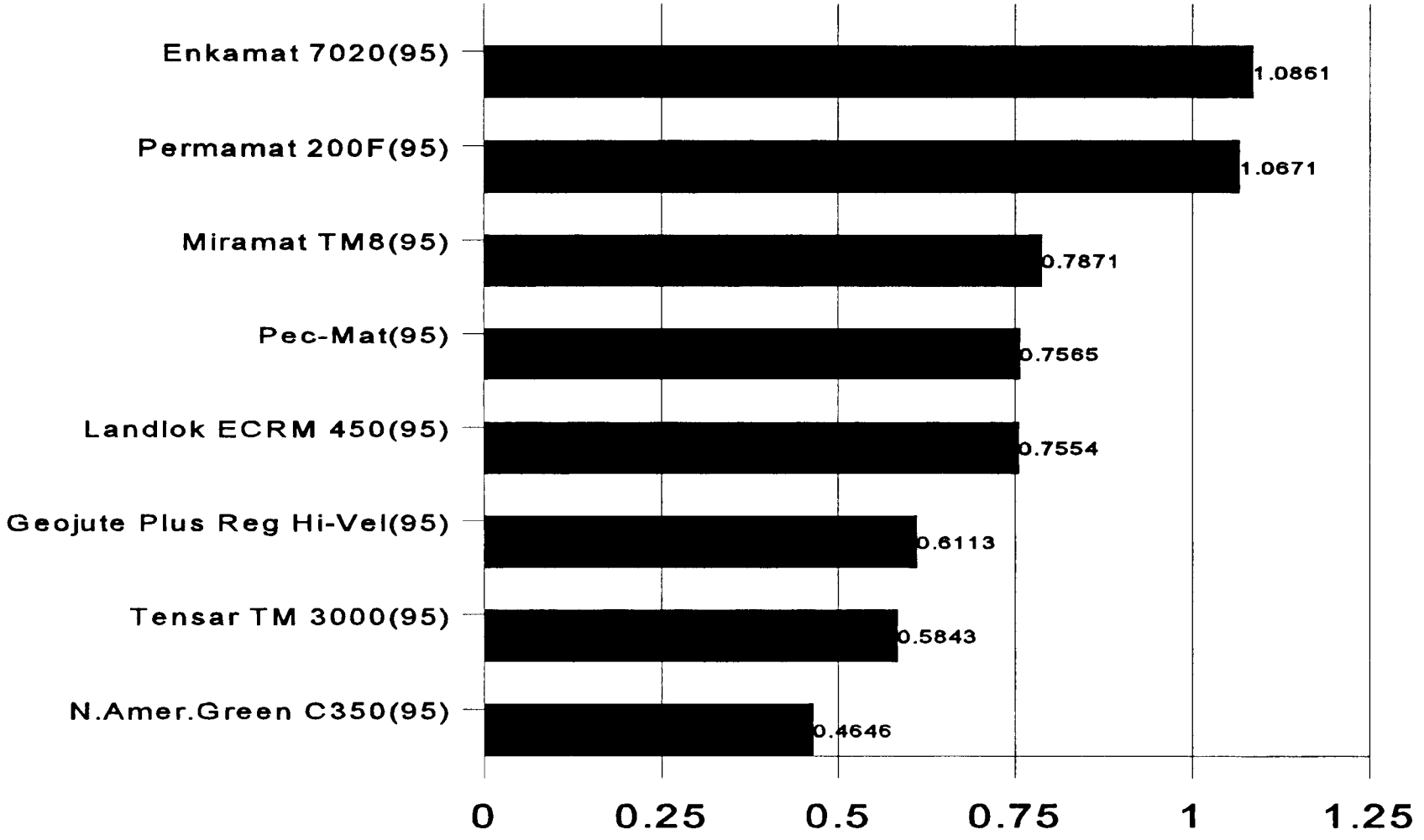
Final Performance Analysis						
No	**Product Evaluated**	**Year**	**Sediment Loss[1]**	**Sediment Standard**	**Vegetation Density[2]**	**Density Standard**
1	*North American Green C350™ Three Phase™*	1995	0.4646	1.00	79.982%	70%
2	*TENSAR® Erosion Mat TM3000*	1995	0.5843	1.00	92.853%	70%
3	Geojute® Plus-Regular High Velocity	1995	0.6113	1.00	59.490%	70%
4	LANDLOK® ECRM 450	1995	0.7554	1.00	78.116%	70%
5	GREENSTREAK® PEC-MAT™	1995	0.7565	1.00	71.830%	70%
6	*Miramat® TM8™*	1995	0.7871	1.00	86.574%	70%
7	*Permamat 200F*	1995	1.0671	1.00	56.954%	70%
8	*Enkamat® 7020*	1995	1.0861	1.00	82.394%	70%
9	*Curlex® II (Double Sided)*	1995	Not Tested	1.00	54.664%	70%

NOTE: Shaded cells (if any) indicate performance which failed to meet currently established minimum performance standards.

1. Expressed as Centimeters (cm) of Channel Deformation

2. Expressed as Percent of Vegetative Cover Achieved by Final Measurement Round

Class 2 - "Flexible Channel Liner" Applications
Average Channel Deformation (Centimeters)
0 - 192 Pascal Shear Stress Flows (0 - 4 Lb/Sq Ft)



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TABULAR DATA
Class 2 "Flexible Channel Liner" Applications

0 - 287 Pascal Shear Stress Flows

Texas Department of Transportation
Final Performance Analysis

Class 2 "Flexible Channel Liner" Applications

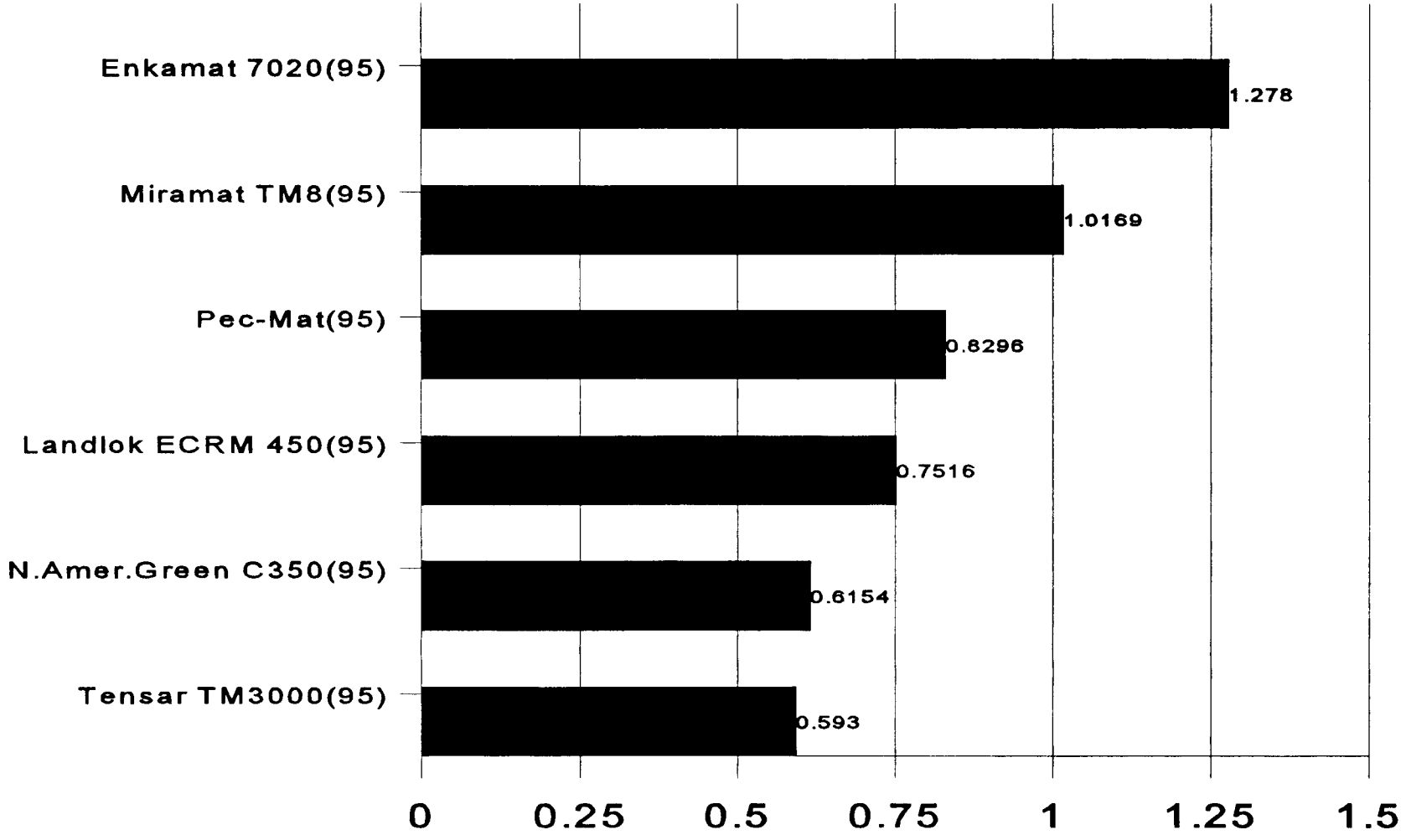
(Shear Stress Range 0 - 287 Pascal)
(> 0 to 6 Lb/Sq Ft)
(Level Used by TxDOT to Produce Approved Material List)

Final Performance Analysis						
No	**Product Evaluated**	**Year**	**Sediment Loss[1]**	**Sediment Standard**	**Vegetation Density[2]**	**Density Standard**
1	*TENSAR® Erosion Mat TM3000*	1995	0.5930	1.00	92.853%	70%
2	Geojute® Plus-Regular High Velocity	1995	Not Tested	1.00	59.490%	70%
3	*North American Green C350™ Three Phase™*	1995	0.6154	1.00	79.982%	70%
4	LANDLOK® ECRM 450	1995	0.7516	1.00	78.116%	70%
5	GREENSTREAK® PEC-MAT™	1995	0.8296	1.00	71.830%	70%
6	*Miramat® TM8™*	1995	1.0169	1.00	86.574%	70%
7	*Permamat 200F*	1995	Not Tested	1.00	56.954%	70%
8	Curlex® II (Double Sided)	1995	Not Tested	1.00	54.664%	70%
7	*Enkamat® 7020*	1995	1.2780	1.00	82.394%	70%

NOTE: Shaded cells (if any) indicate performance which failed to meet currently established minimum performance standards.

1. Expressed as Centimeters (cm) of Channel Deformation
2. Expressed as Percent of Vegetative Cover Achieved by Final Measurement Round

Class 2 - "Flexible Channel Liner" Applications
Average Channel Deformation (Centimeters)
0 -287 Pascal Shear Stress Flows (0 - 6 Lb/Sq Ft)



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TABULAR DATA
Class 2 "Flexible Channel Liner" Applications

0 - 383 Pascal Shear Stress Flows

Texas Department of Transportation
Final Performance Analysis

Class 2 "Flexible Channel Liner" Applications

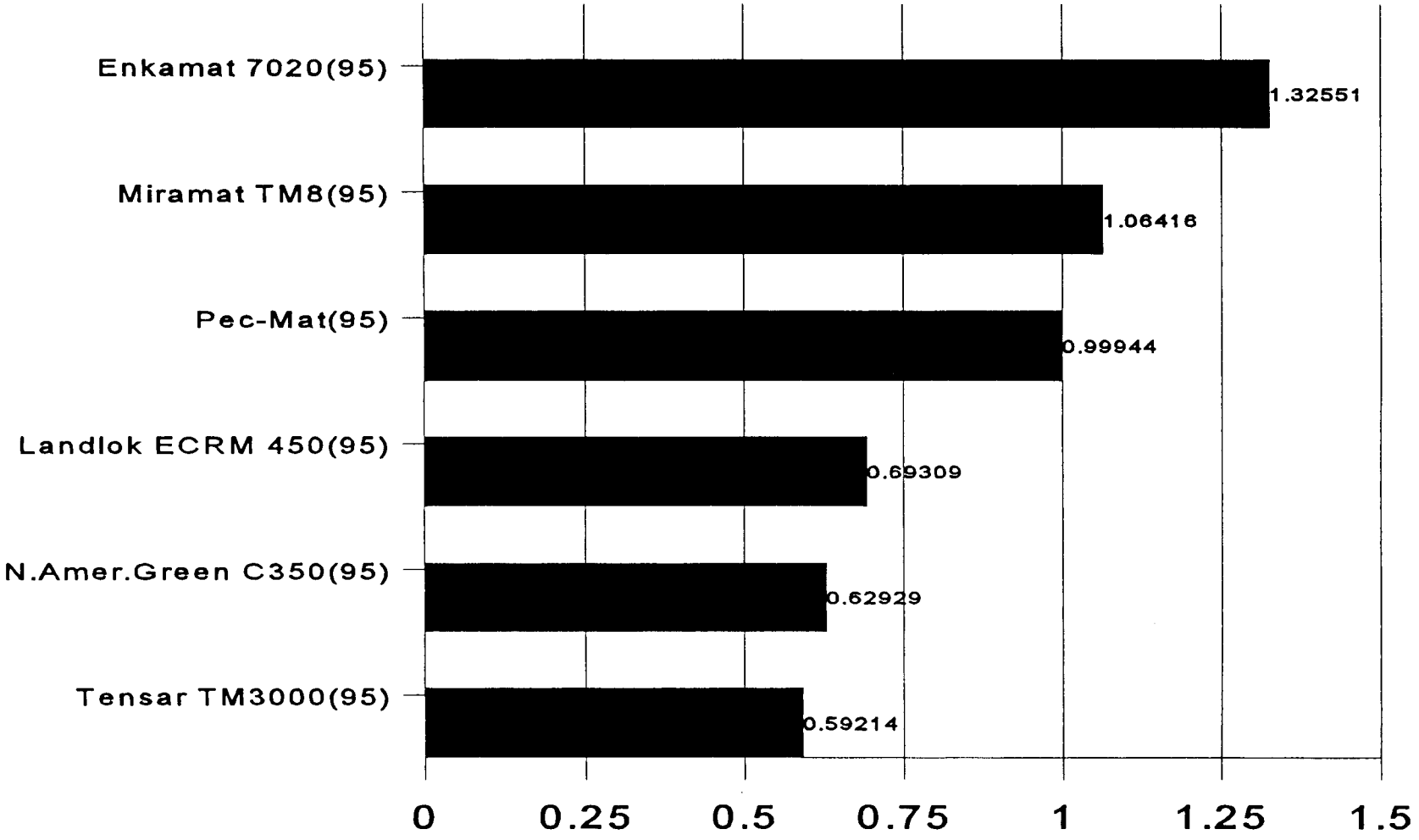
(Shear Stress Range 0 - 383 Pascal)
(0 to 8 Lb/Sq Ft)
(Level Used by TxDOT to Produce Approved Material List)

Final Performance Analysis						
No	**Product Evaluated**	**Year**	**Sediment Loss[1]**	**Sediment Standard**	**Vegetation Density[2]**	**Density Standard**
1	*TENSAR® Erosion Mat TM3000*	1995	0.59214	0.80	92.853%	70%
2	*Geojute® Plus-Regular High Velocity*	1995	Not Tested	0.80	59.490%	70%
3	*North American Green C350™ Three Phase™*	1995	0.62929	0.80	79.982%	70%
4	*LANDLOK® ECRM 450*	1995	0.69309	0.80	78.116%	70%
5	*GREENSTREAK® PEC-MAT™*	1995	0.99944	0.80	71.830%	70%
6	*Miramat® TM8™*	1995	1.06416	0.80	86.574%	70%
7	*Permamat 200F*	1995	Not Tested	0.80	56.954%	70%
8	*Curlex® II (Double Sided)*	1995	Not Tested	0.80	54.664%	70%
9	*Enkamat® 7020*	1995	1.32551	0.80	82.394%	70%

NOTE: Shaded cells (if any) indicate performance which failed to meet currently established minimum performance standards.

1. Expressed as Centimeters (cm) of Channel Deformation
2. Expressed as Percent of Vegetative Cover Achieved by Final Measurement Round

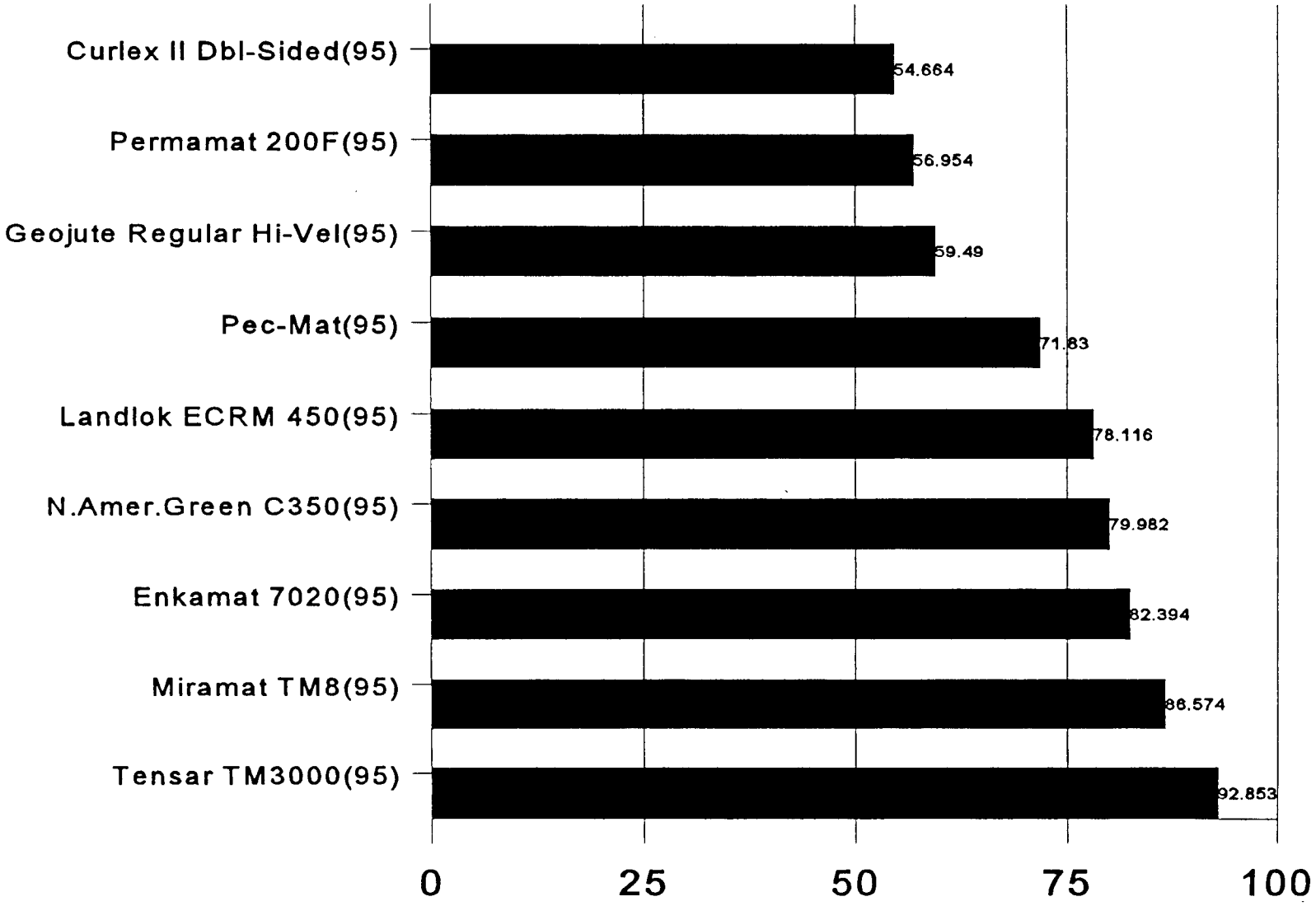
Class 2 - "Flexible Channel Liner" Applications
Average Channel Deformation (Centimeters)
0 -383 Pascal Shear Stress Flows (0 - 8 Lb/Sq Ft)



Class 2 "Flexible Channel Liner" Applications

Final Vegetative Density

Class 2 - "Flexible Channel Liner" Applications
Final Vegetative Density



STATISTICAL ANALYSIS
Class 2 "Flexible Channel Liner" Applications

Soil Displacement
0 - 96 Pascal Shear Stress Flows

Analysis of Variance
Duncan's Multiple Range Test
Confidence Level = 95%

SOIL DISPLACEMENT (CENTIMETERS)
SHEAR STRESS RANGE 0-96 PA

ANALYSIS OF VARIANCE PROCEDURE

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: DEF

NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE, NOT THE EXPERIMENTWISE ERROR RATE

ALPHA= 0.05 DF= 662 MSE= 1.052422
WARNING: CELL SIZES ARE NOT EQUAL.
HARMONIC MEAN OF CELL SIZES= 67.15966

NUMBER OF MEANS	2	3	4	5	6	7	8	9
CRITICAL RANGE	.3476	.3660	.3783	.3874	.3945	.4003	.4051	.4092

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING			MEAN	N	CHANNEL
	A		-0.3541	56	NAG C350(95)
	A				
B	A		-0.4974	111	GEOPLUS HI-V(95)
B	A				
B	A		-0.5611	56	LANDLOK 450(95)
B	A				
B	A		-0.5666	56	TM3000(95)
B	A				
B	A	C	-0.6784	56	MIRAMAT TM8(95)
B		C			
B	D	C	-0.7866	112	CURLEX II(95)
B	D	C			
B	D	C	-0.8648	56	PECMAT(95)
	D	C			
	D	C	-0.9736	56	ENKAMAT 7020(95)
	D				
	D		-1.1487	112	PERMAMAT200F(95)

STATISTICAL ANALYSIS
Class 2 "Flexible Channel Liner" Applications

Soil Displacement
0 - 192 Pascal Shear Stress Flows

ANALYSIS OF VARIANCE PROCEDURE

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: DEF

NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE, NOT THE EXPERIMENTWISE ERROR RATE

ALPHA= 0.05 DF= 1586 MSE= 1.028949
WARNING: CELL SIZES ARE NOT EQUAL.
HARMONIC MEAN OF CELL SIZES= 175.5784

NUMBER OF MEANS	2	3	4	5	6	7	8	9
CRITICAL RANGE	.2124	.2246	.2411	.2367	.2410	.2446	.2476	.2501

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING	MEAN	N	CHANNEL
A	-0.4646	168	NAG C350(95)
A			
B A	-0.5843	168	TM3000(95)
B A			
B A	-0.6113	195	GEOPLUS HI-V(95)
B			
B	-0.7554	168	LANDLOK 450(95)
B			
B	-0.7565	168	PECMAT(95)
B			
B	-0.7871	168	MIRAMAT TM8(95)
C	-1.0671	224	PERMAMAT200F(95)
C			
C	-1.0861	168	ENKAMAT 7020(95)
C			
C	-1.1029	168	CURLEX II(95)

STATISTICAL ANALYSIS
Class 2 "Flexible Channel Liner" Applications

Soil Displacement
0 - 287 Pascal Shear Stress Flows

SOIL DISPLACEMENT (CENTIMETERS)
SHEAR STRESS RANGE 0-287 PA

ANALYSIS OF VARIANCE PROCEDURE

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: DEF

NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE, NOT THE EXPERIMENTWISE ERROR RATE

ALPHA= 0.05 DF= 2286 MSE= 1.298347
WARNING: CELL SIZES ARE NOT EQUAL.
HARMONIC MEAN OF CELL SIZES= 246.728

NUMBER OF MEANS	2	3	4	5	6	7	8	9
CRITICAL RANGE	.2012	.2118	.2190	.2242	.2284	.2317	.2345	.2370

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING	MEAN	N	CHANNEL
A	-0.5930	280	TM3000(95)
A			
B A	-0.6113	195	GEOPLUS HI-V(95)
B A			
B A	-0.6154	280	NAG C350(95)
B A			
B A	-0.7516	280	LANDLOK 450(95)
B			
B C	-0.8296	280	PECMAT(95)
C			
D C	-1.0169	280	MIRAMAT TM8(95)
D			
D E	-1.0950	252	PERMAMAT200F(95)
D E			
D E	-1.1029	168	CURLEX II(95)
E			
E	-1.2780	280	ENKAMAT 7020(95)

STATISTICAL ANALYSIS
Class 2 "Flexible Channel Liner" Applications

Soil Displacement
0 - 383 Pascal Shear Stress Flows

SOIL DISPLACEMENT (CENTIMETERS)
SHEAR STRESS RANGE 0-383 PA

ANALYSIS OF VARIANCE PROCEDURE

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: DEF

NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE, NOT THE EXPERIMENTWISE ERROR RATE

ALPHA= 0.05 DF= 2958 MSE= 1.381532
WARNING: CELL SIZES ARE NOT EQUAL.
HARMONIC MEAN OF CELL SIZES= 296.4919

NUMBER OF MEANS	2	3	4	5	6	7	8	9
CRITICAL RANGE	.1893	.1993	.2060	.2110	.2149	.2180	.2207	.2230

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING	MEAN	N	CHANNEL
A	-0.59214	392	TM3000(95)
A			
A	-0.61128	195	GEOPLUS HI-V(95)
A			
A	-0.62929	392	NAG C350(95)
A			
A	-0.69309	392	LANDLOK 450(95)
B	-0.99944	392	PECMAT(95)
B			
B	-1.06416	392	MIRAMAT TM8(95)
B			
B	-1.09496	252	PERMAMAT200F(95)
B			
B	-1.10286	168	CURLEX II(95)
C	-1.32551	392	ENKAMAT 7020(95)

STATISTICAL ANALYSIS
Class 2 "Flexible Channel Liner" Applications

Final Vegetative Density

ANALYSIS OF VARIANCE PROCEDURE

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: COVER

NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE, NOT THE EXPERIMENTWISE ERROR RATE

ALPHA= 0.05 DF= 315 MSE= 489.9496

NUMBER OF MEANS	2	3	4	5	6	7	8	9
CRITICAL RANGE	10.27	10.81	11.17	11.43	11.64	11.81	11.95	12.08

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING	MEAN	N	CHANNEL
A	92.853	36	TM3000(95)
A			
B A	86.574	36	MIRAMAT TM8(95)
B A			
B A C	82.394	36	ENKAMAT 7020(95)
B C			
B C	79.982	36	NAG C350(95)
B C			
B C	78.116	36	LANDLOK 450(95)
C			
C	71.830	36	PECMAT(95)
D	59.490	36	GEOPLUS HI-V(95)
D			
D	56.954	36	PERMAMAT200F(95)
D			
D	54.664	36	CURLEX II(95)

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APPENDIX A

Standard Specification Item 164
"Seeding for Erosion Control"

Texas Department of Transportation
1995 Standard Specifications
for Construction and Maintenance of
Highways, Streets and Bridges

Water used for preparing the sod for digging and keeping the sod moist from the source until it is planted shall be considered subsidiary to the various pay items involved.

"Fertilizer" will not be paid for directly, but will be considered subsidiary to this Item unless otherwise shown on the plans.

ITEM 164

SEEDING FOR EROSION CONTROL

164.1. Description. This Item shall govern for preparing ground, providing for sowing of seeds, mulching with straw, hay, or cellulose fiber and other management practices on areas shown on the plans and in accordance with this Item.

It includes seeding for permanent erosion control and seeding for temporary erosion control during the initial winter season.

164.2. Materials.

(1) Seed. All seed must meet the requirements of the Texas Seed Law including the labeling requirements for showing pure live seed (PLS = purity x germination), name and type of seed. Seed furnished shall be of the previous season's crop and the date of analysis shown on each bag shall be within nine months of the time of use on the project. Each variety of seed shall be furnished and delivered in separate bags or containers. A sample of each variety of seed shall be furnished for analysis and testing when directed by the Engineer. Buffalograss shall be treated with a dormancy method approved by the Engineer. The species and varieties of seed shall be from among the types specified in Tables 1A and 1B.

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Table 1A. List of Selected Grass Species with Their Scientific and Common Names

Scientific Name	Common Name (Acceptable Varieties)	Season Warm/Cool	Native/ Introduced
Agropyron smithii	Western Wheatgrass	C	N
Andropogon hallii	Sand Bluestem	W	N
Avena sativa	Oats	C	I
Bothriochloa ischaemum	K-R Bluestem	W	I
Bouteloua curtipendula	Sideoats Grama (see seed mix table for appropriate varieties)	W	N
Bouteloua eriopoda	Black Grama	W	N
Bouteloua gracilis	Blue Grama (see seed mix table for appropriate varieties)	W	N
Buchloe dactyloides	Buffalograss	W	N
Cenchrus ciliaris	Buffelgrass	W	I
Chloris guyana	Rhodesgrass	W	I
Cynodon dactylon	Bermudagrass	W	I
Eragrostis trichodes	Sand Lovegrass (see seed mix table for appropriate varieties)	W	N
Festuca arundinaceae	Tall Fescue	C	N
Hordeum vulgare	Barley	C	I

Scientific Name	Common Name (Acceptable Varieties)	Season Warm/Cool	Native/ Introduced
Leptochloa dubia	Green Sprangletop	W	N
Panicum virgatum	Switchgrass (see seed mix table for appropriate varieties)	W	N
Paspalum notatum	Bahiagrass (Pensacola variety)	W	I
Schizachyrium scoparium	Little Bluestem (Texas origin only)	W	N
Setaria italica	Foxtail Millet	W	I
Setaria macrostachya	Plains Bristlegrass	W	N
Sorghastrum avenaceum	Indiangrass (see seed mix table for appropriate varieties)	W	N
Sporobolus cryptandrus	Sand Dropseed	W	N
Triticum aestivum	Wheat (Red, Winter)	C	I

Table 1B. List of Selected Legumes Species with Their Scientific and Common Names

Scientific Name	Common Name	Season Warm/Cool	Native/ Introduced
Trifolium incarnatum	Crimson Clover	C	I
Melilotus officinalis	Yellow Sweetclover	C	I
Vicia villosa	Hairy Vetch	C	I

(2) Fertilizer. Fertilizer shall conform to the requirements of Item 166, "Fertilizer". The fertilizer used shall have the analysis as shown on the plans.

(3) Water. Water shall conform to the requirements of Item 168, "Vegetative Watering".

(4) Mulch.

(a) Straw Mulch or Hay Mulch. Straw mulch shall be oat, wheat or rice straw. Hay mulch shall be prairie grass, bermudagrass or other hay as approved by the Engineer. The straw mulch or hay mulch shall be free of Johnson grass or other noxious weeds and foreign materials. It shall be kept in a dry condition and shall not be molded or rotted.

(b) Cellulose Fiber Mulch. It shall meet the requirements of and be approved by the Director of Construction and Maintenance. A list of pretested and approved materials will be maintained and can be obtained by writing the Director of Construction and Maintenance, 125 East 11th Street, Austin, Texas 78701-2483.

The mulch shall be designed for use in conventional mechanical planting, hydraulic planting of seed or hydraulic mulching of grass seed, either alone or with fertilizers and other additives. The mulch shall be such that, when applied, the material shall form a strong, moisture-retaining mat without the need of an asphalt binder. It shall be kept in a dry condition until applied and shall not be molded or rotted.

(5) Soil Retention Blanket. Soil retention blanket shall meet the requirements of Item 169, "Soil Retention Blanket".

(6) Tacking Agents. Tacking agents for straw or hay mulch shall be SS-1, unless otherwise shown on the plans. A biodegradable tacking agent may be used in lieu of the SS-1 tacking agent when approved by the Engineer. Asphaltic material shall conform to the requirements of Item 300, "Asphalt, Oils and Emulsions".

164.3. Construction Methods. After designated areas have been completed to the lines, grades and cross sections shown on the plans and as provided for in other items of this contract, seeding shall be performed in accordance with the requirements hereinafter described. Unless otherwise approved by the Engineer, all areas to be seeded shall be cultivated to a depth of at least 100 millimeters, except where seeding is to be done using a seed drill suitable for seeding into untilled soil. The seedbeds shall be cultivated sufficiently to reduce the soil to a state of good tilth when the soil particles on the surface are small enough and lie closely enough together to prevent the seed from being covered too deeply for optimum germination.

Cultivation of the seedbed will not be required in loose sand where depth of sand is 100 millimeters or more.

The cross section previously established shall be maintained throughout the process of cultivation. Any necessary reshaping shall be done prior to any planting of seed.

(1) Planting Season and Seed Mixes. All planting shall be done between the dates specified for each highway district except as specifically authorized in writing by the Engineer.

The pure live seed planted per hectare shall be of the type specified in Table 2 for rural areas (warm season), Table 3 for urban areas (warm season), Tables 4A and 4B for temporary erosion control (cool season) and Table 5 for temporary erosion control (warm season), with the mixture, rates and planting dates except as shown on the plans.

Table 2.
Rural Area Species-Specific Warm-Season Seeding Mixtures in Kilograms of Pure Live Seed Per Hectare, by District.

District and Planting Dates *		Mixture for Use in Clay or Tight Soils		Mixture for Use in Sand or Sandy Soils	
1 (Paris)	(Eastern Sections)	(Western Sections)		(All Sections)	
Feb 1 - May 15	Green Sprangletop	1.0	Green Sprangletop	0.8	Green Sprangletop	1.2
	Bermudagrass	1.3	Bermudagrass	1.0	Bermudagrass	1.7
	Little Bluestem	1.9	Little Bluestem	1.6	Bahiagrass	7.5
	Indiangrass (Lometa)	2.6	Indiangrass (Lometa)	2.0	(Pensacola)	
			Switchgrass (Alamo or Blackwell)	1.6		

District and Planting Dates *		Mixture for Use in Clay or Tight Soils		Mixture for Use in Sand or Sandy Soils	
2 (Ft. Worth)	(Eastern Sections)	(Western Sections)		(All Sections)	
Feb 1 - May 1	Green Sprangletop	0.7	Green Sprangletop	0.7	Green Sprangletop	0.8
	Sideoats Grama (El Reno)	2.0	Sideoats Grama (Haskell or El Reno)	2.0	Sideoats Grama (Haskell)	2.5
	Bermudagrass	0.9	Little Bluestem	1.2	Bermudagrass	1.0
	Little Bluestem	1.2	Indiangrass	1.7	Little Bluestem	1.6
	K-R Bluestem	0.8	(Lometa or Cheyenne)		Sand Dropseed	0.2
	Switchgrass (Alamo or Blackwell)	1.3	K-R Bluestem	0.8		
			Switchgrass (Alamo or Blackwell)	1.3		
3 (Wichita Falls)	(Eastern Sections)	(Western Sections, i.e., Clay Co. West)		(All Sections)	
Feb 1 - May 1	Green Sprangletop	0.8	Green Sprangletop	0.8	Green Sprangletop	0.7
**	Sideoats Grama (El Reno)	2.5	Sideoats Grama (El Reno)	2.5	Sideoats Grama (El Reno)	2.0
***	Bermudagrass	1.0	Blue Grama	0.7	Bermudagrass	0.9
	Buffalograss	7.2	(Lovington)		Little Bluestem	1.2
	Western Wheatgr.	3.1	Buffalograss	7.2	Sand Dropseed	0.2
			Western Wheatgr.	3.1	Sand Bluestem	0.2
4 (Amarillo)	(All Sections)				(All Sections)	
Feb 15 - May 15	Green Sprangletop	1.0			Green Sprangletop	0.8
	Sideoats Grama (El Reno)	3.1			Sideoats Grama (El Reno)	2.5
***	Blue Grama (Lovington)	0.9			Blue Grama (Lovington)	0.7
	Buffalograss	9.0			Sand Dropseed	0.2
					Sand Bluestem	0.2

District and Planting Dates *		Mixture for Use in Clay or Tight Soils		Mixture for Use in Sand or Sandy Soils	
5 (Lubbock)	(E. of IH 27)	(W. of IH 27)		(All Sections)	
Feb 15 - May 15 ***	Green Sprangletop	Green Sprangletop	1.0	Green Sprangletop	0.8
	Sideoats Grama (El Reno)	Sideoats Grama (Coronado)	3.1	Sideoats Grama (Coronado)	2.5
	Blue Grama (Lovington)	Blue Grama (Lovington)	0.9	Blue Grama (Lovington)	0.7
	Buffalograss	Buffalograss	9.0	Sand Dropseed	0.2
				Sand Bluestem	0.2
6 (Odessa)	(N. of Pecos River)	(S. of Pecos River)		(All Sections)	
Feb 1 - May 15	Green Sprangletop	Green Sprangletop	1.0	Green Sprangletop	0.7
	Sideoats Grama (Premier or Uvalde)	Sideoats Grama (Premier or Tucson)	3.1	Black Grama	0.3
	Black Grama	Black Grama	0.6	Blue Grama (Hachita)	0.6
	Blue Grama (Hachita)	Blue Grama	0.9	Little Bluestem	1.2
	Little Bluestem			Sand Dropseed	0.2
				Sand Bluestem	0.2
7 (San Angelo)	(All Sections)			(All Sections)	
Feb 1 - May 1	Green Sprangletop			Green Sprangletop	0.8
	Sideoats Grama (Haskell)			Sideoats Grama (Haskell)	2.5
	Buffalograss			Little Bluestem	1.6
	Little Bluestem			K-R Bluestem	0.9
	K-R Bluestem			Sand Dropseed	0.2
8 (Abilene)	(N., W., E. of and including Fisher Co.)	(S. of Fisher Co.)		(All Sections)	
Feb 1 - May 15 ***	Green Sprangletop	Green Sprangletop	1.0	Green Sprangletop	0.8
	Sideoats Grama (Haskell)	Sideoats Grama (Haskell)	3.1	Sideoats Grama (Haskell)	2.5
	Buffalograss	Buffalograss	9.0	K-R Bluestem	0.9
	Blue Grama (Hachita)	Little Bluestem	1.9	Sand Dropseed	0.2
				Sand Bluestem	0.2

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District and Planting Dates *		Mixture for Use in Clay or Tight Soils		Mixture for Use in Sand or Sandy Soils	
9 (Waco)	(E. of IH 35)	(W. of IH 35)		(All Sections)	
Feb 1 - May 15	Green Sprangletop	Green Sprangletop	0.7	Green Sprangletop	1.0
	Bermudagrass	Sideoats Grama (Haskell or Premier)	2.0	Bermudagrass	1.3
	Little Bluestem	Buffalograss	5.9	K-R Bluestem	1.1
	Indiangrass (Lometa)	Little Bluestem	1.2	Sand Dropseed	0.3
	K-R Bluestem	K-R Bluestem	0.8		
	Switchgrass (Alamo)	Switchgrass (Alamo)	1.3		
10 (Tyler)	(All Sections)			(All Sections)	
Feb 1 - May 15	Green Sprangletop			Green Sprangletop	1.9
	Bermudagrass			Bermudagrass	2.6
	Little Bluestem				
	Indiangrass (Lometa)				
	Switchgrass (Alamo)				
11 (Lufkin)	(All Sections)			(All Sections)	
Feb 15 - May 15	Green Sprangletop			Green Sprangletop	1.9
	Bermudagrass			Bermudagrass	2.6
	Little Bluestem				
	Indiangrass (Lometa)				
	Switchgrass (Alamo)				

District and Planting Dates *			Mixture for Use in Clay or Tight Soils		Mixture for Use in Sand or Sandy Soils	
12 (Houston)	(All Sections)				(All Sections)	
Jan 15 - May 15	Green Sprangletop	0.7			Green Sprangletop	1.0
	Bermudagrass	0.9			Bermudagrass	1.3
	Little Bluestem	1.2			Bahiagrass	5.6
	Indiangrass	1.7			(Pensacola)	
	(Lometa)				K-R Bluestem	1.1
	K-R Bluestem	0.8				
	Switchgrass	1.3				
	(Alamo)					
13 (Yoakum)	(Wharton and Matagorda Cos.)		(All Other Sections)		(All Sections)	
Jan 15 - May 15	Green Sprangletop	1.0	Green Sprangletop	0.7	Green Sprangletop	0.8
	Bermudagrass	1.3	Bermudagrass	0.9	Bermudagrass	1.0
	Little Bluestem	1.9	Little Bluestem	1.2	Bahiagrass	4.5
	K-R Bluestem	1.1	Indiangrass	1.7	(Pensacola)	
			(Lometa)		Little Bluestem	1.6
			K-R Bluestem	0.8	K-R Bluestem	0.9
			Switchgrass	1.3		
			(Alamo)			
14 (Austin)	(E. of IH 35)		(W. of IH 35)		(All Sections)	
Feb 1 - May 15	Green Sprangletop	0.7	Green Sprangletop	0.7	Green Sprangletop	1.0
	Bermudagrass	0.9	Little Bluestem	1.2	Bermudagrass	1.3
	Little Bluestem	1.2	Indiangrass	1.7	Sand Lovegrass	0.9
	Indiangrass	1.7	(Lometa)		K-R Bluestem	1.1
	(Lometa)		Buffalograss	5.9		
	Buffalograss	5.9	Sideoats Grama	2.0		
	Sideoats Grama	2.0	(Haskell or Uvalde)			
	(Haskell or Uvalde)		Switchgrass	1.3		
			(Alamo)			

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District and Planting Dates *			Mixture for Use in Clay or Tight Soils		Mixture for Use in Sand or Sandy Soils	
15 (San Antonio)	(Uvalde, Frio, and Atascosa Cos., N.E.)		(Zavala, LaSalle, and McMullen Cos., S.W.)		(All Sections)	
Feb 1 - May 1	Green Sprangletop	0.7	Green Sprangletop	0.7	Green Sprangletop	1.0
	Sideoats Grama	2.0	Sideoats Grama	2.0	Bermudagrass	1.3
	(Haskell or Uvalde)		(Haskell or Uvalde)		Buffelgrass	2.2
	Little Bluestem	1.2	Buffalograss	5.9	K-R Bluestem	1.1
	Bermudagrass	0.9	Plains Bristlegr.	1.1		
	Buffalograss	5.9	K-R Bluestem	0.8		
	K-R Bluestem	0.8	Bermudagrass	0.9		
16 (Corpus Christi)	(E. of U.S. 77)		(W. of U.S. 77)		(All Sections)	
	Green Sprangletop	0.8	Green Sprangletop	0.8	Green Sprangletop	1.0
Jan 15 - May 1	Bermudagrass	1.0	Rhodesgrass	0.5	Bermudagrass	1.3
	Sideoats Grama	2.5	Plains Bristlegr.	1.3	Buffelgrass	2.2
	(Haskell or Uvalde)		Buffalograss	7.2	K-R Bluestem	1.1
	Little Bluestem	1.6	K-R Bluestem	0.9		
	K-R Bluestem	0.9				
17 (Bryan)	(All Sections)				(All Sections)	
Feb 1 - May 15	Green Sprangletop	0.7			Green Sprangletop	1.2
	Bermudagrass	0.9			Bermudagrass	1.7
	Little Bluestem	1.2			Bahiagrass	7.5
	Indiangrass	1.7			(Pensacola)	
	(Lometa)					
	K-R Bluestem	0.8				
	Switchgrass	1.3				
	(Alamo)					

District and Planting Dates *			Mixture for Use in Clay or Tight Soils		Mixture for Use in Sand or Sandy Soils	
18	(E. of U.S. 75)		(W. of U.S. 75)		(All Sections)	
(Dallas)						
Feb 1 -	Green Sprangletop	0.7	Green Sprangletop	0.8	Green Sprangletop	1.2
May 1	Bermudagrass	0.9	Bermudagrass	1.0	Bermudagrass	1.7
	Little Bluestem	1.2	Sideoats Grama	2.5	Sand Dropseed	0.5
	Indiangrass	1.7	(El Reno)			
	(Lometa or Cheyenne)		Little Bluestem	1.6		
	Buffalograss	5.9	Indiangrass	2.0		
	Switchgrass	1.3	(Lometa or Cheyenne)			
	(Alamo or Blackwell)					
19	(All Sections)				(All Sections)	
(Atlanta)						
Feb 1 -	Green Sprangletop	0.7			Green Sprangletop	1.2
May 15	Bermudagrass	0.9			Bermudagrass	1.7
	Little Bluestem	1.2			Bahiagrass	7.5
	Indiangrass	1.7			(Pensacola)	
	(Lometa or Cheyenne)					
	Switchgrass	1.3				
	(Alamo)					
	Bahiagrass	3.7				
	(Pensacola)					
20	(All Sections)				(All Sections)	
(Beaumont)						
Jan 15 -	Green Sprangletop	0.8			Green Sprangletop	1.2
May 15	Bermudagrass	1.0			Bermudagrass	1.7
	Little Bluestem	1.6			Bahiagrass	7.5
	Indiangrass	2.0			(Pensacola)	
	(Lometa)					
	Switchgrass	1.6				
	(Alamo)					
21	(All Sections)				(All Sections)	
(Pharr)						
Jan 15 -	Green Sprangletop	0.8			Green Sprangletop	0.8
May 1	Rhodesgrass	0.5			Bermudagrass	1.0
	Plains Bristlegr.	1.3			Rhodesgrass	0.5
	Buffalograss	7.2			Buffelgrass	1.3
	K-R Bluestem	0.9			Sand Dropseed	0.2

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District and Planting Dates *			Mixture for Use in Clay or Tight Soils		Mixture for Use in Sand or Sandy Soils	
22			(Val Verde Co.)		(All Sections)	
(Laredo)						
Jan 15 -	Green Sprangletop	0.8	Green Sprangletop	1.4	Green Sprangletop	0.8
May 1	Rhodesgrass	0.5	Sideoats Grama	2.7	Bermudagrass	1.0
	Plains Bristlegr.	1.3	K-R Bluestem	1.1	Rhodesgrass	0.5
	Buffalograss	7.2	Buffalograss	9.0	Buffelgrass	1.3
	K-R Bluestem	0.9			Sand Dropseed	0.2
23	(All Sections)				(All Sections)	
(Brownwood)						
Feb 1 -	Green Sprangletop	0.8			Green Sprangletop	0.7
May 15	Little Bluestem	1.6			Little Bluestem	1.2
	Sideoats Grama	2.5			Sideoats Grama	2.0
	(Haskell)				(Haskell)	
	Buffalograss	7.2			Bermudagrass	0.9
	K-R Bluestem	0.9			Sand Lovegrass	0.6
					Sand Dropseed	0.2
24	(All Sections)				(All Sections)	
(El Paso)						
Feb 1 -	Green Sprangletop	0.8			Green Sprangletop	1.0
May 1	Black Grama	0.5			Black Grama	0.6
****	Blue Grama	0.7			Blue Grama	0.9
	(Hachita)				(Hachita)	
	Sideoats Grama	2.5			Sand Dropseed	0.3
	(Tucson)					
	Sand Dropseed	0.2				
25	(All Sections)				(All Sections)	
(Childress)						
Feb 1 -	Green Sprangletop	0.8			Green Sprangletop	0.8
May 15	Sideoats Grama	2.5			Sideoats Grama	2.5
**	(El Reno)				(El Reno)	
	Blue Grama	0.7			Blue Grama	0.7
	(Lovington)				(Lovington)	
	Buffalograss	7.2			Little Bluestem	1.6
	Western Wheatgr.	3.1			Sand Dropseed	0.2

* Planting dates are optima.

** In the seed mix, Western Wheatgrass must be sown between September 1 and February 28.

*** In the seed mix, use Woodward variety of Sand Bluestem in the Rolling Plains (including the Canadian River Valley), and Elida variety of Sand Bluestem in the High Plains.

**** In the seed mix, substitute Premier variety of Sideoats Grama in E. Brewster Co.

Table 3.
Urban Area Species-Specific Warm-Season Seeding Mixtures in Kilograms of Pure Live Seed Per Hectare, by District.

District and Planting Dates *	Mixture for Use in Clay or Tight Soils		Mixture for Use in Sand or Sandy Soils	
1 (All Sections) (Paris)			(All Sections)	
Feb 1 - May 15	Green Sprangletop	1.9	Green Sprangletop	1.9
	Bermudagrass	2.6	Bermudagrass	2.6
2 (Eastern Sections) (Ft. Worth)	(Western Sections)		(All Sections)	
Feb 1 - May 1	Green Sprangletop	1.0	Green Sprangletop	1.2	Green Sprangletop	1.2
	K-R Bluestem	1.1	K-R Bluestem	1.5	K-R Bluestem	1.5
	Bermudagrass	1.3	Buffalograss	12.0	Bermudagrass	1.7
	Buffalograss	9.0				
3 (Eastern Sections) (Wichita Falls)	(Western Sections)		(All Sections)	
	Green Sprangletop	1.2	Green Sprangletop	1.0	Green Sprangletop	1.2
Feb 1 - May 1 **	Bermudagrass	1.7	Sideoats Grama (El Reno)	3.1	Bermudagrass	1.7
	Buffalograss	12.0			Sand Dropseed	0.5
			Western Wheatgr.	3.9		
			Buffalograss	9.0		

District and Planting Dates *	Mixture for Use in Clay or Tight Soils		Mixture for Use in Sand or Sandy Soils	
4 (All Sections) (Amarillo)			(All Sections)	
Feb 15 - May 15	Green Sprangletop	1.0	Green Sprangletop	1.0
	Sideoats Grama (El Reno)	3.1	Sideoats Grama (El Reno)	3.1
	Blue Grama (Lovington)	0.9	Blue Grama (Lovington)	0.9
	Buffalograss	9.0	Sand Dropseed	0.4
5 (All Sections) (Lubbock)			(All Sections)	
Feb 15 - May 15	Green Sprangletop	1.0	Green Sprangletop	1.0
	Sideoats Grama (El Reno)	3.1	Sideoats Grama (Coronado)	3.1
	Blue Grama (Lovington)	0.9	Blue Grama (Lovington)	0.9
	Buffalograss	9.0	Sand Dropseed	0.4
6 (All Sections) (Odessa)			(All Sections)	
Feb 1 - May 15	Green Sprangletop	1.0	Green Sprangletop	1.0
	Black Grama	0.6	Black Grama	0.6
***	Blue Grama (Hachita)	0.9	Blue Grama (Hachita)	0.9
	Sideoats Grama	3.1	Sand Dropseed	0.3
7 (All Sections) (San Angelo)			(All Sections)	
Feb 1 - May 1	Green Sprangletop	1.0	Green Sprangletop	1.0
	Buffalograss	9.0	K-R Bluestem	1.1
	K-R Bluestem	1.1	Sand Dropseed	0.3
	Sideoats Grama (Haskell)	3.1	Sideoats Grama (Haskell)	3.1

District and Planting Dates *			Mixture for Use in Clay or Tight Soils		Mixture for Use in Sand or Sandy Soils	
8 (Abilene)	(All Sections)				(All Sections)	
Feb 1 - May 15	Green Sprangletop	0.8			Green Sprangletop	1.0
	Buffalograss	7.2			Sand Dropseed	0.3
	Sideoats Grama (Haskell)	2.5			Sideoats Grama (Haskell)	3.1
	K-R Bluestem	0.9			K-R Bluestem	1.1
	Blue Grama (Hachita)	0.7				
9 (Waco)	(E. of IH 35)		(W. of IH 35)		(All Sections)	
Feb 1 - May 15	Green Sprangletop	1.0	Green Sprangletop	1.0	Green Sprangletop	0.8
	Bermudagrass	1.3	Sideoats Grama (Premier or Haskell)	3.1	Bermudagrass	1.0
	K-R Bluestem	1.1	K-R Bluestem	1.1	Sideoats Grama (Premier or Haskell)	2.5
	Buffalograss	9.0	Buffalograss	9.0	K-R Bluestem	0.9
					Sand Dropseed	0.2
10 (Tyler)	(All Sections)				(All Sections)	
Feb 1 - May 15	Green Sprangletop	1.9			Green Sprangletop	1.9
	Bermudagrass	2.6			Bermudagrass	2.6
11 (Lufkin)	(All Sections)				(All Sections)	
Feb 1 - May 15	Green Sprangletop	1.9			Green Sprangletop	1.9
	Bermudagrass	2.6			Bermudagrass	2.6
12 (Houston)	(All Sections)				(All Sections)	
Jan 15 - May 15	Green Sprangletop	1.2			Green Sprangletop	1.2
	Bermudagrass	1.7			Bermudagrass	1.7
	K-R Bluestem	1.5			K-R Bluestem	1.5
13 (Yoakum)	(All Sections)				(All Sections)	
Jan 15 - May 15	Green Sprangletop	1.2			Green Sprangletop	1.2
	Bermudagrass	1.7			Bermudagrass	1.7
	K-R Bluestem	1.5			K-R Bluestem	1.5

District and Planting Dates *			Mixture for Use in Clay or Tight Soils		Mixture for Use in Sand or Sandy Soils	
14 (Austin)	(E. of IH 35)		(W. of IH 35)		(All Sections)	
Feb 1 - May 15	Green Sprangletop	1.0	Green Sprangletop	1.0	Green Sprangletop	1.0
	Bermudagrass	1.3	Buffalograss	9.0	K-R Bluestem	1.1
	Buffalograss	9.0	K-R Bluestem	1.1	Bermudagrass	1.3
	Sideoats Grama (Haskell)	3.1	Sideoats Grama (Haskell or Uvalde)	3.1	Sand Lovegrass	0.9
15 (San Antonio)	(E. of U.S. 281)		(W. of U.S. 281)		(All Sections)	
Feb 1 - May 1	Green Sprangletop	1.2	Green Sprangletop	1.0	Green Sprangletop	1.2
	Buffalograss	12.0	Sideoats Grama (Haskell or Uvalde)	3.1	Bermudagrass	1.7
	Bermudagrass	1.7	Buffalograss	9.0	Sideoats Grama (Haskell or Uvalde)	4.1
			Bermudagrass	1.3		
16 (Corpus Christi)	(E. of U.S. 77)		(W. of U.S. 77)		(All Sections)	
Jan 15 - May 1	Green Sprangletop	1.2	Green Sprangletop	1.0	Green Sprangletop	1.0
	Bermudagrass	1.7	K-R Bluestem	1.1	Bermudagrass	1.3
	K-R Bluestem	1.5	Buffalograss	9.0	K-R Bluestem	1.1
			Bermudagrass	1.3	Sand Dropseed	0.3
17 (Bryan)	(All Sections)				(All Sections)	
Feb 1 - May 15	Green Sprangletop	1.2			Green Sprangletop	1.2
	Bermudagrass	1.7			Bermudagrass	1.7
	K-R Bluestem	1.5			K-R Bluestem	1.5
18 (Dallas)	(All Sections)				(All Sections)	
Feb 1 - May 1	Green Sprangletop	1.2			Green Sprangletop	1.2
	Bermudagrass	1.7			Bermudagrass	1.7
	Buffalograss	12.0			Sand Dropseed	0.5
19 (Atlanta)	(All Sections)				(All Sections)	
Feb 1 - May 15	Green Sprangletop	1.9			Green Sprangletop	1.9
	Bermudagrass	2.6			Bermudagrass	2.6

District and Planting Dates *		Mixture for Use in Clay or Tight Soils		Mixture for Use in Sand or Sandy Soils	
20	(All Sections)			(All Sections)	
(Beaumont)					
Jan 15 -	Green Sprangletop	1.7		Green Sprangletop	1.7
May 15	Bermudagrass	1.3		Bermudagrass	1.3
21	(E. of U.S. 281)		(W. of U.S. 281)	(All Sections)	
(Pharr)					
Jan 15 -	Green Sprangletop	1.0	Green Sprangletop	1.0	Green Sprangletop	1.0
May 1	Bermudagrass	1.3	Sideoats Grama	3.1	Bermudagrass	1.3
	K-R Bluestem	1.1	(Premier or Uvalde)		K-R Bluestem	1.1
	Buffalograss	9.0	K-R Bluestem	1.1	Sand Dropseed	0.3
			Buffalograss	9.0		
22			(Val Verde Co.)		(All Sections)	
(Laredo)						
Jan 15 -	Green Sprangletop	1.0	Green Sprangletop	1.0	Green Sprangletop	1.0
May 1	Sideoats Grama	3.1	Sideoats Grama	3.1	Bermudagrass	1.3
	(Premier or Uvalde)		(Haskell or Uvalde)		K-R Bluestem	1.1
	K-R Bluestem	1.1	Buffalograss	9.0	Sand Dropseed	0.3
	Buffalograss	9.0	Bermudagrass	1.3		
23	(All Sections)				(All Sections)	
(Brownwood)						
Feb 1 -	Green Sprangletop	0.8			Green Sprangletop	0.8
May 15	Buffalograss	7.2			K-R Bluestem	0.9
	K-R Bluestem	0.9			Bermudagrass	1.0
	Sideoats Grama	2.5			Sideoats Grama	2.5
	(Haskell)				(Haskell)	
	Bermudagrass	1.0			Sand Dropseed	0.2
24	(All Sections)				(All Sections)	
(El Paso)						
Feb 1 -	Green Sprangletop	0.8			Green Sprangletop	1.0
May 1	Black Grama	0.5			Black Grama	0.6
****	Blue Grama	0.7			Blue Grama	0.9
	Sideoats Grama	2.5			Sand Dropseed	0.3
	(Tucson)					
	Sand Dropseed	0.2				

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District and Planting Dates *		Mixture for Use in Clay or Tight Soils	Mixture for Use in Sand or Sandy Soils	
25	(All Sections)		(All Sections)	
(Childress)				
Feb 1 -	Green Sprangletop	0.8	Green Sprangletop	0.8
May 15	Sideoats Grama	2.5	Sideoats Grama	2.5
**	(El Reno)		(El Reno)	
	Blue Grama	0.7	Blue Grama	0.7
	(Lovington)		(Lovington)	
	Western Wheatgr.	3.1	Western Wheatgr.	3.1
	Buffalograss	7.2	Sand Dropseed	0.2

* Planting dates are optima.

** In the seed mix, Western Wheatgrass must be sown between September 1 and February 28.

*** North of Pecos River use either Premier or Uvalde varieties of Sideoats Grama in the seed mix. South of the Pecos River use either Premier or Tucson varieties in the seed mix.

**** In the seed mix, substitute Premier variety of Sideoats Grama in E. Brewster County.

(2) Broadcast Seeding. The seed or seed mixture, in the quantity specified, shall be uniformly distributed over the areas shown on the plans or where directed by the Engineer. If the sowing of seed is by hand, rather than by mechanical methods, the seed shall be sown in two directions at right angles to each other. If mechanical equipment is used, all varieties of seed as well as fertilizer, may be distributed simultaneously provided that each component is uniformly applied at the specified rate. When seed and fertilizer are to be distributed as a water slurry, the mixture shall be applied to the area to be seeded within 30 minutes after components are placed in the equipment. After planting, the planted area shall be rolled with a light corrugated drum roller or another type of roller approved by the Engineer. All rolling of the sloped areas shall be along the contour of the slopes.

(3) Straw or Hay Mulch Seeding. The seed or seed mixture, in the quantity specified, shall be uniformly distributed over the areas shown on the plans or where directed by the Engineer. If the sowing of seed is by hand, rather than by mechanical methods, the seed shall be sown in two directions at right angles to each other. If mechanical equipment is used, all varieties of seed, as well as fertilizer, may be distributed simultaneously

provided that each component is uniformly applied at the specified rate. When seed and fertilizer are to be distributed as a water slurry, the mixture shall be applied to the area to be seeded within 30 minutes after all components are placed in the equipment

Immediately upon completion of planting of the seed, straw or hay mulch shall be spread uniformly over the seeded area at the rate of approximately 3.4 to 4.5 megagrams of hay mulch or 4.5 to 5.6 megagrams of straw mulch per hectare. When a mulching machine is used it must be approved by the Engineer and may be equipped to inject a tacking agent into the straw or hay mulch uniformly as it leaves the equipment at a rate of 0.25 to 0.5 liter of tacking agent per square meter of mulched area. When the tacking agent is placed by hand, then the rate of application for the tacking agent shall be approximately 0.7 liter per square meter.

(4) Cellulose Fiber Mulch Seeding. The seed or seed mixture, in the quantity specified, shall be uniformly distributed over the areas shown on the plans or where directed by the Engineer. If the sowing of seed is by hand, rather than by mechanical methods, the seed shall be sown in two directions at right angles to each other. If mechanical equipment is used all varieties of seed, as well as fertilizer, may be distributed simultaneously, provided that each component is uniformly applied at the specified rate. When seed and fertilizer are to be distributed as a water slurry, the mixture shall be applied to that area to be seeded within 30 minutes after all components are placed in the equipment.

Immediately upon completion of planting of the seed, cellulose fiber mulch shall be spread uniformly over the seeded area at the following rates:

Sandy soils with 1:3 slope or less - min. 2.3 Mg/ha
Sandy soils with greater than 1:3 slope - min. 2.6 Mg/ha
Clay soils with 1:3 slope or less - min. 2.8 Mg/ha
Clay soils with greater than 1:3 slope - min. 3.4 Mg/ha

Cellulose fiber mulch rates are based on dry mass of mulch per hectare. When used, a mulching machine, approved by the Engineer, shall be equipped to eject the thoroughly wet mulch material at a uniform rate to provide the mulch coverage specified.

(5) Drill Seeding. The seed or seed mixture, in the quantity specified, shall be uniformly distributed over the areas shown on the plans or where directed by the Engineer. All varieties of seed, as well as fertilizer, may be distributed simultaneously provided that each component

is uniformly applied at the specified rate. Seed shall be drilled at a depth of from five (5) to ten (10) millimeters utilizing a pasture or rangeland type drill. All drilling shall be along the contour of the slope. After planting, the area shall be rolled with a roller integral to the seed drill, or a light corrugated drum roller or with another type of roller approved by the Engineer. All rolling of sloped areas shall be on the contour of the slopes.

(6) Straw or Hay Mulching. Mulch shall be spread uniformly over the area indicated on plans or as designated by the Engineer at the rate of approximately 3.4 to 4.5 megagrams of hay mulch or 4.5 to 5.6 megagrams of straw mulch per hectare. When used, a mulching machine approved by the Engineer shall be equipped to inject a tacking agent into the straw or hay mulch uniformly as it leaves the equipment at a rate of 0.25 to 0.5 liter of tacking agent per square meter of mulched area. If the straw or hay mulch and tacking agent are placed by hand, then the rate of application for the tacking agent shall be approximately 0.7 liter per square meter.

(7) Soil Retention Blanket. If specified on the plans, a soil retention blanket shall be applied in accordance with Item 169, "Soil Retention Blanket".

(8) Watering. Watering of the seeded area shall be conducted when, in the judgement of the Engineer, sufficient seedling survival is threatened by insufficient natural precipitation and shall be in accordance with Item 168, "Vegetative Watering".

(9) Fertilizer. Fertilizer, when required, shall be applied in accordance with Item 166, "Fertilizer".

164.4. Seeding for Cool Season Temporary Erosion Control.

(1) Standard Seeding. When specified on the plans or directed by the Engineer, temporary erosion control measures shall be performed. These measures shall consist of the sowing of seed mixtures appropriate for the season and the work and materials as required in Article 164.3. These measures shall be performed over the areas shown on the plans or where directed by the Engineer. Temporary erosion control measures shall be performed in addition to other "Seeding for Erosion Control" as herein specified. The pure live seed, of the cool season plants, planted per hectare shall be of the type specified, with the mixture, rate and planting dates as follows in Tables 4A and 4B, except as shown on the plans.

Table 4A.
Cool Season Grass Seeding Mixtures for Temporary Erosion Control, in Kilograms of Pure Live Seed per Hectare, by District.

Districts & Optimum Planting Dates	Common Name	Rate
Paris (1), Fort Worth (2), Wichita Falls (3), Amarillo (4), Lubbock (5), Abilene (8), Dallas (18), Brownwood (23), Childress (25) August 15 - November 30	Tall Fescue	4.5
	Western Wheatgrass	5.6
	Wheat (Red, Winter)	33.6
Odessa (6), San Angelo (7), El Paso (24) August 15 - November 30	Western Wheatgrass	8.4
	Wheat (Red, Winter)	50.4
Waco (9), Tyler (10), Lufkin (11), Austin (14), San Antonio (15), Bryan (17), Atlanta (19) September 1 - November 30	Tall Fescue	4.5
	Oats	23.5*
	Wheat (Red, Winter)	33.6
Houston (12), Yoakum (13), Corpus Christi (16), Beaumont (20), Pharr (21), Laredo (22) September 1 - November 30	Oats	71.7*

* May substitute Barley at 80.6 kg/ha divided by the number of species in the mix.

(2) **Legume Seeding.** When specified on the plans or directed by the Engineer, the following regionally adapted legumes shall be planted.

Table 4B.
Cool Season Legume Seeding for Temporary Erosion Control, in Kilograms of Pure Live Seed per Hectare, by District.

Districts & Optimum Planting Dates	Common Name	Rate
Paris (1), Fort Worth (2), Wichita Falls (3), Waco (9), Tyler (10), Lufkin (11), Houston (12), Bryan (17), Dallas (18), Atlanta (19), Beaumont (20) August 15 - November 30	Crimson Clover	7.8
Yoakum (13), Austin (14), San Antonio (15), Corpus Christi (16), Pharr (21), Laredo (22) September 1 - November 30	Hairy Vetch	9.0
Amarillo (4), Lubbock (5), Odessa (6), San Angelo (7), Abilene (8), Brownwood (23), El Paso (24), Childress (25) August 15 - November 30	Yellow Sweetclover	4.5

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164.5. Seeding for Warm Season Temporary Erosion Control.

(1) **Standard Seeding.** When specified on the plans or directed by the Engineer, temporary erosion control measures shall be performed. This measure shall consist of the sowing of seed appropriate for the season and the work and materials as required in Article 164.3. These measures shall be performed over the areas shown on the plans or where directed by the Engineer. Temporary erosion control measures shall be performed in addition to other "Seeding for Erosion Control" as herein specified. The pure live seed planted per hectare shall be of the type specified, rate and seed planting date as follows in Table 5 except as shown on the plans.

Table 5.
Warm Season Seeding for Temporary Erosion Control, in Kilograms of Pure Live Seed per Hectare, by District.

Districts & Optimum Planting Dates	Common Name	Rate
Fort Worth (2), Wichita Falls (3), San Angelo (7), San Antonio (15), Corpus Christi (16), Dallas (18), Pharr (21), Laredo (22), El Paso (24) May 1 - August 31	Foxtail Millet	33.6
Paris (1), Amarillo (4), Lubbock (5), Odessa (6), Abilene (8), Waco (9), Tyler (10), Lufkin (11), Houston (12), Yoakum (13), Austin (14), Bryan (17), Atlanta (19), Beaumont (20), Brownwood (23), Childress (25) May 15 - August 31	Foxtail Millet	33.6

164.6. Measurement. "Straw or Hay Mulch" will be measured by the square meter or by the hectare, complete and in place.

All "Seeding", of the type specified, will be measured by the square meter or by the hectare, complete and in place.

164.7. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Broadcast Seeding", "Straw or Hay Mulch Seeding", "Cellulose Fiber Mulch Seeding", "Drill Seeding", "Straw or Hay Mulching", "Standard Seeding for Cool Season Temporary Erosion Control", "Legume Seeding for Temporary Erosion Control" or "Standard Seeding for Warm Season Temporary Erosion Control", of the common names specified. This price will be full compensation for furnishing all materials, including water for seed-fertilizer slurry and

hydraulic mulching, tacking agents if required, and for performing all operations necessary to complete the work.

Unless otherwise shown on the plans, fertilizer will not be paid for directly, but will be considered subsidiary work pertaining to this Item.

"Soil Retention Blanket" will be paid for under Item 169, "Soil Retention Blanket".

Water for irrigating the cultivated area or seedbed, when required, will be paid for under Item 168, "Vegetative Watering".

ITEM 166

FERTILIZER

166.1. Description. This Item shall govern for providing and distributing fertilizer over such areas as designated on the plans and in accordance with these specifications.

166.2. Materials. All fertilizer shall be delivered in bags or containers clearly labeled showing the analysis. The figures in the analysis represent the percent of nitrogen, phosphoric acid, and potash nutrients, respectively, as determined by the methods of the Association of Official Analytical Chemists. The fertilizer is subject to testing by the Texas A&M Feed and Fertilizer Control Service in accordance with the Texas Fertilizer Law.

The fertilizer shall have the analysis shown on the plans. The Contractor shall have the option of providing a fertilizer of a different analysis, if approved by the Engineer. However, the amount of each nutrient specified shall not be less than that shown on the plans.

166.3. Construction Methods. Fertilizer shall be in an acceptable condition for distribution and shall be applied uniformly over the specified area and at the rate shown on the plans. Distribution of fertilizer for the particular item of work shall be approved by the Engineer.

166.4. Measurement. When Fertilizer is specified on the plans to be a pay item, work and acceptable material for "Fertilizer" will be measured by the megagram as determined by approved scales or guaranteed mass of bags or containers as shown by the manufacturer.

166.5. Payment. Unless otherwise specified on the plans, the work performed and materials furnished in accordance with this Item will not be paid for directly but will be considered subsidiary to the various bid items of the contract.

When fertilizer is specified on the plans to be a pay item, the work performed and materials furnished and measured as provided under "Measurement" will be paid for at the unit price bid for "Fertilizer", of the analysis specified. This price shall be full compensation for furnishing all materials and performing all operations necessary to complete the work.

ITEM 168

VEGETATIVE WATERING

168.1. Description. This Item shall govern for the authorized application of water through an aboveground system to promote and sustain growth of grasses and other plants on those portions of the right of way as shown on the plans or as directed by the Engineer, and in accordance with this Item.

168.2. Materials. Water shall be furnished by the Contractor and shall be clean and free of industrial wastes and other substances harmful to the growth of vegetation.

168.3. Construction Methods. This work shall be done only at such time as directed by the Engineer. The Contractor shall furnish and operate watering equipment approved by the Engineer which will insure the distribution of water in a uniform and controllable rate of application. The Contractor shall apply the water in the required quantity where shown on the plans or as directed by the Engineer.

168.4. Measurement. This Item will be measured by the kiloliter as delivered on the designated areas.

168.5. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Vegetative Watering". This price shall be full compensation for furnishing and operating approved watering equipment and measuring devices and for furnishing and applying the water as directed including hauling, equipment, labor and incidentals necessary to complete the work.

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APPENDIX B

Standard Specification Item 169
"Soil Retention Blanket"

Texas Department of Transportation
1995 Standard Specifications
for Construction and Maintenance of
Highways, Streets and Bridges

ITEM 169

SOIL RETENTION BLANKET

169.1. Description. This Item shall govern for providing and placing wood, straw or coconut fiber mat, synthetic mat, paper mat, jute mesh or other material as a soil retention blanket for erosion control on slopes or ditches or for short-term or long-term protection of seeded or sodded areas as shown on the plans or as specified by the Engineer.

169.2. Materials.

(1) Soil Retention Blankets. All soil retention blankets must be prequalified by the Director of Construction and Maintenance prior to use.

Prequalification procedures and a current list of prequalified materials may be obtained by writing to the Director of Construction and Maintenance, 125 East 11th Street, Austin, Texas 78701-2483. A 300 millimeters x 300 millimeters sample of the material may be required by the Engineer in order to verify prequalification. Samples taken, accompanied by the manufacturer's literature, will be sent, properly wrapped and identified, to the Construction and Maintenance Division for verification.

The soil retention blanket shall be one (1) of the following classes and types as shown on plans:

(a) **Class 1.** "Slope Protection"

(i) **Type A.** Slopes 1:3 or flatter - Clay soils

(ii) **Type B.** Slopes 1:3 or flatter - Sandy soils

(iii) **Type C.** Slopes steeper than 1:3 - Clay soils

(iv) **Type D.** Slopes steeper than 1:3 - Sandy soils

(b) **Class 2.** "Flexible Channel Liner"

(i) **Type E.** Short-term duration (Up to 2 years)
Shear Stress (t_d) < 48 Pa

(ii) **Type F.** Short-term duration (Up to 2 years)
Shear Stress (t_d) 48 to 96 Pa

(iii) **Type G.** Long-term duration (Longer than 2 years)
Shear Stress (t_d) > 96 to < 239 Pa

(iv) **Type H.** Long-term duration (Longer than 2 years)
Shear Stress (t_d) $\geq$ 239 Pa

(2) Fasteners. Fasteners shall conform to the requirements shown on Standard Detail Sheet "Soil Retention Blanket (SRB)".

169.3. Construction Methods.

(1) General. The soil retention blanket shall conform to the class and type shown on the plans. The Contractor has the option of selecting an approved soil retention blanket conforming to the class and type shown on the plans and according to the current approved material list.

(2) Installation. The soil retention blanket, whether installed as slope protection or as flexible channel liner in accordance with the approved materials list, shall be placed within 24 hours after seeding or sodding operations have been completed, or as approved by the Engineer. Prior to placing the blanket, the area to be covered shall be relatively free of all rocks or clods over 40 millimeters in maximum dimension and all sticks or other foreign material which will prevent the close contact of the blanket with the soil. The area shall be smooth and free of ruts and other depressions. If as a result of rain, the prepared bed becomes crusted or eroded or if any eroded places, ruts or depressions exist for any reason, the Contractor shall be required to rework the soil until it is smooth and to reseed or resod the area at the Contractor's expense.

Installation and anchorage of the soil retention blanket shall be in accordance with the Manufacturer's recommendations and the Standard Detail Sheet "Soil Retention Blanket (SRB)".

(3) Literature. The Contractor shall submit one (1) full set of manufacturer's literature and manufacturer's installation recommendations for the soil retention blanket selected in accordance with the approved material list.

169.4. Measurement. This Item will be measured by the square meter of surface area covered.

169.5. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement"

will be paid for at the unit price bid for "Soil Retention Blanket" of the class and type shown on the plans. This price shall be full compensation for furnishing all materials, labor, tools, equipment and incidentals necessary to complete the work. Anchors, checks, terminals or junction slots, and wire staples or wood stakes will not be paid for directly but will be considered subsidiary to this Item.

ITEM 170

IRRIGATION SYSTEM

170.1. Description. This Item shall govern for constructing an irrigation system as shown on the plans and as approved by the Engineer.

170.2. General.

License Requirements. The Contractor shall be required to possess an irrigator's license issued by the Texas Board of Irrigators or employ such a licensed irrigator to construct the irrigation system. The Engineer may require documentation of such license for his records. The irrigation system shall be installed and maintained under the supervision of the licensed irrigator who must be on the site at all times during this work or at such times as required by the Engineer.

170.3. Materials. Materials shall conform to the requirements shown on the plans and to the following requirements.

(1) Irrigation Pipe. Irrigation pipe shall be polyvinyl chloride (PVC) conforming to ASTM D 1785, Schedule 40 or ASTM D 2241, SDR 13.5 or SDR 17 or SDR 21, as shown on the plans.

(2) Fittings. Fittings, not including valves or sprinkler heads, shall conform to ASTM D 2466.

(3) Encasement Pipe. Unless otherwise shown on the plans and specifications, encasement pipe shall be PVC conforming to ASTM D 1785, Schedule 40.

(4) Bentonite Slurry. The slurry shall be a viscous mixture of a commercial bentonite and fresh water. The slurry shall contain two (2) to eight (8) percent of the bentonite additive by mass.

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APPENDIX C

Proposed Approved Product List
(based upon 1995 Evaluation Cycle)
Soil Retention Blankets

Class 1 "Slope Protection"
Class 2 "Flexible Channel Liner"

Proposed Approved Product List
Soil Retention Blankets
Specification Item 169

CLASS 1: SLOPE PROTECTION APPLICATIONS

Type A: Slopes 1:3 or Flatter - Clay Soils

Airtrol
Antiwash/Geojute
BonTerra S2
BonTerra S1
C-Jute
Contech Standard
Contech Standard Plus
Curlex I
Erosion Control Straw Blanket Standard
Green Triangle Regular
Green Triangle Superior
Greenstreak Pec-Mat
Landstrand Natural
Miramat TM8
North American Green S75
North American Green SC150
North American Green S150
Polyjute 407GT
Poplar Erosion Blanket
Soil Guard
Soil Saver
Super-Gro
TerraJute
verdyol Excelsior Standard
verdyol Ero-Mat
Webmat 280
Xcel Regular
Xcel Superior

TYPE B: Slopes 1:3 or Flatter - Sandy Soils

Bonterra S1
C-Jute
Contech Standard Plus\
Contech Standard
Green Triangle Superior
Green Triangle Regular
Miramat TB1000
Miramat TM8
North American Green SC150
North American Green S75
North American Green S150
Polyjute 407GT
Poplar Erosion Blanket
Soil Guard
TerraJute
verdyol Ero-Mat
verdyol Excelsior Standard
Xcel Superior
Xcel Regular

CLASS 1 "SLOPE PROTECTION" (continued)

Type C: Slopes Steeper than 1:3 - Clay Soils

Airtrol
Bonterra S2
Contech Standard Plus
Curlex I
Greenstreak Pec-Mat
North American Green SC150
Soil Saver
Soil Guard
Xcel Superior
Miramat TM8
Landstrand Natural
Antiwash/Geojute
C-Jute
Green Triangle Superior
North American Green S150
Polyjute 407GT
Super-Gro
Webmat 280
TerraJute

TYPE D: Slopes Steeper than 1:3 - Sandy Soils

C-Jute
Curlex I
Miramat TB1000
North American Green SC150
Soil Guard
Xcel Superior
Miramat TM8
Contech Standard Plus
Green Triangle Superior
North American Green S150
Polyjute 407GT
TerraJute

CLASS 2 "FLEXIBLE CHANNEL LINER" APPLICATIONS

TYPE E: Shear Stress Range 0 - 96 Pascal

Contech C-45
Enkamat 7020
Landlok ECRM 450
Miramat TM8
North American Green C350 Three Phase
Pec-Mat
Tensar Erosion Mat TM3000
Webmat 280

TYPE F: Shear Stress Range 0 - 192 Pascal

Contech C-45
Landlok ECRM 450
Miramat TM8
North American Green C350 Three Phase
Pec-Mat
Tensar Erosion Mat TM3000
Webmat 280

TYPE G: Shear Stress Range 0 - 287 Pascal

Tensar Erosion Mat TM3000
Pec-Mat
Webmat 280
North American Green C350 Three Phase
Landlok ECRM 450
Contech C-45

TYPE H: Shear Stress Range 0 - 383 Pascal

Contech C-45
Landlok ECRM 450
North American Green C350 Three Phase
Tensar Erosion Mat TM3000