FINAL REPORT

EROSION AND SEDIMENT CONTROL WITH VEGETATIVE BARRIERS

Cooperative Agreement No. 96-7

Between

Texas State Soil and Water Conservation Board

and the

United States Department of Agriculture
Natural Resources Conservation Service

KIKA DE LA GARZA PLANT MATERIALS CENTER
KINGSVILLE, TEXAS
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PREFACE

This report contains the conclusions of a four-year field study to evaluate the use of vegetative barriers to stabilize and control erosion of waterways, gullies and sloping hillsides.

This project was coordinated and funded by the Texas State Soil and Water Conservation Board in conjunction with the U.S. Environmental Protection Agency.

Overall supervision of the field work and its supplementary analyses was provided by John Lloyd-Reilley, Manager, USDA, Natural Resources Conservation Service (NRCS), Kika de la Garza Plant Materials Center (PMC).

Field support was provided by Patrick Conner, Albert Quiroga and Raul David Hernandez of the USDA, NRCS, Kika de la Garza Plant Materials Center. George Farek, Research Assistant, Texas A&M University-Kingsville, Caesar Kleberg Wildlife Research Institute also provided valuable field support.

Successful culmination of the project is the result of the cooperative endeavor among a variety of agencies and organizations with a common interest in soil and water conservation. Appreciation is expressed to the following organizations and individuals:

- Flavio Garza and the NRCS field staff, the Webb County Soil and Water Conservation District, the Laredo National Bank and Brad Schwartz for their cooperation, coordination and assistance at the Laredo field site.
- James Hluchan and Merrill Schramm at the Bellville, NRCS field office, the Austin County Soil and Water Conservation District, Mr. and Mrs. Kott (landowners) and Mr. Myska and Mr. Koy (landowners) for their cooperation, coordination and assistance at the Austin County field sites.
- Fernando Garza and Allen Collins at the San Antonio, NRCS field office, the Bexar County Soil and Water Conservation District, Mrs. Agnes Stanush (landowner) and Mr. Alfred Rakowitz (landowner) for their cooperation, coordination and assistance at the Bexar County field sites.

EXECUTIVE SUMMARY

The Natural Resources Conservation Service (NRCS) has promoted the use of terraces for soil erosion control for over forty years. More recently the concept of using vegetative barriers or grass hedges as a vegetative alternative has been investigated. Vegetative barriers are narrow strips (1-3 feet wide) of stiff, erect densely growing plants, usually grasses, planted across the slope perpendicular to the dominant slope. These barriers function to slow water runoff, trap sediment and prevent gully development.

From 1996 to 2000 the United States Department of Agriculture (USDA), NRCS, Kika de la Garza Plant Materials Center (PMC) along with the Caesar Kleberg Wildlife Research Institute (CKWRI) of Texas A&M University-Kingsville, and cooperating NRCS field offices and Soil and Water Conservation Districts (SWCD) in Austin county, Bexar county, and Webb county established field demonstrations sites of vegetative barriers for the stabilization and control of waterways, gullies and other areas of erosive water-flow.

This study has documented that vegetative barriers can capture sediment and prevent erosion on erosive hillsides. At the Austin county field site, the vegetative barrier treatment prevented the erosion and downstream sediment deposition of over 1,190 cubic feet over a 27-month period. At the San Antonio cropland site the vegetative barriers are providing a flexible, vegetative terrace system that is saving over 5 tons of soil/acre/year on the 14-acre field. The PMC has written 3 articles for publication and conducted 4 presentations and field days to over 125 interested people. The PMC plans to continue to evaluate and promote the use of this promising low-cost erosion control technology.

INTRODUCTION

The Natural Resources Conservation Service (NRCS) has promoted the use of terraces for soil erosion control for over forty years. More recently the concept of using vegetative barriers or grass hedges as a vegetative alternative has been investigated (Kemper et al. 1992). Vegetative barriers are narrow strips (1-3 feet wide) of stiff, erect densely gr. owing plants, usually grasses, planted across the slope perpendicular to the dominant slope. These barriers function to slow water runoff, trap sediment and prevent gully development (Dabney et al. 1993). The barriers inhibit the flow of water because of their dense concentration of thick stems, thus slowing and ponding water and causing sediment to deposit in back of them (Meyers et al. 1994). Over time these deposits can develop into benched terraces (Aase and Pikul, 1995). These barriers function to diffuse and spread the water runoff so that it slowly flows through them without erosion. Vegetative barriers are resilient to failure because water passes over a broad area secured with perennial root reinforcement.

The vegetative barrier concept should not be confused with vegetative filter strips. Vegetative filter strips are a broad area of vegetation ranging from 15 to 30 feet wide whose purpose is to remove nutrients, pesticides and sediment from surface runoff. Vegetative barriers, on the other hand, are narrow strips of vegetation which are designed primarily to slow runoff, capture sediment and resist gully development. However, the two practices can be very complimentary. Research has reported that vegetated filter strips can be effective at nutrient removal and trapping sediment where water flows are shallow and uniform (Magette et al., 1989). Meyer et al., 1994 documented that stiff erect grasses such as vetiver [Vetiver zizanioides (L) Nash] and switchgrass (Panicum virgatum L.) can retard runoff and capture sediment from concentrated flow. Thus, as a vegetative barrier matures it reduces water velocities and establishes a broad uniform vegetative surface for the uptake of nutrients. Vegetative barriers have the potential to not only reduce erosion but can enhance vegetated filter strips in the uptake of nutrients.

Vegetative barriers could be a low-cost option for many farmers and ranchers to meet their conservation needs. It could be an alternative or complimentary practice with conventional terraces, waterways, and critical area stabilization. In many cases it does not require heavy machinery for installation, which eliminates the movement and compaction of the topsoil. It also takes less land out of production since it is only a narrow strip of grass.

In June 1996, the United States Department of Agriculture (USDA), NRCS, Kika de la Garza Plant Materials Center (PMC) along with the Caesar Kleberg Wildlife Research Institute (CKWRI) of Texas A&M University-Kingsville, and cooperating NRCS field offices and Soil and Water Conservation Districts (SWCD) in Austin county, Bexar county and Webb county established a three-year project to evaluate erosion control effectiveness of vegetative barriers. The objectives of this project are to 1) establish field demonstration sites of vegetative barriers for the stabilization and control of waterways, gullies or other areas of erosive water-flow; 2) validate criteria for the effective use of vegetative barriers including a) plant species (vetiver, switchgrass and big sacaton (Sporobolus wrightii Munro ex Scribn.), b) time of planting, c) barrier spacing, d) how to establish barriers; seeding, transplants, wattles, e) barrier density and width; and 3) document the effects of the vegetative barriers on water quality through determination of erosion and sediment patterns.

The Environmental Protection Agency (EPA) through the Texas State Soil and Water Conservation Board provided funding for this project.

METHODS:

PROJECT ORGANIZATION:

At each of the demonstration sites a project team was initially established to exchange ideas and coordinate duties to implement the demonstration project. The project coordinating teams involved the landowner, the local Soil and Water Conservation District, the Natural Resources Conservation Service field personnel, a representative of the Caesar Kleberg Wildlife Research Institute and the manager of the Kika de la Garza Plant Materials Center. This team interacted on a regular basis to ensure the implementation of the project.

STUDY SITES

Three locations were selected for this study. These three sites were picked because they all have threatened and/or impacted water supplies; the Rio Grande River in Webb county, the Mill Creek/ Brazos River in Austin county and Salado Creek/ Martinez Creek in Bexar county. Sediment and/or nutrients from suspected agricultural sources have been listed for the water bodies as a cause for inclusion in the assessment report on non-point source water pollution for the state of Texas. Successful vegetative barriers could effectively reduce sediment production from cropland and rangeland, thus improving the water quality within these stream segments.

These three sites were also selected because they will cover an area that is roughly 325 miles in distance. The sites selected will provide needed information on range of adaptability of vegetative barriers. Austin County has an average annual precipitation of 42 inches while Webb County has an average annual precipitation of only 17 inches. The soil types, topography and agricultural practices vary greatly among these three locations.

1. LAREDO-WEBB COUNTY STUDY SITE

INITIAL PLANTING

The farm selected in Webb County is located south of Laredo, near the Rio Bravo settlement, and is managed by the Laredo National Bank. The soils of the treatment site are a Lagloria silt loam with a 0-1 percent slope and a Copita fine sandy loam with a slope of 0-3 percent. The adjacent farm fields are normally planted to irrigated vegetables.

A baseline survey was conducted on August of 1996 on four vegetative barrier lines prior to planting. Surveying was done using a laser level recorded to a one-tenth of an inch in accordance with Natural Resources Conservation Service established guidelines. On 15 October 1996, Vetiver grass was planted at four barrier locations. The four barriers range in length from 80 feet to 180 feet. The distances between the barriers vary from 56 feet to 333 feet with a vertical index of 1.6 feet to 2.5 feet. Slopes range from 0.5 percent to 4.5 percent.

Vetiver was planted as a single row across the basin depth, which ranged from .8 feet to 1.8 feet in height. Bare-root vetiver clumps of 4 stems were planted end-to-end across the basin half- (½) depth. The outside ½ depth was planted with 4-stem clumps at three-inch (") intervals. Vetiver was 9" tall with 4" roots.

A trencher was used to produce a 6-inch wide trench. A 13-13-13 fertilizer was sprinkled in the trench at approximately an 80#/acre rate of actual nitrogen. Plants were placed in the trench and then backfilled. Straw bundles from 5" to 9" thick were placed across the ½ basin depth locations to prevent dislodging of the plants. Water was added at the time of planting at 200 gallons/barrier.

A second survey of the site was performed on 16 October 1996 right after planting. The survey consisted of measurements at the ends of the barrier and at the ½ depth locations on either side of the barrier and in the middle. Measurements were taken not only at the barrier line but also at 4 feet upstream, 4 feet downstream and 20 feet upstream.

A second site (B) was planted on 1 April 1997. Big sacaton was planted at two barrier locations. Both barriers are 140 feet long. The barriers are 170 feet apart with a 2-foot vertical index and a 1.2- percent slope. Big sacaton was planted as a single row at a three-inch spacing the entire length of the barrier. A second row of Big sacaton was planted 9 inches uphill from the first row. The second row was at a 6-inch spacing and was planted only across the basin half-depth. The basin depths were approximately 1 foot. The plants were 5 months old with 1-13 stems at a 9" height and 6" roots. They were grown in paper plant bands. Plants in the first row at the half depth locations were grown in 3"x 3"x 6" bands while all the others were grown in 1" x 1" x 6" bands. A trencher was used to produce a 6-inch wide trench and then backfilled. The second row was planted using a narrow planting bar. No water was applied. Straw bundles were placed across the half basin depth locations. A second survey of the site was performed on 2 April 1997.

Vegetation analyses was conducted at each of the elevation survey sites along the barrier using a one square-foot frame. At each of the locations percent survival, stem density (numbers per square-foot), height (centimeters), and base width (centimeters) were recorded. Two, twenty-foot transect lines were evaluated at each barrier to determine gaps between plants (number of spaces greater than 15 centimeters apart) and the largest gap (centimeters).

2. AUSTIN COUNTY STUDY SITES

Two farms were selected in Austin County. One farm is owned by Mr. & Mrs. Kott and the other is owned by Mr. Koy who purchased it from Mr. Myska.

A) KOTT STUDY SITE

INITIAL PLANTING

Two critical area gully sites were selected for treatment on the Kott farm. The soil of the treatment site is a Frelsburg clay with a 3 to 10 percent slope. The sites had been shaped as an NRCS critical area in 1995. Surrounding areas are well-managed little bluestem pastures. Small head cuts were starting to reestablish at these sites in 1996.

A baseline survey was conducted in August 1996 on three vegetative barrier lines of site A prior to planting. On 7 October 1996 vetiver grass was planted at site A. The three barriers range in length from 55 to 195 feet. The distances between the barriers vary from 59 to 72 feet with a vertical index of 2.1 feet. Slopes range from 2.9 percent to 4.5 percent.

Vetiver was planted as a single row across the basin depth, which ranged from 1.1 to 2.0 feet in height. Bareroot vetiver clumps of 4 stems were planted end-to-end across the basin ½ depth. The outside ½ depth was planted with 4-stem clumps at a three-inch interval. Vetiver was 9" tall with 4" roots. A trencher was used to produce a 6-inch wide trench. A 13-13-13 fertilizer was sprinkled in the trench at approximately an 80#/acre rate of actual nitrogen. Plants were placed in the trench and then backfilled. Straw bundles from 5 inches to 9 inches thick were placed across the ½ basin depth locations to prevent dislodging of the plants. No water was applied.

A second survey of the site was performed on 9 October 1996 right after planting. The survey consisted of measurements at the ends of the barrier and at the ½ depth locations on either side of the barrier and in the middle. Measurements were taken not only at the barrier line but also at 4 feet upstream, 4 feet downstream and 20 feet upstream.

A second site (Site B) was planted on 15 April 1997. Big sacaton was planted at three barrier locations. The barriers range in length from 25 to 53 feet. The distances between the barriers vary from 24 to 31 feet with a vertical index of 1.5 to 2.4 feet. Slopes range from 3.6 percent to 10.8 percent.

Big sacaton was planted as a single row at a three-inch spacing the entire length of the barrier. The basin depths varied from 1.0 to 2.1 feet. The plants were 5 months old with 1-13 stems at a 9" height and 6" roots. Plants at the ½ depth locations were grown in 3"x3"x 6" paper plant bands while all the others were grown in 1"x 1"x 6" bands. A trencher was used to produce a 6-inch wide trench. A 13-13-13 slow release fertilizer was sprinkled in the trench at approximately a 280#/acre rate of actual nitrogen. Plants were placed in the trench and then backfilled. No water was applied. Straw bundles were placed across the 1/2-basin depth locations. A survey of the site was performed on 15 April 1997.

The results of the vegetation survey conducted on 12 May 1997 revealed virtually a 100% mortality for the vetiver grass. Therefore, a second row of plants (big sacaton) was planted 18 inches uphill from the vetiver plants at site A on 15 April 1997. Big sacaton was planted at a 3-inch interval at the basin ½ depth locations and at a 6-inch interval at the outside locations. Plants were 5 months old with 1-13 stems at 9" height and 6" roots. All plants were grown in 1" x 1" x 6" paper plants bands. A trencher was used for planting. A 13-13-13 slow release fertilizer was added at a 280#/acre rate of actual nitrogen. No water was applied. Fences were constructed upon completion of planting to prevent cattle grazing.

Vegetation analyses was conducted at each of the elevational survey sites along the barrier using a one square-foot frame. At each of the locations percent survival, stem density, height and base widths were recorded. Two, ten-foot transect lines were evaluated at each barrier to determine gaps between plants.

MYSKA/KOY STUDY SITE

INITIAL PLANTING

Two critical area gully sites were selected for treatment on the Myska/Koy farm. The soils of the treatment site are a Frelsburg clay at 1 to 8 percent slope and a Latium clay at 2 to 12 percent slope. The sites were crudely shaped to eliminate the head cuts in September 1996. Surrounding areas are severely overgrazed pasture.

A baseline survey was conducted in August 1996 on 14 barrier lines at site A and three barrier lines at site B. On 16 September 1997, vetiver grass was planted at both locations. The barriers range in length from 25 feet to 100 feet. The distance between the barriers varies from 13 feet to 74 feet with a vertical index from 1.7 feet to 2.5 feet. Slopes range from 2.8 percent to 16 percent.

Vetiver was planted as a single row across the basin depth, which ranged from 1.4 feet to 5.0 feet in height. Bareroot vetiver clumps of 4 stems were planted end-to-end across the basin ½ depth. The outside ½ depth was planted with 4 stem clumps at a three-inch interval. Vetiver was 9" tall with 4" roots. A trencher was used to produce a 6-inch wide trench. A 13-13-13 fertilizer was sprinkled in the trench at approximately an 80#/acre rate of actual nitrogen. Plants were placed in the trench and then backfilled. Straw bundles from 5 inches to 9 inches thick were placed across the ½ basin depth locations to prevent dislodging of the plants. No water was applied.

A second survey of the site was performed on 16 September 1997 right after planting. The survey consisted of measurements at the ends of the barrier and at the ½ depth locations on either side of the barrier and in the middle. Measurements were taken not only at the barrier line but also at 4 feet upstream, 4 feet downstream and 20 feet upstream.

A second row of plants (big sacaton) was planted 9 inches uphill from the vetiver plants at both sites on 17 April 1997. Big sacaton was planted at a 3-inch interval at the basin ½ depth locations and at a 6-inch interval at the outside locations. Plants were 2 months old with 1-4 stems at a 6-inch height and 6 inch roots. All plants were grown in 1" x 1" x 6" paper plant bands. Vetiver grass was spot planted on 13 May 1997 at a 6-inch interval at the basin ½ depth locations. All plants were planted with narrow planting bars. No water or fertilizer was used. Fences were constructed upon completion of initial plantings to prevent cattle grazing.

Vegetative analyses were conducted at each of the elevational survey sites along the barriers using a one square-foot frame. At each of the locations percent survival, stem density, height and base widths were recorded. Two, ten foot transects lines were evaluated at each barrier to determine gaps between plants. Velocities (feet per second-ft/sec) and volume of surface runoff (cubic feet per second-cfs) were determined using the Natural Resources Conservation Service WWCALC engineering software program.

3. BEXAR COUNTY STUDY SITE

Two farms were selected in Bexar County. One farm is owned by Mrs. Agnes Stanush and the other by Mr. Alfred Rakowitz. The Zigmond study site was terminated because of poor cooperator support.

STANUSH STUDY SITE

INITIAL PLANTING

A ninety-acre field was selected for treatment at this site. The soil of the treatment site is a Houston clay with a 1 to 5 percent slope. The field is planted to wheat. We treated the waterway in March 1997. On 25 March 1997, switchgrass was either seeded or transplanted on eight barrier lines of the waterway. The barriers were approximately 40 feet long. The distance between the barriers varied from 60 feet to 180 feet with a vertical index from 1.6 feet to 2.9 feet. Slopes range from 1.3 percent to 2.5 percent.

Switchgrass transplants were planted as a single row across the basin depth, which was approximately 1.0 feet in height. The plants were 1 year old with 5 to 10 stems at a 9-inch height and 6-inch roots. All plants were grown in 3" x 3" x 6" paper plant bands. Switchgrass transplants were planted end-to-end across the basin. A trencher was used to produce a 6-inch wide trench. A 13-13-13 slow release fertilizer was sprinkled in the trench at approximately a 280#/acre rate of actual nitrogen. Plants without straw bundles were planted at barriers 1 and 6. Plants with straw bundles were planted at barriers 2 and 3. At barriers 4, 5, 7 and 8 no transplants were used. Seed was broadcast on these sites at a rate of 100 pounds per acre of pure live seed. At barrier 5, a North American Green C-350 turf reinforcement mat was placed over the seeding. At barrier 7, a straw bundle was placed directly downstream of the seeding.

A survey of the site was performed on 27 March 1997 right after planting. The survey consisted of measurements at the ends of the barrier and at the 1/2-depth locations on either side of the barrier and in the middle. Measurements were taken not only at the barrier line but also at 4 feet upstream, 4 feet downstream and 20 feet upstream.

RAKOWITZ STUDY SITE

INITIAL PLANTING

A fourteen-acre field was selected for treatment at this site. The soil of the treatment site is primarily a Houston-Sumter clay with a 5 to 10 percent slope. The field is normally planted to grain sorghum. We seeded switchgrass on three nine hundred foot terraces at a 13 pounds of pure live seed per acre (#pls. /ac) rate with a Tye no-till drill into disked sorghum residue on October 20, 1997. The distances between the barriers are 90 feet with a vertical index from 2.1 to 3.3 feet. Slopes range from 2.4 percent to 5.8 percent.

At five of the concentrated runoff sites additional treatments were used. At all sites, the first row was planted with switchgrass transplants that were two and a half months old, 9 inches tall and with 6-inch roots. These transplants were grown in 3" x 3" x 6" paper plant bands. A trencher was used to produce a 6-inch wide trench. A 13-13-13 slow release fertilizer was sprinkled in the trench at approximately a 280#/acre rate of actual nitrogen. Plants were placed in the trench end-to-end and then backfilled. No water was applied. Six-inch straw bundles were placed, staked and tied down approximately 30' across the channel width at each transplant location. At row 1 of terrace 2 and 3 we planted with a planter bar 1" x 3" switchgrass transplants at a 6-inch spacing as a second row. At row 2 of terrace 2 we planted with a planter bar 1" x 6" switchgrass transplants at a 6-inch spacing as a second row.

A survey of the site was performed on October 23, 1997 right after planting. The survey consisted of measurements at seven to nine locations on each terrace. Measurements were taken not only at the terrace barrier line but also at 4 feet upstream, 4 feet downstream and 20 feet upstream.

RESULTS AND DISCUSSION

LAREDO – WEBB COUNTY

Both vetiver grass and big sacaton had good survival throughout 1997. The established vetiver plants grew tall and vigorous (Table 1). By March of 1998, there were virtually no gaps between plants except where there was tractor damage. The big sacaton plants survived well but did not grow as robust as the vetiver grass. (Table 2) There were many small gaps between plants despite a better than average rainfall year in 1997 (Table 3).

On March 3, 1998, we replanted damaged sections of site A with vetiver and planted at each terrace a second row of vetiver in the concentrated flow zone. We also spot-planted big sacaton and extended the second row on terrace 1 of site B.

There was 100% mortality for the newly planted vetiver and big sacaton plants outside of the concentrated flow zone by November 1998. The severe drought of 1998 prevented plants from becoming established in 1998, despite 3 separate waterings. Furthermore, established vetiver plants went from a mean 98% coverage to 59% and big sacaton went from 92% to 79%. Survival of both species was restricted to the middle of the concentrated flow zone.

Results of the topographic surveys are presented in Tables 4 and 5. The elevations have not changed significantly since the initial planting survey. The largest increase in sediment has been at station 3 on terrace 2 of the vetiver barrier. Five inches of sediment have been captured at this site and surveys have indicated that it has caught this much sediment as far as 20 feet upstream. Terrace 2 was the only terrace with significant soil disturbances upstream. There was a road that was actively used between terrace 1 and terrace 2. The interspaces between the other terraces were left undisturbed. The small amount of rain along with gentle slopes, good soil infiltration and undisturbed surfaces prevented any soil movement at the other terraces.

It appears that established vegetative barriers will capture sediment and prevent erosion in areas of concentrated water flow. However, the dependability of plant survival and growth in such an arid area as Laredo suggests that nonvegetated practices for erosion control be utilized unless there is an assurance of timely irrigation.

TABLE 1

Vegetation Results from October 1996 Planting of Vetiver grass (Site A) in Laredo, Texas.

Barrier	Percent Survival				Stem Density (#/ft^2)				Height (cm)			
	4/97	10/97	3/98	11/98	4/97	10/97	3/98	11/98	4/97	10/97	3/98	11/98
1	70	94	100	80	5	23	3	0	48	74	88	84
2	94	90	90	71	13	26	9	4	69	80	88	100
3	88	95	100	63	9	25	14	3	65	73	91	99
4	60	65	100	20	9	12	13	1	54	51	76	91

Barrier	Base Width (cm)				Gaps (# spaces > 15 cm)				Largest Gap (cm)			
	4/97	10/97	3/98	11/98	4/97	10/97	3/98	11/98	4/97	10/97	3/98	11/98
1	3	6	8	9	19	5	2	7	111	27	25	122**
2	3	9	10	13	6	6	6	2	66	66*	63	549**
3	2	8	9	11	0	2	3	3	9	35*	122**	274**
4	2	5	11	5	9	6	4	10	23	71*	69	307**

* Tractor damage
**Outside concentrated flow zone

TABLE 2

Vegetation Results from April 1997 Planting of Big Sacaton (Site B) in Laredo, Texas

Barrier	Percent Survival			Stem Density (#/ft^2)			Height (cm)		
	10/97	3/98	11/98	10/97	3/98	11/98	10/97	3/98	11/98
1	84	100	78	10	9	3	61	52	52
2	100	100	81	13	14	6	65	65	50

Barrier	Base Width (cm)			Gaps (# spaces > 15 cm)			Largest Gap (cm)		
	10/97	3/98	11/98	10/97	3/98	11/98	10/97	3/98	11/98
1	4	4	8	3	0	9	25	13	91*
2	4	4	6	3	0	7	27	13	91*

*Tractor damage

TABLE 3:

Monthly Rainfall Totals and High and Low Temperatures at Laredo, TX.

MONTH	TEMPERATURE (°F) HIGH			TEMPERATURE (°F) LOW			RAINFALL (INCHES)		
	1996	1997	1998	1996	1997	1998	1996	1997	1998
January		64	84		26	32		.11	.08
February		90	94		34	37		.99	.89
March		96	102		44	34		3.08	1.12
April		102	104		44	49		2	.04
May		103	109		54	60		2.61	.00
June		106	114		54	60		2.57	.04
July		108	113		71	73	6.94	1.10	.21
August		110	110		73	72	5.47	Trace	.96
September		106	104		61	72	3.42	1.07	2.83
October	96	100	100	40	42	49	1.26	5.46	2.71
November	94	85	86	34	41	49	1.07	1.56	1.42
December	86	83	86	17	23	32	0.28	.25	.12
						TOTAL	18.44	21.05	10.42

TABLE 4:

Elevation in Feet at the Vetiver Vegetative Barriers at Laredo, Texas

TERRACE **DATE** **STATIONS**

TERRACE	DATE	1	2	3	4	5
1	10/16/96	96.7	96.0	95.4	96.1	96.3
	4/2/97	96.6	95.9	95.3	96.0	96.2
	7/8/97	96.7	95.9	95.4	96.0	96.3
	2/19/98	96.7	95.9	95.3	96.0	96.3
	6/16/98	96.7	96.0	95.4	96.0	96.3
	1/20/99	96.8		95.5	96.1	96.4
2	10/16/96	95.5	94.3	92.9	93.9	94.7
	4/2/97	95.4	94.2	92.8	93.8	94.6
	7/8/97		94.2	93.0	93.8	94.7
	2/19/98		94.2	93.1	93.8	94.7
	6/16/98		94.2	93.1	93.8	94.7
	1/20/99		94.3	93.3	93.9	94.8
3	10/16/96	92.7	91.9	91.3	91.9	92.5
	7/8/97	92.6	92.0	91.3	92.0	92.6
	2/19/98	92.6	91.9	91.3	91.9	92.6
	6/16/98	92.7	92.0	91.3	91.9	92.5
	1/20/99	92.6	92.0	91.4	92.0	
4	10/16/96	90.5	90.5	89.7	90.1	90.4
	7/8/97	90.6	90.5	89.6	90.2	90.4
	2/19/98		90.5	89.6	90.2	90.5
	6/16/98	90.6	90.5	89.5	90.2	90.4
	1/20/99	90.6	90.5	89.7	90.2	90.6

TABLE 5:

Elevation in Feet at the Big Sacaton Vegetative Barriers at Laredo, Texas

TERRACE	DATE	STATIONS 1	2	3	4	5
1	4/2/97	99.6	99.7	99.2	99.6	99.5
	7/8/97	99.7	99.8	99.2	99.6	99.6
	2/19/98	99.7	99.8	99.2	99.6	99.5
	6/16/98	99.7	99.7	99.2	99.5	99.4
	1/20/99	99.7	99.7	99.2	99.6	99.5
2	4/2/97	98.4	97.6	97.0	97.8	98.3
	7/8/97	98.5	97.7	97.1	97.9	98.4
	2/19/98	98.4	97.7	97.1	97.9	98.4
	6/16/98	98.5	97.7	97.1	97.9	98.4
	1/20/99	98.6	97.8	97.1	98.0	98.5

KENNEY-AUSTIN COUNTY

KOTT STUDY SITE

The results of the vegetation survey conducted on 12 May 1997 revealed virtually 100% mortality for the vetiver grass. The reasons for the plant mortality are speculative. Cold weather may have been a contributing factor to vetiver mortality. There were several days of well below freezing temperatures (Table 6). However, it is felt that cool-season competition from plants such as bur clover may have been the main reason for the death loss. At the Koy/Myska farm in Kenney, Texas, vetiver survival was 61 percent for the same year. The soils are poor at the Koy/Myska study site and there is very little vegetative cover. The lack of cover provides less insulating protection but also less competition. Therefore, cold weather maybe a reason for vetiver mortality but cool-season plant competition maybe an even greater cause.

Big sacaton survival and growth has been very good at this site (Table 7 and 8). In the concentrated flow zone the plants have grown especially large and dense with very little gaps between plants. This site has a gentle slope with very fertile soil and has received good rainfall throughout the study period. Minor plant damage did occur occasionally due to harvester ant and fire ant colonies as well as armadillo digging, which required periodic maintenance.

Results of the topographic surveys are presented in table 9. The elevations have not changed significantly since the initial planting survey. The largest increase in sediment has been for Terrace 2 at site B. Approximately 3 inches of sediment have been captured at this site. Following the initial shaping and planting of this critical area, there has been little soil disturbance and good vegetative cover within the drainage area. This probably accounts for the minimal soil movement and capture at the vegetative barriers.

MYSKA/KOY STUDY SITE

Results of the vegetation surveys are presented in tables 10 and 11. Total survival of vetiver grass for the winter of 1996 at Site A averaged 61 percent. Numerous gaps between plants exceeded the 15-centimeters/6 inches threshold established by the Kika de la Garza Plant Materials Center. Previous research at the PMC revealed that it took from 1-2 years for plants planted 15 centimeters apart to close the gap and become a solid hedge (Texas Natural Resources Conservation Service Technote 1996). Subsequent investigations indicate that a gap as wide as 30 centimeters maybe acceptable where an extensive root system binds together and prevents downcutting.

Following spot planting in April 1997 and March 1998, vetiver grass produced a summer survival rate of 93% in 1997 and 97% in 1998. By November of 1998, the vetiver grass at site A had produced very large plants that averaged 117 centimeters tall with a base width of 14 centimeters. Furthermore, there were very few gaps with the largest being 36 centimeters and these gaps were on the outside edge of the barriers.

Vetiver grass performed better when planted in the spring versus the fall at this site. Competition from cool-season vegetation and freezing temperatures had a detrimental impact on vetiver survival. Vetiver appears to prefer planting in the spring at a time when it is starting its period of rapid growth. Planting at this time also helps it avoid mortality from sediment burial. It is remarkable that we were able to establish a solid vegetative barrier at this site since it is a crudely shaped gully with very poor, hard clay subsoil. We had to fight high velocities at some barriers and dry subsoil on the outer slopes during the summer.

Big sacaton plantings in the spring of 1997 and 1998 produced a summer survival rate of 86% in 1997 and 94% in 1998. However, the plants did not grow very tall or robust. The big sacaton plants were planted about 23 centimeters away from the established vetiver plants and thus had to compete with the vetiver for light and moisture. Since the big sacaton plants were only about 23 centimeters tall versus the 91 centimeters tall vetiver plants, they were at an extreme disadvantage. The competition plus the nature of the poor clay subsoil made it hard for these plants to grow very big. This subsequently resulted in numerous small gaps of 10 centimeters in width between plants.

Results of the topographic surveys are presented in table 12 and table 13. At site A terraces 1, 4, 5, 7, 11 and 12 all accumulated significant amounts of sediment, ranging from 5 inches to 8 inches both at the barrier and four feet upstream. The other terraces either revealed slight sediment accumulations or little change. However, where vegetative barriers had steep, bare, side slopes, like barriers 5 and 11, soil was redistributed across the basin. Figure 1 shows sediment gains or losses at selected vegetative barriers.

In general, the vegetative barriers have helped to keep this gully stable and noneroding whereas an adjacent gully has substantially eroded. Initial measurements on October 7, 1996 of this untreated gully had measurements of its two gully heads of 73 feet and 100 feet from an established benchmark. On January 5, 1999, the measurements were 66 feet and 90 feet from the benchmark. At approximately 7 feet deep by ten feet wide, there was a loss at this gully of approximately 1,190 cubic feet of sediment over a 27-month period.

This treatment site provided us with a great deal of insight on the parameters necessary for establishing a vegetative barrier. Immediately after planting on September 18, 1996, an estimated ten-year rainfall event (3.5'" in 6 hrs) occurred that washed out several of the vegetative barriers. Severe runoff broke the straw bundles and dislodged the plants. At high velocities, straw bundles staked through the middle will not stay secured. They must be staked and woven down with baling string. We resecured all the bundles on September 19, 1996, and they have remained secure throughout the study.

Vegetative barriers 4,5,6,7 and 10 developed plunge pools because of the high velocity of the surface runoff (Table 14). This forced us to add concrete cylinders at these locations. We were afraid that the deep plunge pools would threaten the stability of the entire gully treatment.

Vegetative barriers 8 and 14 had velocities greater than vegetative barriers 4 and 7, which failed. The difference between these barriers and the ones that failed were the length and steepness of upstream conditions and narrowness of the channel downstream of the vegetative barrier.

Vegetative barrier 3 stayed stable with a barrier length of 30 feet and a slope greater than 10% for 60 feet upstream. Vegetative barrier 4 failed with an average slope greater than 10% for 80 feet upstream. The channel width for barrier number 4 was only 20 feet and narrowed to 15 feet directly below the barrier. The velocity as it approached vegetative barrier 5 was 7.7 feet per second (ft./sec.). This velocity on the bare soil below barrier 4 is what caused the plunge pool, which required remedial treatment.

Vegetative barrier number 10 failed with a slope of 9% for 30 feet upstream. Vegetative barrier 10 had a channel width of only 15 feet that narrowed to five feet directly below the barrier. Again, the velocity below the barrier was well over 7 ft./sec. and caused the plunge pool that nearly undermined the vegetative barrier.

Vegetative barrier 8 stayed stable despite a velocity of 6 ft./sec. and a channel width that was 15 feet both at the barrier and downstream of the barrier. The slope averaged less than 6% for over 80 feet upstream and the downstream barrier had a velocity of only 5.2 ft./sec. Vegetative barrier 14 also stayed stable with a velocity of approximately 6 ft./sec. The slope was roughly 7.5% and the channel width was 20 feet. Thirty feet upstream the slope was less than 4% and the velocity was less than 4 ft./sec., while downstream the slope flattened out and the velocity was less than 6 ft./sec.

It appears at our site that vegetative barriers will be stable when constructed appropriately for velocities at 4 ft./sec. and volume less than 50 cubic ft./sec. Vegetative barriers will probably be stable at higher velocities up to 6 ft./sec. when the channel width is constructed and maintained at a consistent width at the barrier and downstream of the barriers. Optimum channel width for the grass hedges at our site was between twenty and thirty feet wide. Vegetative barrier length should be based on the width determined by the grass waterway calculation and should extend a minimum of 1 ½ to 2 feet in vertical height. Extending the height up to 2 feet allows for increased sediment capacity and helps prevent water flow around the barrier ends. Side slopes should be a minimum of 10:1 or gentler to prevent erosion on these slopes. It is recommended that any treatment gully be designed as a waterway in the shape of a trapezoid with a consistent flat bottom (figure 2). The limiting factor on velocity should be the soil velocity relationship. "Permissible velocities for channels lined with vegetation" and "Permissible velocity for vegetated spillways" in the SCS-TP-61 handbook provides a useful guide for this relationship (Table 15) and (Table 16). At our site, which had erosion resistant soils and slopes between 5-10%, the suggested permissible velocity would be 3.5 ft/sec. This is the permissible velocity suggested for native grass mixtures, and the suggested value for the bare soil, native plant composition that existed at our test site. At this time, we would not recommend exceeding the velocities established for specified seed mixtures for newly constructed sites. As a repair or secondary treatment for existing vegetated sites or grass waterways we might be able to use vegetative barriers at increased velocities of 1 to 2 ft./sec. above these levels.

TABLE 6:

Monthly Rainfall Totals and High and Low Temperatures at Kenney/Bellville TX

MONTH	TEMPERATURE (°F) HIGH		LOW		RAINFALL (INCHES)	
	1997	1998	1997	1998		
January	80	78	25	36	4.81	2.48
February	82	79	34	35	6.10	6.23
March	88	86	40	30	5.95	2.61
April	88	90	41	46	5.03	2.02
May	94	102	57	61	6.24	0.03
June	95	107	63	66	4.85	0.09
July	103	108	73	75	1.69	.073
August	104	108	69	74	3.22	6.68
September	102	104	60	72	3.57	11.26
October	95	94	42	48	8.29	15.67
November	89	84	39	44	6.16	11.51
December	78	81	27	22	5.25	2.86
				TOTAL	61.16	62.98

TABLE 7:

Vegetation Results from April 1997 Planting of Big Sacaton at the Kott Study Site in Kenney, TX.

SITE A

BARRIER	PERCENT SURVIVAL			STEM DENSITY (#/ft^2)			HEIGHT (cm)		
	9/97	3/98	11/98	9/97	3/98	11/98	9/97	3/98	11/98
1	100	100	100	2	2	2	54	54	69
2	100	100	94	3	3	6	67	67	80
3	100	100	100	6	6	7	61	61	82

BARRIER	BASE WIDTH (cm)			GAPS (# spaces > 15cm)			LARGEST GAP (cm)		
	9/97	3/98	11/98	9/97	3/98	11/98	9/97	3/98	11/98
1	4	4	8	1	1	1	19	19	20
2	4	4	8	2	2	2	16	16	25
3	4	4	8	0	0	1	12	12	18

TABLE 8:

Vegetation Results from April 1997 Planting of Big Sacaton at the Kott Study Site in Kenney, TX.

SITE B

BARRIER	PERCENT SURVIVAL			STEM DENSITY ($\#/ft^2$)			HEIGHT (cm)		
	9/97	3/98	11/98	9/97	3/98	11/98	9/97	3/98	11/98
1	100	100	100	14	14	9	56	56	77
2	100	100	100	10	10	14	59	59	85
3	100	100	100	6	6	6	66	66	80

BARRIER	BASE WIDTH (cm)			GAPS (#spaces > 15cm)			LARGEST GAP (cm)		
	9/97	3/98	11/98	9/97	3/98	11/98	9/97	3/98	11/98
1	4	4	15	0	0	0	9	9	0
2	4	4	13	0	0	0	10	10	0
3	5	5	8	0	0	0	8	8	0

TABLE 9:

Elevation in Feet at the Vegetative Barrier at the Kott Study Site in Kenney, Texas.

SITE A

TERRACE **DATE** **STATIONS**

TERRACE	DATE	1	2	3	4	5
1	7/29/97	96.2	95.5	95.1	95.4	96.4
	2/12/98	96.2	95.7	95.1	95.6	96.5
	6/23/98	96.2	95.7	95.1	95.6	96.5
	1/5/99	96.2	95.6	95.1	95.6	96.5
2	7/29/97	94.8	93.3	93.0	93.4	93.5
	2/12/98	94.9	93.4	93.0	93.5	93.6
	6/23/98	94.9	93.5	93.0	93.5	93.6
	1/5/99	94.9	93.5	93.0	93.5	93.5
3	7/29/97	92.3	91.5	90.9	91.9	92.8
	2/12/98	92.4	91.6	91.0	92.0	92.9
	6/23/98	92.2	91.7	91.0	92.0	93.0
	1/5/99	92.4	91.6	91.0	92.1	92.9

SITE B

TERRACE **DATE** **STATIONS**

TERRACE	DATE	1	2	3	4	5
1	4/15/97	95.2	94.6	94.2	95.0	95.5
	7/29/97	95.2	94.5	94.2	95.0	95.4
	2/12/98	95.4	94.7	94.3	95.1	95.6
	6/23/98	95.3	94.7	94.4	95.1	95.5
	1/5/99	95.3	94.7	94.4	95.1	95.5
2	4/15/97	93.5	93.2	92.6	93.2	94.2
	7/29/97	93.5	93.2	92.7	93.3	94.2
	2/12/98	93.6	93.4	92.8	93.4	94.3
	6/23/98	93.7	93.3	92.8	93.4	94.3
	1/5/99	93.7	93.3	92.8	93.4	94.3
3	4/15/97			90.0.	91.5	
	7/29/97		92.0	90.1	91.2	
	2/12/98			90.2	91.3	
	6/23/98		92.2	90.2	91.7	
	1/5/99		92.2	90.2	91.7	

TABLE 10:

Vegetation Results from Planting of Vetiver Grass at the Myska/Koy Study Site in Kenney, TX.

SITE A

BARRIER	PERCENT SURVIVAL				STEM DENSITY (#/ft ^{2})				HEIGHT (cm)			
	5/97	9/97	3/98	11/98	5/97	9/97	3/98	11/98	5/97	9/97	3/98	11/98
1	50	89	60	100	5	0		13	64	70		122
2	67	89	87	100	3	3		8	53	79		111
3	60	100	90	100	5	6		17	63	89		136
4	22	83	86	100	3	8		10	64	84		119
5	58	93	100	95	4	8		12	51	87		124
6	39	100	100	95	4	12		11	63	91		115
7	58	80	100	95	6	3		3	54	82		105
8	50	100	100	92	3	3		9	47	91		123
9	58	100	100	92	8	15		18	48	91		138
10	80	100	100	100	7	9		10	62	91		126
11	93	92	100	100	9	4		1	61	87		93
12	70	100	100	100	6	3		6	52	89		119
13	71	86	100	95	5	2		2	54	84		103
14	93	86	100	100	8	1		4	56	86		108

SITE B

BARRIER	PERCENT SURVIVAL				STEM DENSITY (#/ft ^{2})				HEIGHT (cm)			
	5/97	9/97	3/98	11/98	5/97	9/97	3/98	11/98	2/97	9/97	3/98	11/98
1	58	83	100	100	5	9		4	73	86		120
2	55	80	83	93	6	9		11	57	85		126
3	50	100	100	100	11	4		17	58	77		143

TABLE 10: Continued

Vegetation Results from Planting of Vetiver Grass at the Myska/Koy Study Site in Kenney, TX.

SITE A

BARRIER	BASE WIDTH (cm)				GAPS (# spaces > 15cm)				LARGEST GAP (cm)			
	5/97	9/97	3/98	11/98	5/97	9/97	3/98	11/98	5/97	9/97	3/98	11/98
1	2	4.3		13	12	6		2	74	25		18
2	1	8		12	24	6		0	103	91		0
3	2	8		20	17	4		2	115	91		36
4	2	8		13	9	2		1	72	144		30
5	2	8		17	8	2		0	136	37		0
6	2	10		14	7	2		1	91	23		20
7	2	7		13	3	0		0	305	0		0
8	1	7		13	9	3		0	89	30		0
9	1	11		22	7	2		0	198	47		0
10	1	8		13	5	6		0	137	49		0
11	2	7		10	1	0		0	19	0		0
12	1	6		13	5	1		0	33	27		0
13	2	7		12	9	0		0	61	0		0
14	2	8		10	2	0		0	19	0		0

SITE B

BARRIER	BASE WIDTH (cm)				GAPS (#spaces > 15cm)				LARGEST GAP (cm)			
	5/97	9/97	3/98	11/98	5/97	9/97	3/98	11/98	5/97	9/97	3/98	11/98
1	2	7		12	7	3		0	86	24		0
2	1	14		14	8	6		0	67	80		63
3	2	5		16	8	1		2	91	33		30

TABLE 11

Vegetation Results from Planting of Big Sacaton at the Myska/Koy Study site in Kenney Texas

SITE A

BARRIER	PERCENT SURVIVAL			STEM DENSITY (#/ft^2)			HEIGHT (cm)		
	9/97	3/98	11/98	9/97	3/98	11/98	9/97	3/98	11/98
1	50	93	100	0		1	7.5		41
2	83	82	100	0		1	11		23
3	100	83	80	1		0	29		17
4	78	75	100	0		1	16		29
5	100	86	80	0		0	12		19
6	89	100	100	0		0	25		24
7	100	60	100	0		0	23		19
8	50	89	100	0		0	18		13
9	100	100	100	0		0	23		25
10	100	100	62	0		0	22		20
11	72	100	50	0		0	21		15
12	89	100	83	1		0	16		21
13	100	89	83	0		0	12		19
14	86	100	75	1		0	16		18

SITE B

BARRIER	PERCENT SURVIVAL			STEM DENSITY (#/ft^2)			HEIGHT (cm)		
	9/97	3/98	11/98	9/97	3/98	11/98	9/97	3/98	11/98
1	100	89	83	0		0	12		27
2	100	89	60	0		1	19		45
3	89	89	75	0		0	27		16

TABLE 11 Continued

Vegetation Results from Planting of Big Sacaton at the Myska/Koy Study site in Kenney Texas

BARRIER	BASE WIDTH (cm)			GAPS (# spaces > 15cm)			LARGEST GAP (cm)		
	9/97	3/98	11/98	9/97	3/98	11/98	9/97	3/98	11/98
1	1		5			1			30
2	1		5			2			30
3	1		3			8			76
4	1		5			1			46
5	1		3			3			66
6	2		5			4			20
7	1		5			5			30
8	1		3			4			53
9	2		3			5			30
10	2		3			2			23
11	2		3			5			56
12	3		4			5			46
13	1		5			8			91
14	2		4			5			122

SITE B

BARRIER	BASE WIDTH (cm)			GAPS (# spaces > 15cm)			LARGEST GAP (cm)		
	9/97	3/98	11/98	9/97	3/98	11/98	9/97	3/98	11/98
1	1		3			6			48
2	2		3			5			30
3	2		3			4			30

TABLE 12

Elevation in feet at the vegetative barrier site at the Myska/Koy study site in Kenney, Texas

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SITE A

TERRACE	DATE	STATIONS 1	2	3	4	5
1	7/30/97	115.6		115.2		115.5
	2/11/98	115.6		115.6		115.6
	3/28/98	115.6	115.7	115.3	115.1	115.5
	6/24/98	115.5	115.4	115.3	115.1	115.5
	1/699	115.8	115.7	115.6	115.0	115.5
2	7/30/97	111.9	111.2	110.9		112.3
	2/11/98	111.8	111.2	110.9		112.2
	6/24/98	111.7	111.2	110.8		112.2
	1/6/99	111.7	111.1	110.9		112.1
3	9/19/96	111.3	109.0	108.5	109.1	110.4
	4/18/97	111.1	108.9	108.5	109.1	110.4
	7/30/97	111.2	109.1	108.7	109.3	110.5
	2/11/98	111.1	108.9	108.5	109.2	110.4
	6/24/98	111.2	108.8	108.6	109.2	110.5
	1/6/99	111.1	108.9	108.4	109.1	110.4
4	9/19/96	108.5	107.3	106.5	107.4	108.5
	4/18/97	108.4	107.2	106.7	107.3	108.3
	7/30/97	108.5	1075	106.9	106.7	108.4
	2/11/98	108.4	107.4	106.9	107.5	108.4
	6/24/98	108.5	107.4	106.9	107.5	108.4
	1/6/99	108.3	107.4	106.1	107.4	108.2
5	9/19/96	107.3	105.6	104.5	105.4	107.6
	4/18/97	107.2	105.6	104.7	105.5	107.4
	7/30/97	107.3	105.7	104.9	105.5	107.6
	2/11/98	107.1	105.6	104.9	105.4	107.4
	6/24/98	107.2	105.6	105.0	105.5	107.5
	1/6/99	107.1	105.7	105.2	105.5	107.3

TABLE 12 Continued

Elevation in feet at the vegetative barrier site at the Myska/Koy study site in Kenney, Texas

SITE A

TERRACE	DATE	STATIONS 1	2	3	4	5
6	9/19/96	106.0	103.1	102.7	102.9	105.4
	4/18/97	106.0	103.4	102.5	102.9	105.5
	7/30/97	106.1	103.5	102.7	103.1	105.6
	2/11/98	105.9	103.4	102.7	103.0	105.4
	6/24/98	106.0	103.4	102.7	103.0	105.4
	1/24/99	105.8	103.4	102.9	103.5	105.3
7	9/16/96	103.7	101.6	100.6	101.2	102.9
	4/18/97	103.7	101.6	100.8	101.3	102.8
	7/30/97	103.9	101.8	100.9	101.4	103.0
	2/11/98	103.7	101.8	100.9	101.4	102.9
	6/24/98	103.9	101.7	101.0	101.4	103.0
	1/6/99	103.7	101.7	101.0	101.4	102.9
8	7/30/97	101.0	99.5	98.8	98.9	101.3
	2/11/98	100.8	99.5	98.7	98.8	101.1
	6/24/98	100.6	99.5	98.7	98.8	101.2
	1/6/99	100.8	99.5	98.9	98.9	101.1
9	9/16/96	98.9	97.6	96.9	97.1	99.8
	4/18/97	98.9	97.5	96.7	97.2	99.9
	7/30/97	98.9	97.5	96.8	97.2	99.9
	2/11/98	98.9	97.5	96.7	97.2	99.8
	6/24/98	98.9	97.5	96.6	97.2	99.8
	1/6/99	98.9	97.5	97.1	97.2	99.8
10	9/16/96	97.5	95.0	94.6	95.8	97.5
	4/18/97	96.2	95.0	94.1	95.8	96.9
	7/30/97	96.4	94.9	94.5	95.8	96.9
	2/11/98	96.4	94.9	94.4	95.7	96.7
	6/24/98	96.4	94.9	94.2	95.7	96.8
	1/6/99	96.4	95.0	94.8	95.8	96.8

TABLE 12 Continued

Elevation in feet at the vegetative barrier site at the Myska/Koy study site in Kenney, Texas

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SITE A

TERRACE	DATE	STATIONS 1	2	3	4	5
11	9/19/96	95.1	92.3	91.3	92.4	95.5
	4/18/97	93.9	92.5	91.4	92.3	94.4
	7/30/97	94.2	92.5	91.5	92.4	94.5
	2/11/98	94.0	92.4	91.6	92.3	94.4
	6/24/98	94.1	92.6	91.5	92.4	94.4
	1/6/99	94.0	92.5	91.7	92.4	94.4
12	7/30/97	92.0	90.0	89.6	89.9	92.4
	2/11/98	91.8	90.0	89.9	89.8	92.4
	6/24/98	92.0	90.1	90.1	90.0	92.6
	1/6/99	92.0	90.1	90.1	90.1	92.5
13	7/30/97	90.2	88.8	88.1	88.8	90.8
	2/11/98	90.2	88.7	88.0	88.7	90.7
	6/24/98	90.4	88.8	88.0	88.8	90.8
	1/6/99	90.2	88.7	88.0	88.7	90.9
14	7/30/97	88.1	86.7	85.4	87.1	88.8
	2/11/98	88.2	86.6	85.2	87.0	88.7
	6/24/98	88.3	86.7	85.4	87.0	88.8
	1/6/99	88.2	86.6	85.5	87.1	88.8

TABLE 13

Elevation in Feet at the Vegetative Barriers at the Myska/Koy Study Site in Kenney, Texas

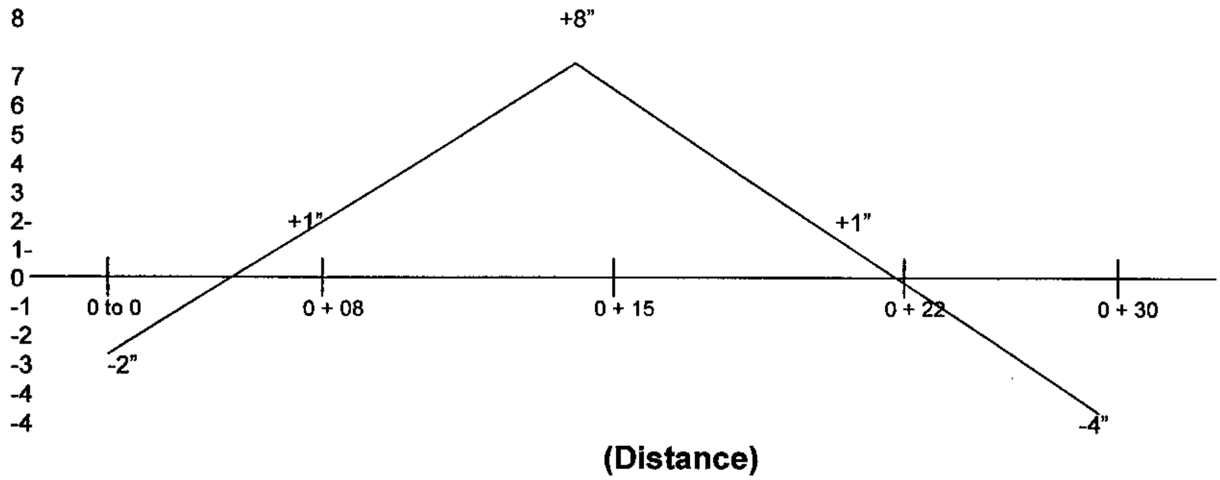
SITE B

TERRACE	DATE	STATIONS 1	2	3	4	5
1	9/16/96	102.9	102.2	101.3	101.8	102.9
	7/30/97	102.8	102.2	101.3	101.8	103.0
	2/11/98	102.9	102.2	101.4	101.8	103.0
	6/23/98	102.9	102.2	101.3	101.7	103.0
	1/5/99	102.8	102.2	101.8	101.8	103.0
2	9/19/96	101.4	100.1	99.4	99.9	100.8
	10/10/96	101.4	100.1	99.4	99.7	100.9
	4/18/97	101.4	100.0	99.3	99.5	100.9
	7/30/97	101.4	100.1	99.4	99.5	100.9
	2/11/98	101.3	100.0	99.3	99.6	100.9
	6/23/98	101.3	100.1	99.4	99.6	100.9
	1/2/99	101.3	100.0	99.3	99.6	100.9
3	10/10/96	99.3	97.9	96.9	97.8	99.6
	4/18/97	99.2	97.9	96.7	97.9	99.6
	7/30/97	99.2	97.9	96.7	98.0	99.6
	2/11/98	99.2	97.9	96.7	97.8	99.6
	6/23/98	99.2	97.9	96.7	97.8	99.6
	1/5/99	99.2	97.9	96.8	97.8	99.6

FIGURE 1

Sediment Gains or Losses (in inches) at selected Vegetative Barriers at the Myska/Koy Study Site A in Kenney, Texas

TERRACE 5



TERRACE 12

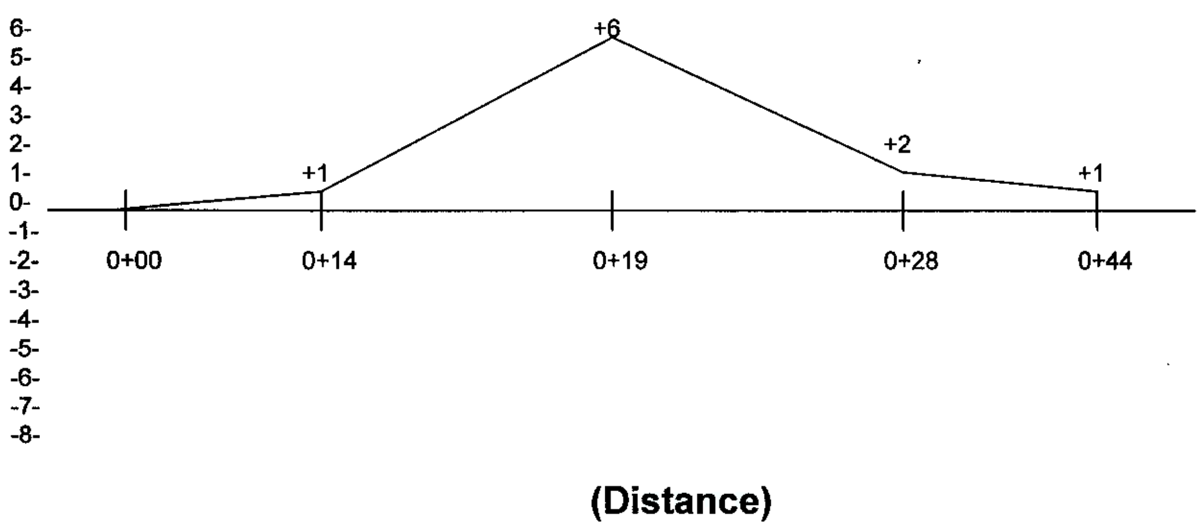


FIGURE 1 CONTINUED

Sediment Gains or Losses (in inches) at selected Vegetative Barriers at the Study Site in Kenney, Texas

TERRACE 7

TERRANCE 11

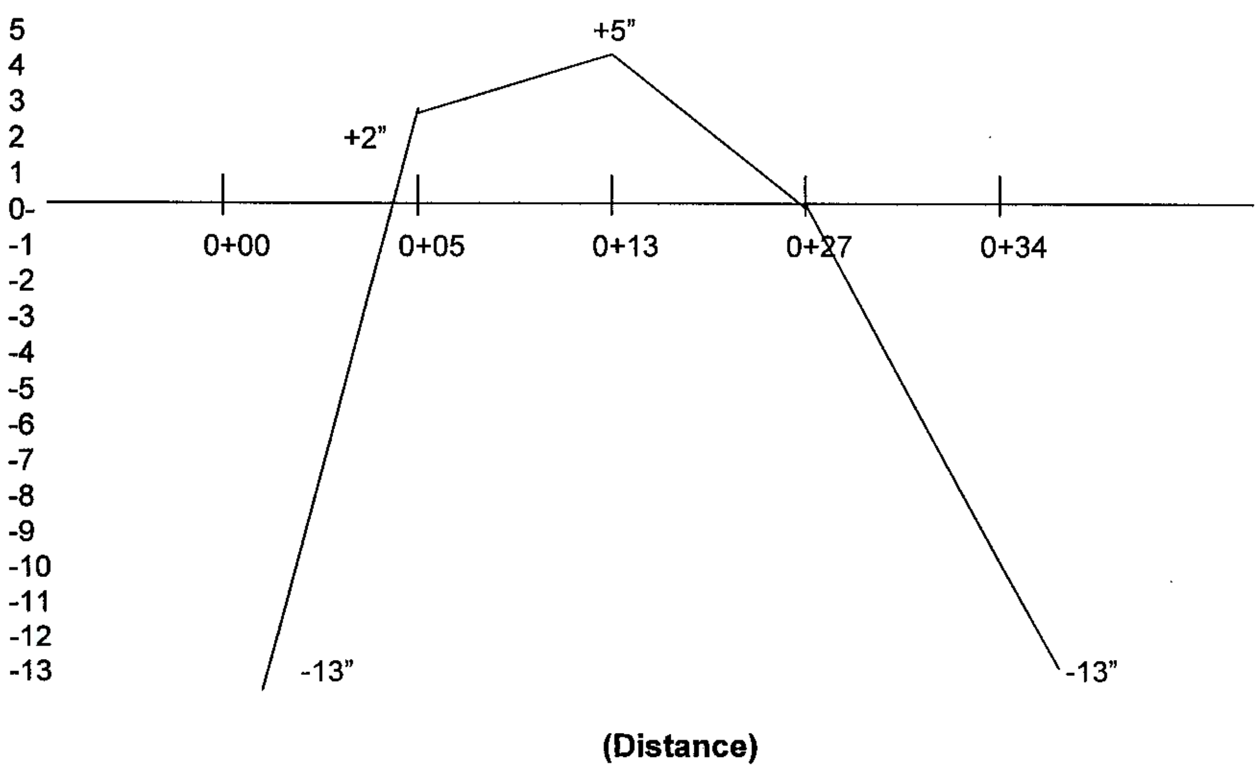


FIGURE 2

Trapezoidal design of a vegetative barrier.

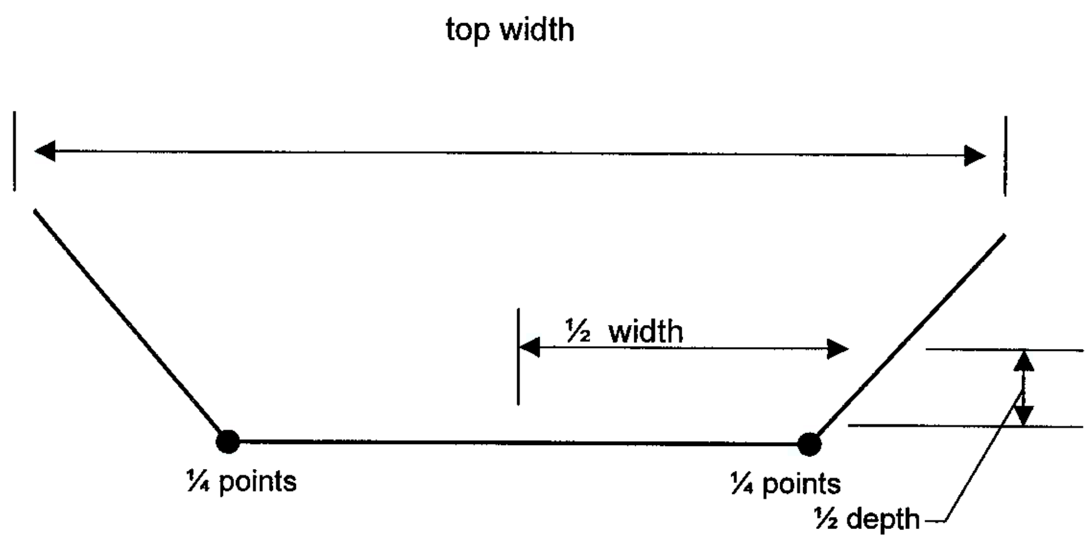


TABLE 14

Velocity and Discharge of Surface Runoff at the Vegetative Barriers at the Mysksa/ Koy Study Site in Kenney, Texas

SITE A

BARRIER	DISCHARGE (CFS)	VELOCITY (FT./SEC)	PLUNGE POOL (FT)
1	27	2.7	
2	27	2.5	
3	27	3.8	
4	35	4.9	2
5	40	7.7	1.7
6	40	9.6	2.1
7	40	5.4	2.0
8	47	6.1	
9	47	5.2	
10	47	7.0	1.8
11	47	4.5	
12	52	3.5	
13	52	3.5	
14	52	6.0	

SITE B

BARRIER	DISCHARGE (cfs)	VELOCITY (ft./sec)	PLUNGE POOL (ft)
1	34	2.93	
2	34	6.70	2.5
3	34	6.70	2.4

TABLE 15

Permissible velocities for channels lined with vegetation[1]. The values apply to average, uniform stands of each type of cover

COVER SOILS		SLOPE RANGE[2]	PERMISSIBLE VELOCITY EROSION RESISTANT SOILS	EASILY ERODED SOILS
		Percent	Ft. per. sec.	Ft. per. sec.
Bermudagrass	}.........	0-5	8	6
		5-10	7	5
		over 10	6	4
Buffalograss Kentucky bluegrass Smooth brome Blue grama	}.........	0-5 5-10 over 10	7 6 5	5 4 3
Grass mixture	}.........	[2]0-5	5	4
		5-10	4	3
Lespedeza sericea Weeping lovegrass Yellow bluestem Kudzu Alfalfa Crabgrass	}.........	[3]0-5	3.5	2.5
Common lespedeza[4] Sudamgrass[2]	}............	[5]0-5	3.5	2.5

[1]Use velocities exceeding 5 feet per second only where good covers and proper maintenance can be obtained.
[2]Do not use on slopes steeper than 10 percent, except for side slopes in a combination channel.
[3]Do not use on slopes steeper than 5 percent, except for side slopes in a combination channel.
[4]Annuals—used on mild slopes or as temporary protection until permanent covers are established
[5]Use on slopes steeper than 5 percent is not recommended.

TABLE 16

Permissible velocity for vegetated spillways[1]

Vegetation	Permissible velocity[2]: Erosion-resistant soils[3], Slope of exit Channel, pct 0-5 (ft/s)	Erosion-resistant soils[3], Slope of exit Channel, pct 5-10 (ft/s)	Easily eroded soils[4], Slope of exit channel, pct 0-5 (ft/s)	Easily eroded soils[4], Slope of exit channel, pct 5-10 (ft/s)
Bermudagrass Bahiagrass	8	7	6	5
Buffalograss Kentucky bluegrass Smooth brome Tall fescue Reed canarygrass	7	6	5	4
Sod-forming Grass-legume Mixtures	5	4	4	3
Lespedeza sericea Weeping lovegrass Yellow bluestem Native grass mixtures	3.5	3.5	2.5	2.5

[1]SCS-TP-61

[2]Increase values 10 percent when the anticipated average use if the spillway is not more frequent than once in 5 years, or 25 percent when the anticipated average use is not more frequent than once in 10 years.

[3]Those with a higher clay content and higher plasticity. Typical soil textures are silty clay, sandy clay, and clay.

[4]Those with a high content of fine sand or silt and lower plasticity, or non-plastic. Typical soil textures are fine sand, silt, sandy loam, and silty loam.

SAN ANTONIO – BEXAR COUNTY

Stanush Study Site

Table 17 shows the results of our vegetation surveys at the Stanush study site. Switchgrass transplants installed in March of 1997 survived and grew vigorous in the first year at barriers 1, 2, 3, and 6. At barriers 4A, 7A and 8A, no switchgrass plants became established from the switchgrass seeding at the 100 pounds per acre seeding rate. At barrier 5A, only a 33% stand of switchgrass was established from seeding and installation of a turf reinforcement mat.

Attempts at installing a seeded row of 1"x1"x6" switchgrass transplants next to the established rows of switchgrass in October 1997 were unsuccessful. The planting of a double row of vetiver grass and switchgrass at barriers 4B, 5B, 7B and 8B in April 1998 was also unsuccessful. However, we learned several things from these plantings. Switchgrass transplants can not compete in an established bermuda grass waterway. Established switchgrass also appears to be weakening and becoming thinner.

Vetivergrass grown in 3"x3"x6" paper bands had better survival rate than bare-root vetiver transplants in the dry year of 1998 (Table 18). The vetiver in paper bands had survival rates that ranged from 18% to 90% at barriers 4B, 5B, 7B and 8B, where as the bare-root transplants had survival rates of 5% to 18%. The vetivergrass also appears to compete better with bermudagrass than switchgrass.

In March of 1999, we replanted barriers 4 and 5. We installed a double row of vetivergrass and switchgrass. We sprayed a 20-foot area of bermudagrass with roundup one month prior to planting. After planting, we watered all the transplants. We had virtually a 100% survival from this planting on rows 4C and 5C. Adequate spring moisture secured establishment of this planting despite a very dry summer. The only mortality occurred where cows were allowed to graze and bed down on the barrier, which was evident in the gaps at row 5C.

Results of the topographic surveys are presented in Table 19. Barrier one is the only barrier that captured sediment. In the middle of the barrier as much as 5" was captured at the barrier, as well as 7" at 4 feet upstream and 4" at twenty feet upstream. Barrier one did not have a straw bundle but stayed stable at estimated 10-year storm velocities of 1.2 feet per second. The other three barriers either had no change or lost 1-2 inches of sediment. These barriers lost sediment primarily from the outside edges where the switchgrass was thinner from competing with bermudagrass under extremely droughty conditions. Although some soil was lost from this site, despite both vegetative barriers and a grass waterway, it is our feeling that even more soil would have been lost without them. The vegetative barriers have helped slow down the water in the waterway as well as spread out the water flows and sediment deposits. This was especially noticeable following the floods of October 1998. It is our recommendation that where vegetative barriers are to be employed on a bermudagrass waterway that vetiver be the species of choice.

Rakowitz Study Site

The October 1997 and the March 1998 seedings of switchgrass were complete failures. 1998 was an extremely dry year but the fall of 1997 had good soil moisture and moderate temperatures. It has been our experience at this location and other sites that seeding switchgrass on heavy clay soils has provided very poor grass stands. We recommend that switchgrass seedings be limited to the coarser textured loams and sandy soils.

We seeded eastern gamagrass in March 9, 1999 in two rows at a rate of 3-4 pure live seed per foot at 1-2 inch planting depth. We ended up in December 1999 with a 20% stand. Although the stand was better with eastern gamagrass than with switchgrass, it still was not adequate. We would like to evaluate another seeding of eastern gamagrass before completely disgarding it as a viable option for a vegetative barrier. Economically, seeding provides the most attractive method for establishing a vegetative barrier. However, in Texas it may be effective only for the coarser textured soil.

An alternative to seeding is the transplanting of small 1"x3" plants with a mechanical transplanter. In April, 1998 and in April 1999 we transplanted 1"x3" switchgrass plants as a double row at a 7-inch spacing. Table 20 shows the vegetative results of these transplants at the Rakowitz study site. Barrier A-4 and B-4 had only a 25% survival rate in the extremely dry year of 1998. But in 1999, the switchgrass transplants had a 100% survival rate. This method seems extremely practical for establishing vegetative barriers on heavy clay soil of cropland in South Central Texas.

Barriers A-1, A-2, A-3, and B-2 and B-3 averaged a winter survival rate of 80% from hand transplanting of switchgrass in October 1997. The 3"x6" container material had an 84% survival rate but the smaller material in the 1"x3" or 1"x6" containers had a 73% survival rate. It appeared that the main reason for mortality was that the small plants got bent over and buried by sediment in these concentrated flow zones especially at the straw bundles.

Spot planting was done in the spring of 1998. However, the extremely dry year of 1998 saw the average survival rate fall to 72% and by the spring of 1999, the average rate was at 68% and the second row of small transplants was at 38%. The established switchgrass survived the drought adequately but small transplants had a very difficult time. Furthermore, in October of 1998 when the drought finally broke a 100-year storm event scoured out many of the small plants.

Based on our experience at this site, we recommend that a double row of transplants be installed in the spring. Transplants should have at least 6" of top growth to prevent and this should allow them to outgrow any sediment deposits. Furthermore, the landowner should be prepared to water the transplants in the concentrated flow zone both at planting and periodically during the summer if an extreme drought persists.

Table 20 shows the largest gaps for barriers A-2, A-3, B-2 and B-3 exceeding 30 centimeters in November, 1998. These large gaps were primarily caused by scouring around the edges of the vegetative barriers. The barriers extended in length to a vertical height of roughly .5 feet. It is our recommendation that the vegetative barrier extend in length to a vertical height of 1.5-2 feet. If this is not done, then sediment that is captured behind the barrier will flatten out the basin and cause water to try to flow around the outer edges.

The results of the topographic surveys are presented in Table 21. Sediment was either captured at these barriers or there was no change in elevation. Sediment deposits ranged from 2 inches to 5 inches. It is interesting to note that even without a solid vegetative stand these barriers maintained stability and captured sediment under a 100-year storm event in October of 1998.

Estimations using the Universal Soil Loss Equation (USLE) indicate that conventional tillage of sorghum at this site results in the loss of roughly 29 tons/acre of soil. Using the vegetative barriers, the soil loss was reduced by 5 tons/acre. When the vegetative barriers were incorporated with conservation tillage the soil loss was reduced to 11 tons/acre. If the farmer adjusts his crop sequence to include an alternating year of either hay grazer or wheat the soil loss is only 5 tons/acre which is the soil loss tolerance established by NRCS for this soil.

TABLE 17

Vegetation Results from Plantings at Stanush Study Site in San Antonio, Texas

BARRIER	PERCENT SURVIVAL					STEM DENSITY(#/ft²)				HEIGHT (cm)			
	10/97	4/98	11/98	4/99	12/99	10/97	11/98	4/99	12/99	10/97	11/98	4/99	12/99
1-Switchgrass transplants	100	100	89	83	83	23	30	19	37	73	78	61	66
Row 2-Switchgrass		0	0										
2-Switchgrass transplants and bundle	100	100	100	93	100	20	15	18	22	67	70	67	65
Row 2-Switchgrass		50	0										
3-Switchgrass transplants and bundle	100	100	100	93	100	25	31	38	37	73	76	74	73
Row 2-Switchgrass		17	0										
4A-Switchgrass Seed	0												
4B-Vetiver grass		5/22											
Row 2-Switchgrass		0											
4C-Vetiver					100				5				77
Row 2-Switchgrass					100				11				
5A-TRM and Seed	33					5				43			
5B-Vetiver		5/18											
Row 2-Switchgrass		0											
5C-Vetiver					83				8				69
Row 2-Switchgrass					100				9				13
6-Switchgrass transplants	100	100	100	100	100	26	49	75	59	77	83	82	77
Row 2-Switchgrass		33	0										
7A-Seed and Bundle	0												
7B-Vetiver				10/90	20/90				0/3				44/66
Row 2-Switchgrass				0	0								
8A-Seed	0												
8B-Vetivergrass			18/90		25/100				0/1				39/63
Row 2-Switchgrass			0										

TABLE 17 CONTINUED

Vegetation Results from Plantings at Stanush Study Site in San Antonio, Texas

Barrier	Base Width (cm)				Gaps (# spaces > 15cm)				Largest Gap (cm)			
	10/97	11/98	4/99	12/99	10/97	11/98	4/99	12/99	10/97	11/98	4/99	12/99
1-Transplants	7	11	11	14	0	1	5	4	13	33	30	30
2-Transplant/bundle	5	0	8	11	3	0	0	0	20	15	15	13
3-Transplant/bundle	5	15	13	13	0	1	3	4	10	43	20	48
4C-Vetivergrass and Switchgrass				10 9				0 0				13 13
5A-TRM and Seed	3								3meters			
5C-Vetiver and Switchgrass				9 7				1 9				53 76
6-Transplants	6	15	14	14	0	3	2	2	13	30	20	30
7B-Vetivergrass				6/10				3/5				183/38
8B-Vetivergrass				6/10				5/5				91/18

TABLE 18

Monthly Rainfall Totals and High and Low Temperatures at San Antonio, Texas

MONTH	TEMPERATURE (°F) HIGH			TEMPERATURE (°F) LOW			RAINFALL (inches)		
	1997	1998	1999	1997	1998	1999	1997	1998	1999
January	84	81	82	24	35	23	0.70	1.33	0.23
February	82	81	89	31	35	29	3.35	2.52	0.0
March	88	87	91	40	32	32	2.73	1.46	0.20
April	91	88	89	40	40	37	4.28	0.12	1.32
May	97	100	93	52	58	53	4.29	0.0	2.78
June	98	107	95	52	64	69	10.21	0.0	3.37
July	98	103	99	66	73	69	0.03	0.0	1.97
August	101	103	104	68	69	71	0.36	6.74	2.11
September	100	94	99	60	70	49	0.32	2.62	0.22
October	94	93	93	38	45	41	6.60	13.20	0.87
November	80	81	84	32	45	31	1.68	2.70	0.09
December	77	80	83	25	23	25	2.23	0.04	0.22
						TOTAL	36.78	31.09	13.38

TABLE 19

Elevation in Feet at the Vegetative barriers at the Stanush Study Site in San Antonio, Texas

TERRACE	DATE	STATIONS 1	2	3	4	5
1	3/26/97	95.7		94.7		95.8
	7/15/97	95.6		94.5		95.7
	1/27/98	95.6		94.6		95.8
	6/30/98	95.6		94.9		95.8
	1/14/99	95.5		95.1		95.7
	7/27/99	95.5		95.1		95.7
	12/3/99	95.4		95.0		95.7
2	3/26/97	94.5	94.4	93.1	94.0	94.3
	7/15/97	94.5	94.3	93.0	93.9	94.3
	1/27/98	94.5	94.2	92.9	93.9	94.3
	6/30/98	94.4	94.2	92.9	93.9	94.2
	1/14/99	94.3	94.1	93.2	93.8	94.1
	7/27/99	94.3	94.1	93.1	93.8	94.2
	12/3/99	94.2	94.1	93.2	93.8	94.2
3	3/26/97	92.0	91.3	90.4	91.2	
	7/15/97	92.0	91.2	90.4	91.1	
	1/27/98	92.0	91.1	90.4	91.1	91.8
	6/30/98	91.9	91.1	90.3	91.0	91.8
	1/14/99	91.9	91.2	90.5	91.3	92.0
	7/27/99	91.8	91.2	90.4	91.3	92.0
	12/3/99	91.7	91.2	90.5	91.3	92.0
6	3/26/97	85.0		83.8		85.2
	7/15/97	85.0		83.7		85.1
	1/27/98	84.9		83.7		85.1
	6/30/98	84.9		83.7		85.0
	1/14/99	85.0		83.7		85.1
	7/27/99	84.8		83.7		85.1
	12/3/99	84.8		83.8		85.0

TABLE 20

Vegetation Results from Switchgrass Plantings at the Rakowitz Study Site in San Antonio, Texas

Barrier	PERCENT SURVIVAL				STEM DENSITY($\#/ft^2$)				HEIGHT (cm)			
	4/98	11/98	4/99	12/99	4/98	11/98	4/99	12/99	4/98	11/98	4/99	12/99
A-1					6	69	71	111	23	79	89	134
Row 1	97	99	100	100								
Row 2		69	10									
A-2												
Row 1	91	72	83	100	6	42	52	75	23	75	91	120
Row 2	88	57	57									
A-3												
Row 1	88	83	77	83	6	34	42	59	23	74	80	137
Row 2	71	56	48									
B-2												
Row 1	73	90	97	83	6	25	39	40	23	75	71	120
Row 2	60	57										
B-3												
Row 1	72	90	100	83	6	20	24	27	23	75	71	120
Row 2		50	37									
A-4												
Row 1		25		100				12				63
Row 2		25		100				6				46
B-4												
Row 1		25		100				14				73
Row 2		25		100				5				23

BARRIER	BASE WIDTH (CM)				GAPS (# SPACES>15CM)				LARGEST GAP (CM)			
	4/98	11/98	4/99	12/99	4/98	11/98	4/99	12/99	4/98	11/98	4/99	12/99
A-1												
Row 1		10	13	15		1	1	2	15	20	20	18
Row 2												
A-2												
Row 1		13	13	15		10	11	8	15	91	91	89
Row 2												
A-3												
Row 1		11	14	15		4	8	6	15	79	79	76
Row 2												
B-2												
Row 1		7	10	15		4	2	2	15	51	33	53
Row 2												
B-3												
Row 1		9	13	14		3	0	2	15	66	0	56
Row 2												
A-4												
Row 1				8				0				15
Row 2				10				0				15
B-4												
Row 1				8				0				15
Row 2				8				1				30

TABLE 21

Elevation in Feet at the Vegetative Barrier at the Rakowitz Study Site in San Antonio, Texas

TERRACE	DATE	STATIONS 1	2	3
A-1	10/23/97	90.7	90.4	90.7
	1/27/98	90.7	90.4	90.7
	6/30/98	90.6	90.3	90.7
	1/14/99	90.9	90.8	90.8
	7/27/99	90.8	90.8	90.7
	12/3/99	90.8	90.7	90.7
A-2	10/23/97	87.5	87.0	87.3
	1/27/98	87.5	87.0	87.3
	6/30/98	87.4	87.0	87.3
	1/14/99	87.6	87.5	87.5
	7/27/99	87.5	87.3	87.4
	12/3/99	87.4	87.3	87.4
A-3	10/23/97	84.4	83.9	84.2
	1/27/98	84.4	83.8	84.2
	6/30/98	84.3	84.1	84.2
	1/14/99	84.4	84.2	84.3
	7/27/99	84.3	84.1	84.3
	12/3/99	84.3	84.1	84.3
B-2	10/23/97	91.0	90.4	90.9
	1/27/98	91.0	90.4	91.0
	6/30/98	91.0	90.6	91.0
	1/14/99	91.1	90.7	91.1
	7/27/99	91.0	90.6	91.0
	12/3/99	91.1	90.5	90.9
B-3	10/23/97	86.8	86.4	86.6
	1/27/98	86.8	86.4	86.6
	6/30/98	86.8	86.6	86.6
	1/14/99	87.0	86.6	86.5
	7/27/99	86.9	86.6	86.6
	12/3/99	86.9	86.6	86.5

Conclusion and Recommendations

This study has documented that vegetative barriers can capture sediment and prevent erosion on erosive hillsides. However, vegetative barriers must be appropriately designed and constructed. Vegetative barriers for concentrated flow areas must be surveyed, designed and shaped similar to grass waterways. Velocities and volume of surface runoff must be carefully calculated. The barrier should be spaced as close to 2 feet in vertical height as possible to prevent excessive erosion between barriers and to assist in water velocity reduction and improve sediment deposition.

A double row of transplant makes a very effective barrier in the concentrated flow area. It is important that both rows be planted at the same time and at a minimum of 18 to 36 inches apart to avoid competition and ensure that both rows grow big and vigorous. Furthermore, the length of the barrier must extend to a vertical height of 1.5 to 2 feet to prevent scouring around the edges. In high velocity, concentrated flow sites a straw bundle or some other reinforcement will be required to stabilize the site and secure the transplants.

Vetiver and switchgrass have shown themselves to be good grasses for vegetative barrier establishment. These grasses perform better when planted in the spring with a good watering at planting time.

Seeding switchgrass on clay soils to achieve a vegetative barrier or terrace appears to be a high-risk endeavor. With the erratic rainfall that South Texas experiences, along with clay soils that quickly dry up and crust over, the chances for a switchgrass seeding are not good. We believe that small transplants established with the use of a mechanical transplanter may be a more effective alternative for vegetative terraces. Complete guidelines for the establishments of vegetative barriers are provided in the booklet "Vegetative Barriers for Erosion Control".

There are numerous advantages to vegetative barriers. Vegetative barriers can capture sediment and reduce concentrated water velocities. They can provide an effective technique for constructing water and sediment control basins. They can revitalize and support waterways by capturing and spreading eroded sediment. They also can enhance nutrient uptake of filter areas. Furthermore, vegetative barriers can provide critical wildlife habitat when annual crops deteriorate.

However, there are several factors in Texas that must be resolved before vegetative barriers will reach full conservation use. Can vegetative barriers provide a proven <u>cost effective</u> and <u>labor effective</u> alternative to conventional methods of conservation? Will there be adequate contractor and landowner interest to apply this alternative practice? In order to answer these questions, government agencies will have to encourage and assist landowners over the next several years in the application of this practice. In this effort, the Plant Materials Center conducted four slide presentations and field days at

Laredo, Austin, Bellville and San Antonio, Texas. Over 125 people attended these presentation and showed interest in the application of this practice. The PMC has also written 3 articles for publication in the Land & Water magazine, Texas Agri-News, and the Journal of the Soil and Water Conservation Society. Furthermore, the PMC will continue to evaluate and promote the use of this promising low-cost erosion control technology.

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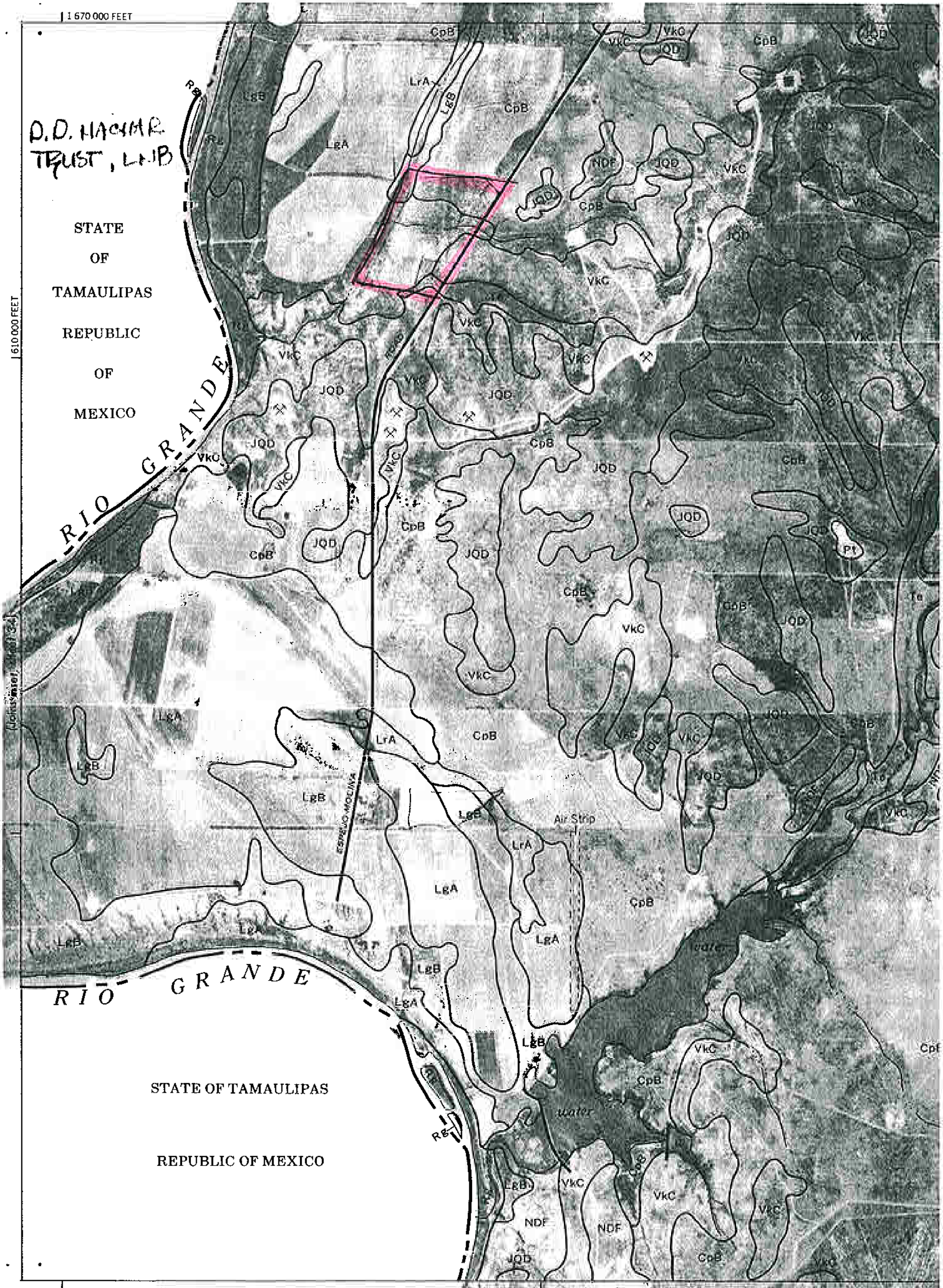
SOIL AND SITE MAPS
ENCLOSURE 1

WEBB COUNTY

REPUBLIC OF MEXICO
TAMAULIPAS
LAREDO INTERNATIONAL AIRPORT
LAREDO
NUEVO LAREDO
RIO GRANDE
ZAPATA
WEBB COUNTY
TEXAS
1967
1970 CENSUS FIGURES
HIGHWAYS REVISED TO JULY 1, 1978
KEY TO BASE SHEETS



WEBB COUNT TEXAS NO. 95

This map is compiled on 1976 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies.
Coordinate grid ticks and land division corners, if shown, are approximately positioned.

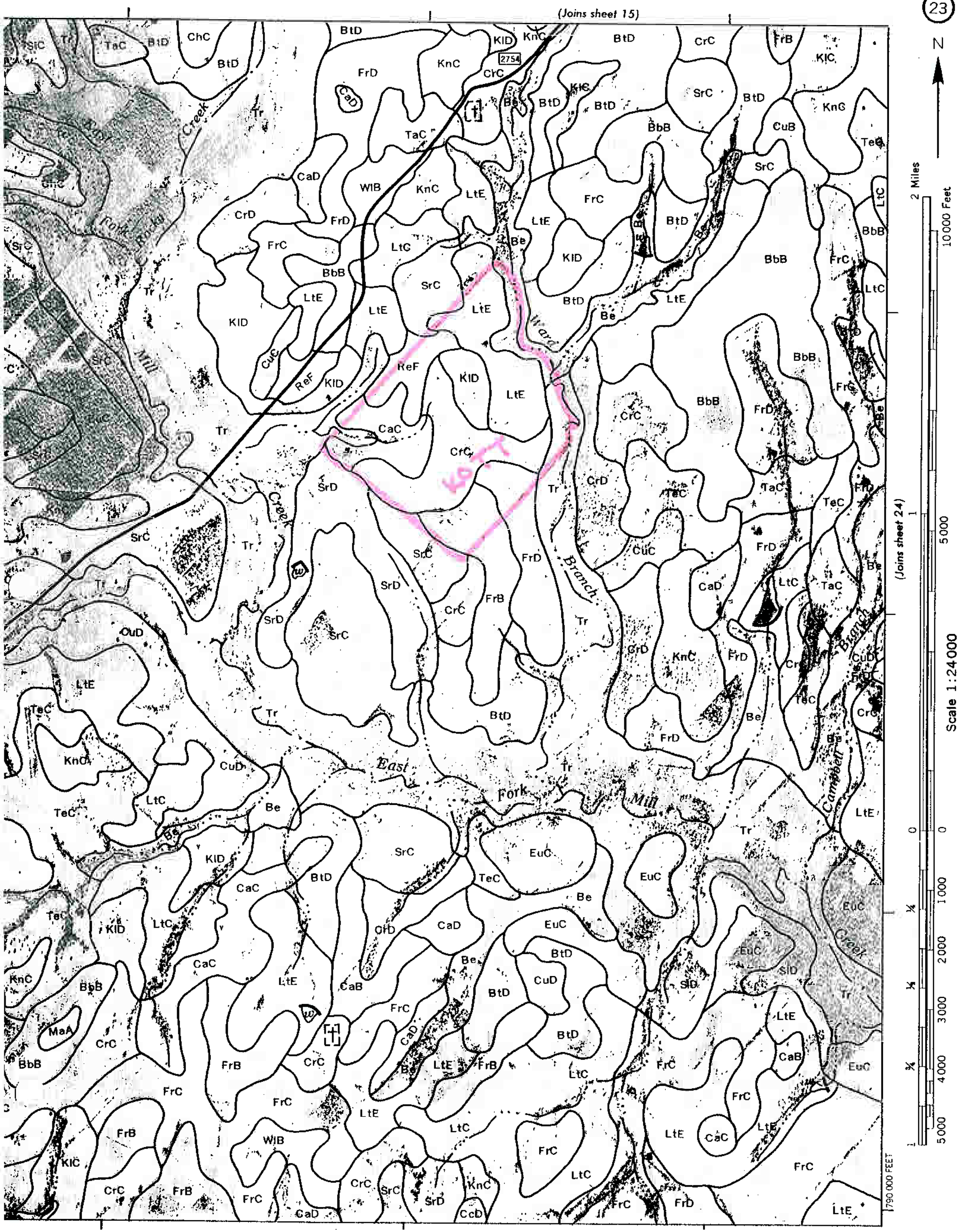
AUSTIN COUNTY

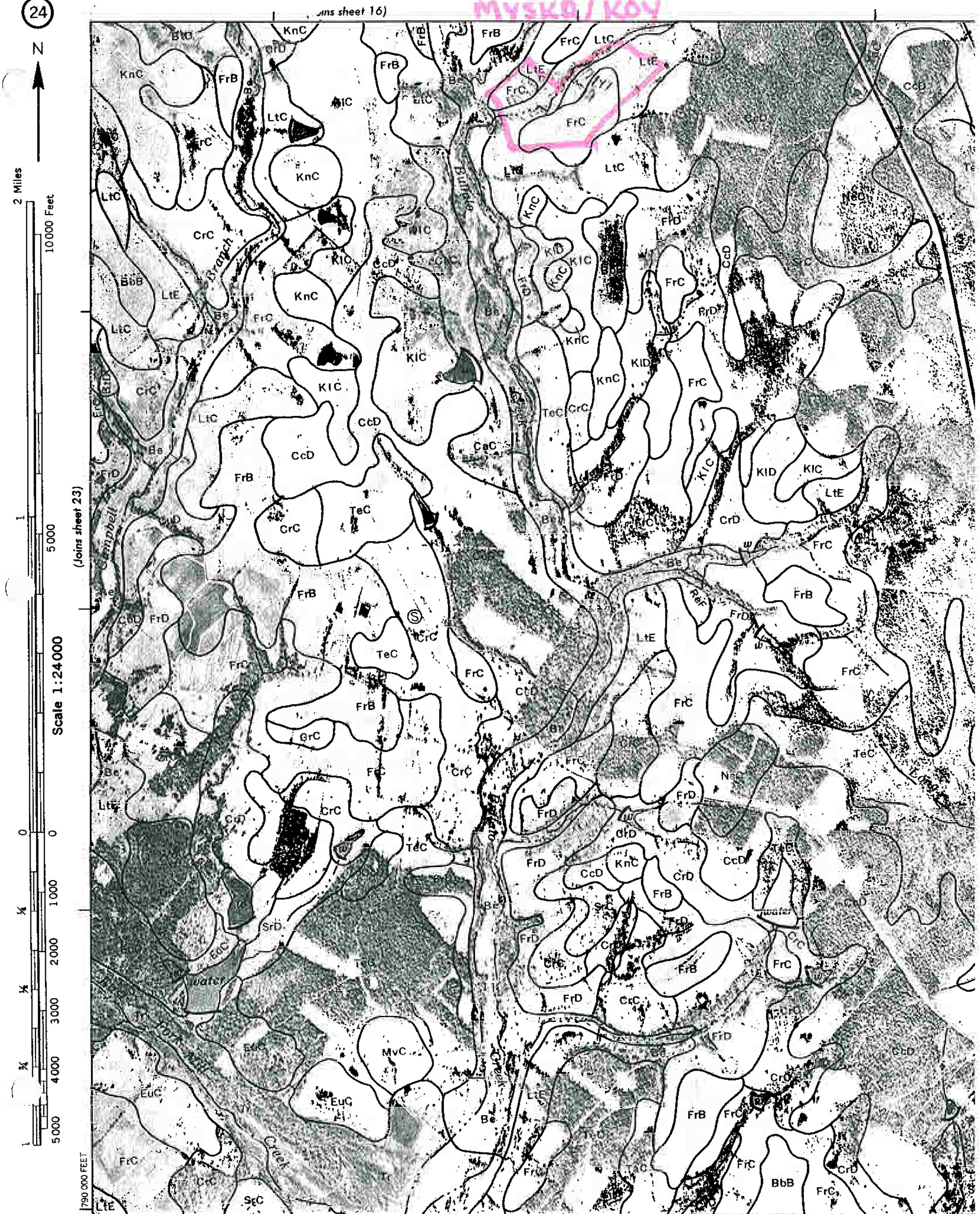
GENERAL HIGHWAY M

AU TIN COUNT

TEXAS

TEXAS — SHEET NUMBER 23

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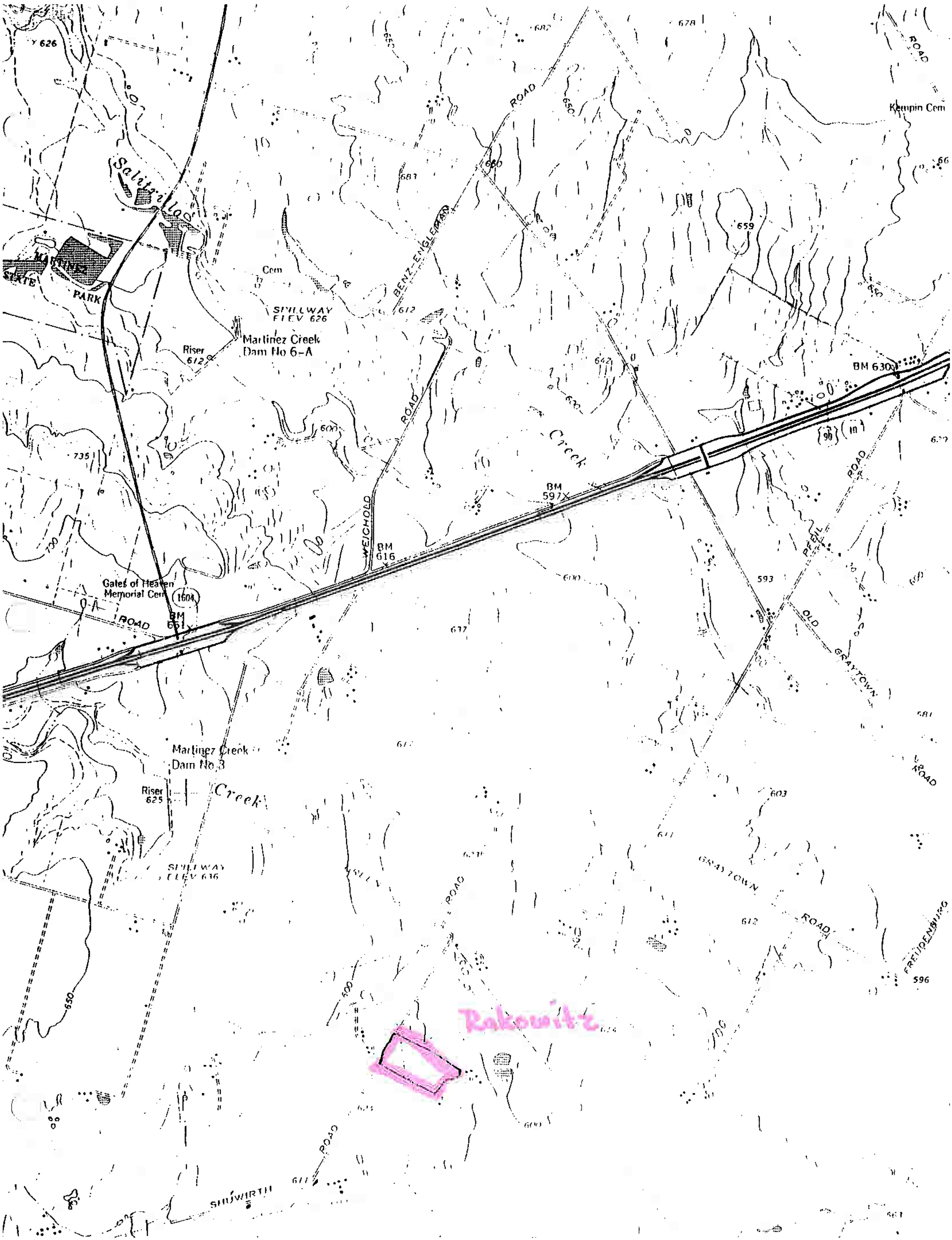
BEXAR COUNTY



MARTINEZ STATE PARK
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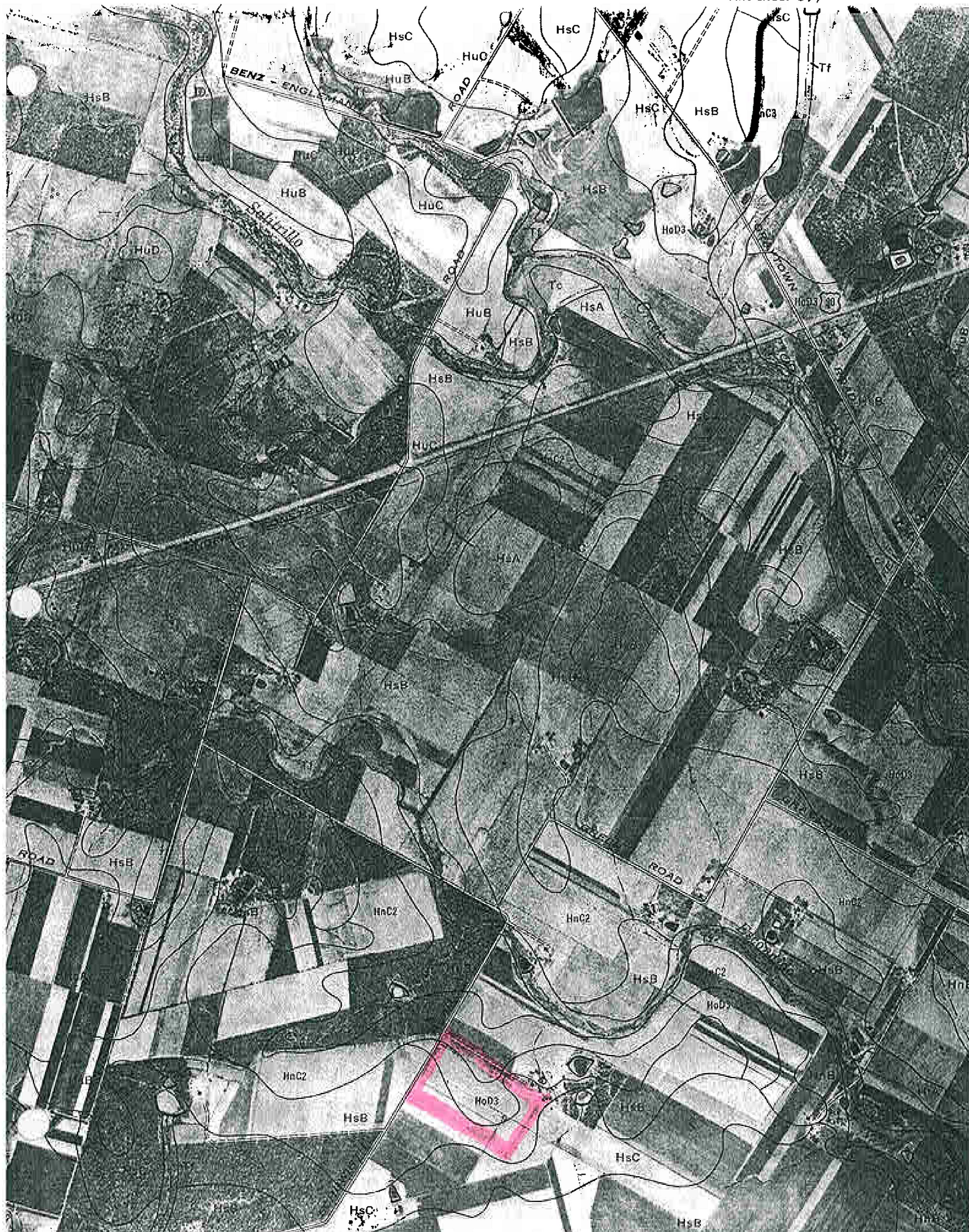
Com
SPILLWAY ELEV 626
Martinez Creek Dam No 6-A
Riser 612
BENZ-ENGLEMAN ROAD
Kempin Cem
BM 630
Creek
BM 597
WEICHOLD ROAD
BM 616
Gates of Heaven Memorial Cem
1604
BM 651
PFEIL ROAD
OLD GRAYTOWN ROAD
Martinez Creek Dam No 3
Riser 625
Creek
SPILLWAY ELEV 636
GRAYTOWN ROAD
FREUDENBURG ROAD
Rakowitz
SHUWIRTH ROAD

(47)

(Joins sheet 39)



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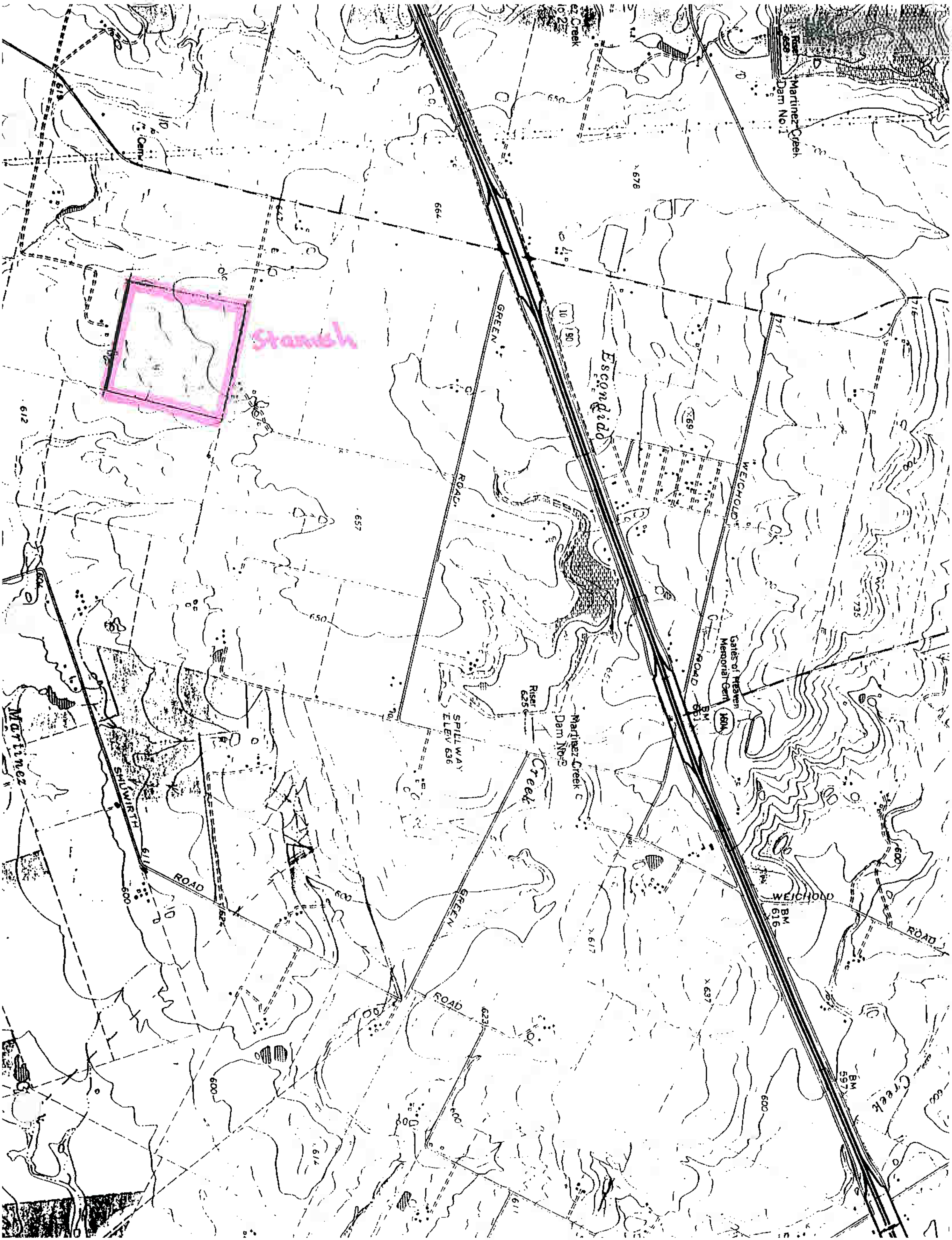
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Martinez Creek Dam No.1
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WEICHOLD ROAD
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SPILLWAY ELEV 636
Riser 625
BM 616
BM 597
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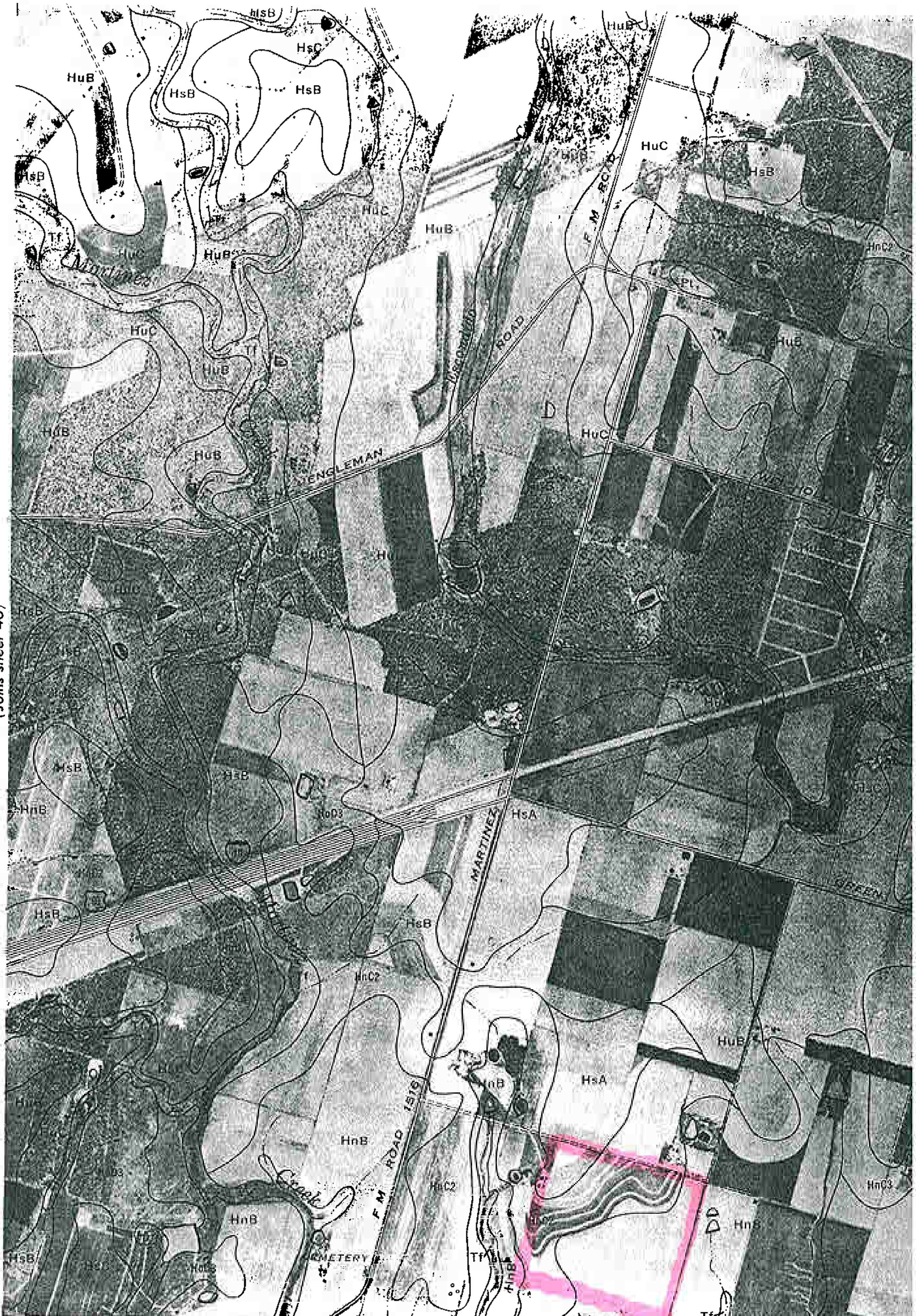
This map is one of a set compiled in 1965 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Texas Agricultural Experiment Station.

(Joins sheet 46)



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AGENDA OF FIELD DAYS
ENCLOSURE 2

AGENDA
CORE4 TRAINING
June 1 – 2, 1999

Residue Management and Conservation Buffers - Intergrating Conservation Practices To Prevent Pesticide Losses to the Environment

DAY 1 - Kingsville

9:00	Introduction to CORE4 Efforts	Jim Childers
	Purposes, Applicability, Design Procedures, Considerations	
	Residue Management	Jim Childers
	Tillage Equipment Considerations	Jim Childers
12:00	Lunch	
1:00	Purposes, Applicability, Design Procedures, Considerations	
	Filter Strips	John Freeman
	Field Borders	John Freeman
3:00	Adjourn	

DAY 2

9:00	Purposes, Applicability, Design Procedures, Considerations	
	Cross Wind Trap Strips	Jerry Pearce
	Herbaceous Wind Barriers	John Freeman
	Riparian Forest Buffers	Jerry Pearce
12:00	Lunch	
12:30	Purposes, Applicability, Design Procedures, Considerations	
	Vegetative Barriers / [illegible]	John Lloyd-Reilly
1:30	Filter Strip Field Visit	Robert Schmidt
	Review the various practices that need to be used in combination to be most effective in prèventing pesticide movement to the water bodies in this given situation in Kleberg County to Escondido Creek and Baffin Bay.	
3:00	Adjourn	

AGENDA
CORE4 TRAINING
June 3 – 4, 1999

Residue Management and Conservation Buffers - Intergrating Conservation Practices To Prevent Pesticide Losses to the Environment

DAY 1 - Kenedy

9:00	Introduction to CORE4 Efforts	Jim Childers
	Residue Management	
	Residue Management Design Procedures	
	Tillage Equipment	
	Lunch	
1:00	Filter Strips	John Freeman
	Field Borders	
	Design Procedures/Considerations	
3:00	Adjourn	

DAY 2

9:00	Contour Buffer Strips	Jerry Pearce
	Herbaceous Wind Barriers	John Freeman
	Riparian Forest Buffers	Jerry Pearce
	Lunch	
12:30	Vegetative Barriers	John Lloyd-Reilly
1:30	Contour Buffers Strips Field Visit	Harvey Kahlden
	Discuss the Considerations and Specifications of Contour Buffers Strips in Karnes County to minimize the agricultural effects and impacts upon the water quality of the receiving waters. Review the various practices that need to be used in combination to be most effective in preventing pesticide movement to the water bodies in this given situation.	
3:00	Adjourn	

AGENDA

CORE4 TRAINING

June 8 - 9, 1999

Residue Management and Conservation Buffers - Intergrating Conservation Practices To Prevent Pesticide Losses to the Environment

DAY 1 - Bellville

9:00	Introduction to CORE4 Efforts	Jim Childers
	Purposes, Applicability, Design Procedures, Considerations	
	Residue Management	Jim Childers
	Tillage Equipment Considerations	Jim Childers
12:00	Lunch	
1:00	Purposes, Applicability, Design Procedures, Considerations	
	Contour Buffer Strips	Jerry Pearce
	Riparian Forest Buffers	Jerry Pearce
3:00	Adjourn	

DAY 2

9:00	Purposes, Applicability, Design Procedures, Considerations	
	Filter Strips	John Freeman
	Field Borders	John Freeman
	Vegetative Barriers	John Lloyd Reilly
12:00	Lunch	
12:30	Purposes, Applicability, Design Procedures, Considerations	
	Vegetative Barriers Field Visit	Jim Hluhan
	Review the various practices that need to be used in combination to be most effective in preventing pesticide movement to the water bodies in this given situation in Austin County.	
3:00	Adjourn	

AGENDA
CORE4 TRAINING
June 10 - 11, 1999

Residue Management and Conservation Buffers - Intergrating Conservation Practices To Prevent Pesticide Losses to the Environment

DAY 1 - Austin

9:00	Introduction to CORE4	Jim Childers
	Purposes, Applicability, Design Procedures, Considerations	
	Filter Strips	John Freeman
	Field Borders	John Freeman
12:00	Lunch	
1:00	Purposes, Applicability, Design Procedures, Considerations	
	Contour Buffer Strips	Jerry Pearce
	Riparian Forest Buffers	Jerry Pearce
3:00	Adjourn	

DAY 2

9:00	Purposes, Applicability, Design Procedures, Considerations	
	Residue Management	Jim Childers
	Tillage Equipment Considerations	Jim Childers
	Vegetative Barriers	John Lloyd Reilly
12:00	Lunch	
12:30	Purposes, Applicability, Design Procedures, Considerations	
	Vegetative Barriers/Filter Strip Field Visit	Mike Rainey
	Review the various practices that need to be used in combination to be most effective in preventing pesticide movement to the water bodies in this given situation in Travis County.	
3:00	Adjourn	

AGENDA
CORE4 TRAINING
Sept 15 – 16, 1999

Residue Management and Conservation Buffers - Integrating Conservation Practices To Prevent Pesticide Losses to the Environment

DAY 1 - Laredo

9:30	Introduction to CORE4 Efforts	Jim Childers
	Purposes, Applicability, Design Procedures, Considerations	
	Residue Management	Jim Childers
	Tillage Equipment Considerations	Jim Childers
½ hour	Lunch	
	Purposes, Applicability, Design Procedures, Considerations	
	Filter Strips	John Freeman
	Field Borders	John Freeman
	Herbaceous Wind Barriers	John Freeman
3:00	Adjourn	

DAY 2

9:30	Purposes, Applicability, Design Procedures, Considerations	
	Cross Wind Traps	Jerry Pearce
	Contour Buffer Strips	Jerry Pearce
	Riparian Forest Buffers	Jerry Pearce
½ hour	Lunch	
	Purposes, Applicability, Design Procedures, Considerations	
	Vegetative Barriers	John Lloyd-Reilly
1:30	Vegetative Barrier Field Visit	Flavio Garza
	Review the various practices that need to be used in combination to be most effective in preventing pesticide movement to the water bodies in this given situation in Webb County.	
3:00	Adjourn	

Ponds and Pastures CEU Workshop

Boysville,Converse, Tx.
March 31, 2000

AGENDA

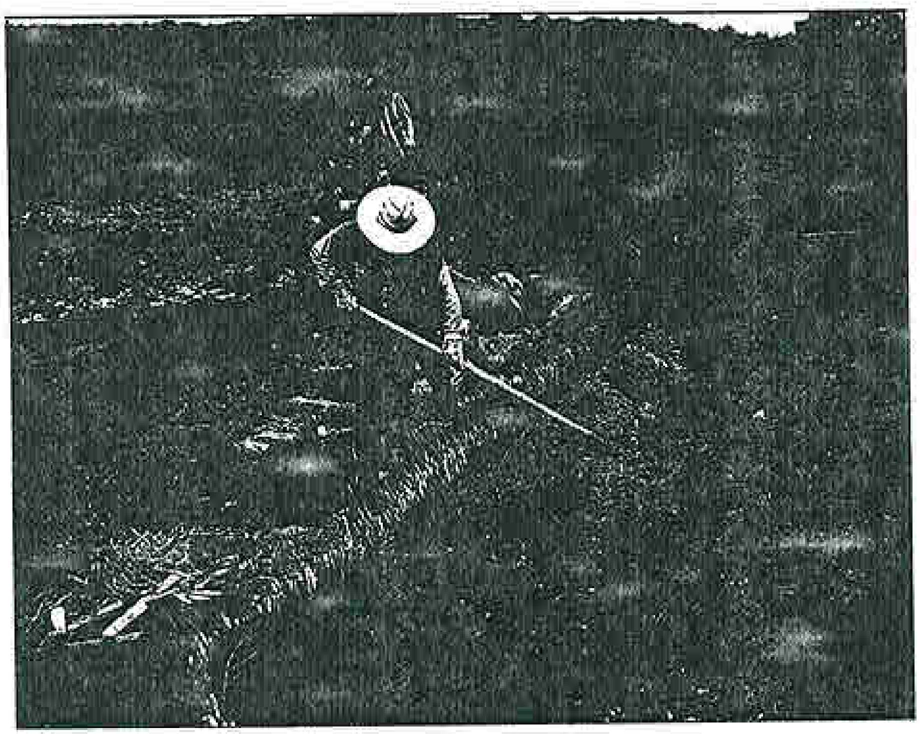
8:00-8:30	Registration
8:30-9:30	Labels and Labeling for Aquatic Herbicides - Jose Juarez, Texas Department of Agriculture Inspector
9:30-10:30	Pond Design, Construction, Stocking Rates and Fish Management Dr. Michael Masser, Extension Fisheries Specialist
10:30-12:30	Weed/brush control in and around ponds using Chemical and Biological thods Dr. Michael Masser, Extension Fisheries Specialist
12:30-1:00	Lunch
1:00-2:00	Laws and Regulations concerning Triploid Grass Carp and other Non-Native Species Bob Zerr, Texas Parks and Wildlife Department
2:00-3:00	Using Fire for Brush Control Vivian Garcia, Zone Range Management Specialist, Natural Resource Conservation Service
3:00-4:00	Implementing a Nutrient, Herbicide, and Environmental Quality Management Plan for Pastures Dr. Charles Stickler, Extension Agronomist
4:00-5:00	Hay and Forage Grasses for Central/South Texas , Pasture Renovation, New Pastures, and Labeled Chemicals Dr. Charles Stickler, Extension Agronomist
5:00-5:30	Erosion Management Systems on Farm Land John Reilley, Plant Material Center
5:30- ?	Site visit to erosion control demonstration for those interested.

NEWS ARTICLES
ENCLOSURE 3

Gully Erosion Control with Vegetative Barriers

by George Farek and John Lloyd-Reilley

In June of 1996, the Kika de la Garza Plant Materials Center (PMC) was looking for a study site to evaluate the ability of vegetative barriers to control gully erosion. Vegetative barriers, or grass hedges as they are sometimes called, are narrow strips (1-3 feet wide) of stiff, erect densely growing grasses planted across the slope perpendicular to the dominant slope. They function to slow water runoff, trap sediment and prevent gully development. They inhibit the flow of water because of their dense concentration of thick stems, thus slowing and ponding water and causing sediment to deposit in back of them. Over time, these deposits can develop into benched terraces. These barriers function to spread water runoff so that it slowly flows through them without erosion. Vegetative barriers are resilient to failure because water passes over a broad area secured with perennial root reinforcement.



Jim Hluchan, District Conservationist with the USDA Natural Resources Conservation Service in Bellville, Texas, found a site with a deep 7-foot gully in an over-grazed pasture near Kenney, Texas. With funding and support from the Austin County Soil and Water Conservation District, Texas State Soil and Water Conservation Board, Texas A&M - Kingsville, and the US Environmental Protection Agency, the Plant Materials Center started to work.

In September of 1996, we shaped the gully head to a 5:1 slope. Then we planted vetiver grass (Vetiveria zizanioides) across the gully basin. Vetiver grass is an introduced species that has been used in Thailand as an effective vegetative barrier. It is an ideal erosion control plant, as it will grow to 6 feet tall, a foot wide, and produce dense tillering with 50 to 200 stems per square foot. Vetiver is a sterile plant that does not produce viable seed. The PMC propagates vetiver vegetatively for select erosion control sites.

Vegetative barriers or grass hedges can be an effective erosion control treatment for gullies and waterways. The treatment site should be surveyed, designed and shaped similar to a grass waterway.

The gully site was planted using a walk-behind trencher that produced a 6-inch wide trench. A 13-13-13 fertilizer was sprinkled in the trench at approximately an 80 pound per acre rate. The vetiver plants were bare-root clumps that were 9 inches tall with 4 inch roots. They were placed end-to-end in the trench and then back-filled. Straw bundles that were approximately 5 inches thick were placed on the downstream side across the basin to prevent dislodging of the plants. Three years after planting, the site has a dense stand of vetiver grass and has captured over 6 inches of sediment behind the vegetative barriers.

Vetiver grass performed successfully at runoff velocities of 6 feet per second. The limiting factor on site establishment is the soil-runoff velocity relationship. Where runoff velocities exceed the bare soil value, there is the threat of developing plunge pools that can threaten the stability of the vegetative barriers.

Vetiver grass had only a 61 percent survival rate when planted in the fall. When replanted in April, it established a 93 percent stand. It is known to be sensitive to freezing temperatures, therefore, it is best to plant it in the spring when it is starting its period of rapid growth.

Switchgrass (*Panicum virgatum*) is another species that can be used as a vegetative barrier. It is a native species with good frost tolerance. It is recommended that two rows of transplants be used to minimize gaps, reduce replanting, and ensure good functionality of the vegetative barrier. **L&W**

For questions concerning the application of vegetative barriers, you may contact the Kika de la Garza Plant Materials Center, 3409 N FM 1355, Kingsville, TX 78363-2704, (361)595-1313.

KIKA DE LA GARZA PMC 3409 N FM 1355 KINGSVILLE, TX. 78363-2704

USDA NRCS
Natural Resources Conservation Service

United States
Department of
Agriculture

Date: 4/4/00

Number of pages including cover sheet: 2

FAX

To:
Sergio / Mendi
Texas Agri-news

Phone:
Fax phone: (956) 585-2304
CC:

From:
John Lloyd-Reilley

Phone: 361-595-1313
Fax phone: 361-595-1313

REMARKS: ☐ Urgent ☑ For your review ☐ Reply ASAP ☐ Please comment

Please consider publishing the following article.
If any questions, please give me a call

John

EROSION AND SEDIMENT CONTROL WITH VEGETATIVE BARRIERS

The Natural Resources Conservation Service (NRCS) has promoted the use of terraces for soil erosion control for over forty years. More recently the concept of using vegetative barriers or grass hedges as a vegetative alternative has been investigated. Vegetative barriers are narrow strips (1-3 feet wide) of stiff, erect densely growing plants, usually grasses, planted across the slope perpendicular to the dominant slope. These barriers function to slow water runoff, trap sediment and prevent gully development. The barriers inhibit the flow of water because of their dense concentration of thick stems, thus slowing and ponding water and causing sediment to deposit in back of them. Over time these deposits can develop into benched terraces. These barriers function to diffuse and spread the water runoff so that it slowly flows through them without erosion. Vegetative barriers are resilient to failure because water passes over a broad area secured with perennial root reinforcement.

In June of 1996, The United States Department of Agriculture (USDA), NRCS, Kika de la Garza Plant Materials Center (PMC) along with the Caesar Kleberg Wildlife Research Institute (CKWRI) of Texas A&M University-Kingsville, and cooperating NRCS field offices and Soil and Water Conservation Districts (SWCD) in Austin County, Bexar County, and Webb County established a three-year project to evaluate erosion control effectiveness of vegetative barriers. The Environmental Protection Agency (EPA) through the Texas State Soil and Water Conservation Board provided funding for this project.

On March 31,2000 a conservation workshop was conducted by the Bexar County Agriculture Extension Office which included a talk and field tour of the Alfred Rakowitz farm to show the plantings of vegetative terraces and grass waterway barriers. The switchgrass and vetiver grass plantings have produced very effective vegetative barriers. Switchgrass barriers captured up to 6 inches of sediment following a 100 year rainfall event in October of 1998 at the study site.

Vegetative barriers can be a low-cost option for many farmers to meet their conservation needs. It could be an alternative or complimentary practice with conventional terraces, waterways and critical area stabilization. In many cases it does not require heavy machinery for installation, which eliminates the movement and compaction of the topsoil. It also can take less land out of production since it is only a narrow strip of grass. For more information concerning vegetative barriers, contact your local NRCS office, Soil and Water Conservation District office, or the Kika de la Garza PMC in Kingsville, Texas (361-595-1313).

SOIL AND WATER CONSERVATION SOCIETY

To foster the science and the art of soil, water, and related natural resource management to achieve sustainability.

International Headquarters
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Ankeny, Iowa 50021-9764
Telephone (515) 289-2331
FAX (515) 289-1227
email: swcs@swcs.org
http://www.swcs.org

April 27, 2000

John Lloyd-Reilley
Kika de la Garza Plant
Materials Center
3409 N. FM 1355
Kingsville, TX 78363

Dear Mr. Lloyd-Reilley:

This letter acknowledges receipt of your manuscript, "Vegetative Barriers For Gully Erosion Control."

Its Accession Number will be **00–38**. Please refer to it in any correspondence.

We have forwarded the manuscript to W.J. Busscher, technical editor for the *Journal of Soil and Water Conservation.* Dr. Busscher will coordinate our peer review of the manuscript and will correspond with you about acceptance, rejection, or additional revision. The peer review process normally takes about three to four months.

If accepted for publication as a feature or research report, the manuscript will be subject to a page charge, as outlined in the enclosed *Journal* editorial policy. I am aware of your request for a page waiver and left a message on your answering machine this morning. We can discuss the situation, policy, and options when you are back in the office and call our office.

If accepted, it will take up to six months to be published from acceptance date.

We appreciate the opportunity to consider your manuscript for publication.

Sincerely,

J.K. Eckhart

J. K. Eckhart
Technical Editor,
Journal of Soil and Water Conservation
515–289–~~1227~~ (x16)
2331

VEGETATIVE BARRIERS FOR GULLY EROSION CONTROL

ABSTRACT

Vegetative barriers are currently being evaluated as an alternative conservation practice. Vegetative barriers are narrow strips 0.3-1 meter (1-3 feet) wide of stiff, erect, densely growing plants, usually grasses, planted across the slope perpendicular to the dominant slope. The objective of this study was to establish a series of vegetative barriers and assess their ability to control gully erosion. Vetiver grass (Vetiveria zizanioides (L) Wash) barriers stabilized and captured up to 20 centimeters (8 inches) of sediment at the study site. Vegetative barriers should be surveyed, designed, and shaped similar to grass waterways. Velocities and volumes of surface runoff must be carefully calculated. Vegetative barriers can add erosion control effectiveness on high velocity critical sites when combined with grass waterways by slowing and dispersing surface water runoff to prevent down-cutting and channelization.

INTERPRETIVE SUMMARY

Vegetative barriers are currently being evaluated as an alternative conservation practice. Vegetative barriers are narrow strips 0.3-1 meter (1-3 feet) wide of stiff, erect, densely growing plants, usually grasses, planted across the slope perpendicular to the dominant slope. Vegetative barriers function to stair-step water down the hillside. Vegetative barriers slow water runoff, trap sediment and prevent gully development. Vetiver grass (Vetiveria zizanioides) barriers stabilized and captured up to 20 centimeters of sediment at the study site. Before installing a vegetative barrier a trained technician should survey and design the problem site. Vegetative barriers can add erosion control effectiveness by slowing and dispersing surface water runoff and prevent gullying.

Key words: erosion control, conservation practice, sediment, grass hedge, vegetative barrier, bioengineering

INTRODUCTION

Vegetative barriers or grass hedges are currently being evaluated as an alternative conservation practice. Over forty years ago, the USDA-Soil Conservation Service referenced the use of vegetative barriers in an agriculture handbook on conservation (USDA-SCS, 1954). More recently, the World Bank has promoted the use of vetiver grass (Vetiveria zizanioides (L) Wash) as a hedge against erosion (NRC, 1993).

Vegetative barriers are narrow strips 0.3-1 meter (1-3 feet) wide of stiff, erect, densely growing plants, usually grasses, planted across the slope perpendicular to the dominant slope. Vegetative barriers are essentially a vegetative alternative to a constructed water and sediment control basin.

Vegetative barriers function to slow water runoff, trap sediment and prevent gully development (Dabney et al., 1993). Vegetative barriers inhibit the flow of water because of their dense concentration of thick stems, thus slowing and ponding water and causing sediment to deposit in back of them (Meyers et al., 1994). Over time these deposits can develop into benched terraces (Aase and Pikul, 1995). These barriers function to diffuse and spread the water runoff so that it slowly flows through them without erosion. Vegetative barriers are resilient to failure because water passes over a broad area secured with perennial root reinforcement.

The objective of this study was to establish a series of vegetative barriers and assess their ability to control gully erosion. Support and funding was provided by the Austin County Soil and Water Conservation District, the Texas State Soil and Water Conservation Board, the United States Environmental Protection Agency, Texas A&M-Kingsville and the USDA-Natural Resources Conservation Service.

MATERIAL AND METHODS

The study was conducted on a farm near Kenney, Texas, in Austin County. The treatment field was a severely overgrazed pasture with a 210 meters (700 feet) long gully with a 2 meter (7 feet) head-cut. The soils of the field were Frelsburg clay with a 1 to 8 percent slope and a Latium clay with a 2 to 12 percent slope. In September of 1996 we crudely shaped the gully head to a 5:1 slope.

A design elevational survey was conducted in August, 1996, on 14 vegetative barrier lines. On September 16, 1996, vetiver grass was planted at each of the 14 vegetative barriers which were established sequentially down the gully. The vegetative barriers ranged in length from 7.5 meters (25 feet) to 30 meters (100 feet) in length. The distance between the vegetative barriers varied from 4 meters (13 feet) to 22 meters (74 feet) with a vertical index from .5 meters (1.7 feet) to .75 meters (2.5 feet). Slopes ranged from 2.8 percent to 16 percent.

Vetiver was planted as a single row across the basin depth, which ranged from .4 meters (1.4 feet) to 1.5 meters (5.0 feet) in height. Bareroot vetiver clumps of 4 stems were planted end-to-end across the basin 1/2 depth. The outside 1/2 depth was planted with 4 stem clumps at an eight centimeter (three-inch) interval. Vetiver was 23 centimeters (9 inches) tall with 10 centimeters (4 inches) roots. A trencher was used to produce a 15 centimeters (6-inch) wide trench. A 13-13-13 fertilizer was sprinkled in the trench at approximately an 80#/acre rate of actual nitrogen. Plants were placed in the trench and then backfilled. Straw bundles from 13 centimeters (5 inches) to 23 centimenters (9 inches) thick were placed on the downstream side across the 1/2 basin depth locations to prevent dislodging of the plants. No water was applied.

A second elevational survey of the site was performed on September 16, 1996, right after planting. Additional surveys were conducted every 6 months until January 1999. The survey consisted of measurements at the ends of the vegetative barriers and at the 1/2 depth locations on either side of the vegetative barriers and in the middle. Measurements were also taken at 1.2 meters

(4 feet) upstream, 1.2 meters (4 feet) downstream, and 6 meters (20 feet) upstream. A vegetational survey was conducted on May 12, 1997, and every 6 months until November 1998. Measurements were taken on percent survival, stem density (numbers per .09 square meters (one-square foot), height (centimeters), base width (centimeters), and gaps between plants (number of spaces greater than 15 centimeters apart). Velocities (meters per second-m/sec) and volume of surface runoff (cubic meters per second-cms) were determined using the Natural Resources Conservation Service WWCALC engineering software program.

RESULTS AND DISCUSSION

VEGETATIVE BARRIER STABILITY

Immediately after planting on September 18, 1996, an estimated ten year rainfall event [9 centimeters (3.5") in 6 hrs] occurred that washed out several of the vegetative barriers (Table 1). Severe runoff broke the straw bundles and dislodged the plants. At high velocities, straw bundles staked through the middle will not stay secure. They must be staked and woven down with baling string. We resecured all the bundles on September 19, 1996, and they have remained secure throughout the study.

Vegetative barriers 4, 5, 6, 7 and 10 developed plunge pools because of the high velocity of the surface runoff (Table 2). This forced us to add concrete cylinders at these locations. We were afraid that the deep plunge pools would threaten the stability of the entire gully treatment.

Vegetative barriers 8 and 14 had velocities greater than vegetative barriers 4 and 7 which failed. The difference between these barriers and the ones that failed were the length and steepness of upstream conditions and the narrowness of the channel downstream of the vegetative barriers.

Vegetative barrier 3 stayed stable with a barrier length of 9 meters (30 feet) and a slope greater than 10% for 18 meters (60 feet) upstream. Vegetative barrier 4 failed with an average slope greater than 10% for 24 meters (80 feet) upstream. The channel width for barrier number 4 was only 6 meters (20 feet) and narrowed to 4.5 meters (15 feet) directly below the barrier. The velocity as it approached barrier 5 was 2.3 meters per second (7.7 ft./sec.). This velocity on the bare soil below barrier 4 is what caused the plunge pool which required remedial treatment.

Vegetative barrier number 10 failed with a slope of 9% for 9 meters (30 feet) upstream. Vegetative barrier 10 had a channel width of only 4.5 meters (15 feet) that narrowed to 1.5 meters (5 feet) directly below the barrier. Again the velocity below the barrier was well over 2.1 m/sec. (7 ft./sec) and caused the plunge pool that nearly undermined the barrier.

Vegetative barrier 8 stayed stable despite a velocity of 1.8 m/sec (6 ft./sec.) and a channel width that was 4.5 meters (15 feet) both at the barrier and downstream of the barrier. The slope averaged less than 6% for over 24 meters (80 feet) upstream and the downstream barrier had a velocity of only 1.6 m/sec (5.2 ft./sec.). Vegetative barrier 14 also stayed stable with a velocity of approximately 1.8 m/sec. The slope was roughly 7.5% and the channel width was 6 meters (20 feet). Nine meters (30 feet) upstream the slope was less than 4% and the velocity was less than 1.2 m/sec (4 ft./sec.). Downstream the slope flattened out and the velocity was less than 1.8 m/sec.

It appears that vegetative barriers will be stable when constructed appropriately for velocities at 1.2 m/sec (4 ft./sec.). Vegetative barriers will probably be stable at higher velocities up to 1.8 m/sec (6 ft./sec.) when the channel width is maintained at a consistent width at the barrier and downstream of the barrier. Optimum channel width for the vegetative barriers at our site was between six and nine meters (20-30 feet) wide. Vegetative barrier length should be based on the width determined by the grass waterway calculation with a minimum of .4 to .6 meters (11/2 to 2 feet) in vertical basin depth to accommodate sediment deposits and prevent erosive side flow.

The limiting factor on velocity should be the soil velocity relationship. "Permissible velocities for channels lined with vegetation" and "Permissible velocity for vegetated spillways" in the SCS-TP-61 handbook provides a useful guide for this relationship (Table 3). At our site, which had erosion resistant soils and slopes between 5-10%, the suggested permissible velocity would be 1 m/sec (3.5 ft/sec.). This is the permissible velocity suggested for native grass mixtures, and the suggested value for the bare soil, native plant composition that existed at our test site. At this time, we would not recommend exceeding the velocities established for specified seed mixtures for newly constructed sites, unless additional soil treatment such as rock or turf reinforcement matting is added. As a repair or secondary treatment for existing vegetated sites, we probably can use vegetative barriers at increased velocities of .3 to .6 m/sec above these levels.

VETIVER GRASS PERFORMANCE

Vetiver grass is an introduced plant species that has been used throughout Southeast Asia as an effective vegetative barrier. It is an ideal erosion control plant as it will grow to 2 meters (6 feet) tall, a .3 meter 1(foot) wide and produce dense tillering with 50 to 200 stems per .09 square meters (1.0 square foot). Vetiver is a sterile plant that does not produce viable seed. The results of the vegetation survey conducted on May 12, 1997, are presented in Table 4. Total survival of vetiver for the winter averaged 61% across all the barriers. Numerous gaps between plants exceeded the 15 centimeter (6 inches) threshold targeted by the PMC for a successful barrier planting. Spot planting of the gaps was done in April of 1997 and 1998. The results of the vegetation survey conducted on September 16, 1997, revealed a summer survival rate of 93%. By November of 1998, there were very few gaps with the worst being no more than 30 centimeters (12 inches) on the outside edge of the barrier.

Vetiver grass performed better when planted in the spring versus the fall at this site. Competition from cool season vegetation and freezing temperatures had a detrimental impact on vetiver survival. Vetiver appears to prefer planting in the spring at a time when it is starting its period of rapid growth. Vetiver mortality at some barriers was located at the lowest point of the barriers, indicating that high velocities may have been a factor. In the summer, most of the vetiver mortality was located at the outside edges where reduced soil moisture may have been encountered. Any growth of vetiver is remarkable at this site since it was a crudely shaped gully with very poor, hard clay subsoil.

In general it is recommended that two rows of transplants be used to minimize gaps, reduce replanting, and ensure functionality for any vegetative barrier. Switchgrass (Panicum virgatum) is another species that can be used as a vegetative barrier. It is a native species with good frost tolerance. It can be incorporated as a second row with vetiver to make an effective vegetative barrier where livestock grazing does not occur.

SEDIMENT MOVEMENT

Results of the topographic surveys are presented in Table 5. Barriers 1, 4, 5, 6, 7, 11 and 12 all accumulated significant amounts of sediment, ranging from 13 centimeters (5 inches) to 20 centimeters (8 inches) both at the barrier and 1.2 meters (4 feet) upstream. The other barriers either revealed slight sediment accumulations or little change. However, where vegetative barriers had steep, bare, side slopes, like barriers 10 and 11, soil was redistributed across the basin. Figure 1 shows sediment gains or losses at selected vegetative barriers.

It appears that where a good solid vegetative barrier is established, substantial soil will accumulate. However, we recommend that where side slopes exceed a 10:1 grade that the channel be designed and shaped as a trapezoid with a consistent, flat bottom.

In conclusion, vegetative barriers can help stabilize gullies when appropriately designed and constructed. Gullies should be surveyed, designed, and shaped similar to grass waterways. Velocities and volumes must be carefully calculated. Vegetative barriers can add erosion control effectiveness on high velocity critical sites when combined with grass waterways by slowing and dispersing surface water runoff to prevent down-cutting and channelization.

TABLE 1:

Monthly Rainfall Totals and High and Low Temperatures at Kenney/Bellville TX

MONTH	TEMPERATURE (°C) HIGH 1997	HIGH 1998	LOW 1997	LOW 1998	RAINFALL (centimeters) 1996	1997	1998
JANUARY	26.4	26	-4	2		12.2	6.3
FEBRUARY	28	26	1	2		15.5	15.8
MARCH	31	30	5	-1		15.1	6.6
APRIL	31	32	5	8		12.8	5.1
MAY	34	39	14	16		15.8	0.1
JUNE	35	42	18	19		12.3	2.3
JULY	40	42	23	24		4.3	0.2
AUGUST	40	42	21	23		8.2	17
SEPTEMBER	39	40	16	22	25	9.1	28.6
OCTOBER	35	33	6	9	5	21.1	39.8
NOVEMBER	32	29	4	7	8	15.6	29.2
DECEMBER	25	27	-3	-6	7	13.3	7.3
				TOTAL		155.3	157.0

TABLE 2

Velocity and Discharge of Surface Runoff at the Vegetative Barriers in Kenney, Texas.

VEGETATIVE BARRIER	DISCHARGE (cms)	VELOCITY (m/sec)	PLUNGE POOL Meters
1	.76	.81	
2	.76	.75	
3	.76	1.14	
4	.98	1.47	.6
5	1.12	2.31	.5
6	1.12	2.88	.6
7	1.12	1.62	.6
8	1.32	1.83	
9	1.32	1.56	
10	1.32	2.10	.5
11	1.32	1.35	
12	1.46	1.05	
13	1.46	1.05	
14	1.46	1.80	

TABLE 3

Permissible velocities for channels lined with vegetation[1]. The values apply to average, uniform stands of each type of cover.

COVER	SLOPE RANGE[2]	PERMISSIBLE VELOCITY EROSION RESISTANT SOILS	EASILY ERODED SOILS
	Percent	Meters/sec.	Meters/sec.
Bermudagrass }.........	0-5	2.4	1.8
	5-10	2.1	1.5
	over 10	1.8	1.2
Buffalograss	0-5	2.1	1.5
Kentucky bluegrass	5-10	1.8	1.2
Smooth brome }.........	over 10	1.5	.9
Blue grama			
Grass mixture }.........	[2]0-5	1.5	1.2
	5-10	1.2	.9
Lespedeza sericea			
Weeping lovegrass			
Yellow bluestem			
Kudzu }.........	[3]0-5	1.1	.75
Alfalfa			
Crabgrass			
Common lespedeza[4] }............	[5]0-5	1.1	.75
Sudangrass[2]			

[1]Use velocities exceeding 5 feet per second only where good covers and proper maintenance can be obtained.
[2]Do not use on slopes steeper than 10 percent, except for side slopes in a combination channel.
[3]Do not use on slopes steeper than 5 percent, except for side slopes in a combination channel.
[4]Annuals—used on mild slopes or as temporary protection until permanent covers are established
[5]Use on slopes steeper than 5 percent is not recommended.

TABLE 4:

Vegetation Results from Planting of Vetiver Grass at the Study Site in Kenney, Texas.

BARRIER	PERCENT SURVIVAL			STEM DENSITY (#/.09m ^{2})			HEIGHT (cm)		
	5/97	9/97	11/98	5/97	9/97	11/98	5/97	9/98	11/98
1	50	89	100	5	0	13	64	70	122
2	67	89	100	3	3	8	53	79	111
3	60	100	100	5	6	17	63	89	136
4	22	83	100	3	8	10	64	84	119
5	58	93	95	4	8	12	51	87	124
6	39	100	95	4	12	11	63	91	115
7	58	80	95	6	3	3	54	82	105
8	50	100	92	3	3	9	47	91	123
9	58	100	92	8	15	18	48	91	138
10	80	100	100	87	9	10	62	91	126
11	93	92	100	9	4	1	61	87	93
12	70	100	100	6	3	6	52	89	119
13	71	86	95	5	2	2	54	84	103
14	93	86	100	8	1	4	56	86	108

TABLE 4: Continued

Vegetation Results from Planting of Vetiver Grass at the Study Site in Kenney, Texas.

BARRIER	BASE WIDTH (cm)			GAPS (# spaces > 15cm)			LARGEST GAP (cm)		
	5/97	9/97	11/98	5/97	9/97	11/98	5/97	9/97	11/98
1	2	4.3	13	12	6	2	74	25	18
2	1	8	12	24	6	0	103	91	0
3	2	8	20	17	4	2	115	91	0
4	2	8	13	9	2	1	72	144	30
5	2	8	17	8	2	0	136	37	0
6	2	10	14	7	2	1	91	23	20
7	2	7	13	3	0	0	305	0	0
8	1	7	13	9	3	0	89	30	0
9	1	11	22	7	2	0	198	47	0
10	1	8	13	5	6	0	137	49	0
11	2	7	10	1	0	0	19	0	0
12	1	6	13	5	1	0	33	27	0
13	2	7	12	9	0	0	61	0	0
14	2	8	10	2	0	0	19	0	0

TABLE 5

Elevation in meters at the vegetative barriers at the study site in Kenney, Texas

BARRIER	DATE	STATIONS 1	2	3	4	5
1	7/30/97	34.68		34.56		34.68
	2/11/98	34.68		34.68		34.68
	3/28/98	34.68	34.71	34.59	34.53	34.65
	6/24/98	34.65	34.62	34.59	34.53	34.65
	1/6/99	34.74	34.71	34.68	34.50	34.65
2	7/30/97	33.36	33.27		36.90	
	2/11/98	33.54	33.36	33.27		33.36
	6/24/98	33.51	33.36	33.54		33.36
	1/6/99	33.51	33.33	33.27		33.63
3	9/19/96	33.39	32.70	32.55	32.73	33.12
	7/30/97	33.33	32.67	32.55	32.73	33.12
	2/11/98	33.36	32.73	32.61	32.79	33.15
	3/28/98	33.33	32.64	32.55	32.76	33.12
	6/24/98	33.36	32.67	32.58	32.76	33.15
	1/6/99	33.33	32.67	32.52	32.73	33.12
4	9/19/96	32.55	32.19	31.95	32.22	32.55
	4/18/97	32.52	32.16	32.01	32.19	32.49
	7/30/97	32.55	32.25	32.07	32.01	32.52
	2/11/98	32.52	32.22	32.07	32.25	32.52
	6/24/98	32.55	32.22	32.07	32.25	32.52
	1/6/99	32.49	32.22	32.13	32.22	32.46
5	9/19/96	32.19	31.68	31.35	31.62	32.28
	7/30/97	32.16	31.68	31.41	31.65	32.22
	2/11/98	32.19	31.71	31.47	31.65	32.28
	3/28/98	32.13	31.68	31.47	31.62	32.22
	6/24/98	32.16	31.68	31.50	31.65	32.25
	1/6/99	32.13	31.71	31.56	31.65	32.19

TABLE 5 Continued

Elevation in meters at the vegetative barrier site at the study site in Kenney, Texas

BARRIER	DATE	STATIONS 1	2	3	4	5
6	9/16/96	31.8	30.93	30.81	30.87	31.62
	4/18/97	31.8	31.02	30.75	30.87	31.65
	7/30/97	31.83	31.05	30.81	30.93	31.68
	2/11/98	31.77	31.02	30.81	30.90	31.62
	6/24/98	32.80	31.02	30.81	30.90	31.62
	1/24/99	31.74	31.02	30.87	31.05	31.59
7	9/16/96	30.48	30.48	30.36	30.87	
	4/18/97	31.11	30.48	30.24	30.39	30.84
	7/30/97	31.17	30.54	30.27	30.42	30.90
	2/11/98	31.11	30.54	30.27	30.42	30.87
	6/24/98	31.17	30.51	30.30	30.42	30.90
	1/24/99	31.11	30.51	30.30	30.42	30.87
8	7/30/97	30.30	29.85	29.64	29.67	30.39
	2/11/98	30.24	29.85	29.61	29.64	30.33
	6/24/98	30.18	29.85	29.61	29.64	30.36
	1/6/99	30.24	29.85	29.67	29.67	30.33
9	9/19/96	29.67	29.28	29.07	29.13	29.94
	4/18/97	29.67	29.25	29.01	29.16	29.97
	7/30/97	29.67	29.25	29.04	29.16	29.97
	2/11/98	29.67	29.25	29.01	29.16	29.97
	3/24/98	29.67	29.25	29.13	29.16	29.97
	1/6/99	29.64	29. 25	29.13	29.16	29.97
10	9/19/96	29.25	28.50	28.92	28.74	29.25
	4/18/97	28.86	28.50	28.23	28.74	29.07
	7/30/97	29.92	28.47	28.35	28.74	29.07
	2/11/98	28.92	28.47	28.32	28.71	29.01
	6/24/98	28.92	28.47	28.26	28.71	29.04
	1/6/99	28.92	28.50	28.44	28.74	29.04

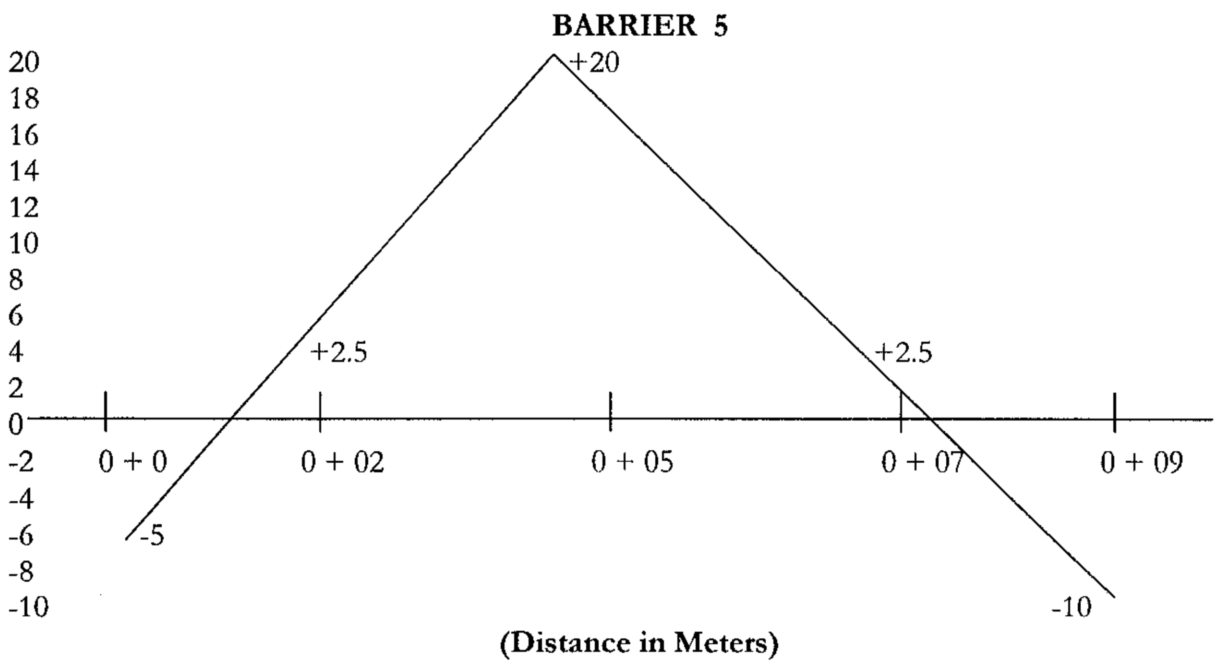
TABLE 5 Continued

Elevation in meters at the vegetative barrier site at the study site in Kenney, Texas

BARRIER	DATE	STATIONS				
		1	2	3	4	5
11	9/1696	28.53	27.69	27.39	27.72	28.65
	4/18/97	28.17	27.75	27.39	27.69	28.32
	7/30/97	28.26	27.75	27.39	27.72	28.35
	2/11/98	28.20	27.72	27.39	27.69	28.32
	6/24/98	28.23	27.78	27.39	27.72	28.32
	1/6/99	28.20	27.75	27.39	27.72	28.32
12	7/30/97	27.60	27.00	26.88	26.97	27.72
	2/11/98	27.54	27.00	26.97	26.94	27.72
	6/24/98	27.60	27.03	27.03	27.00	27.78
	1/6/99	27.60	27.03	27.03	27.03	27.75
13	7/30/97	27.06	26.64	26.43	26.64	27.24
	2/11/98	27.06	26.61	26.40	26.61	27.21
	6/24/98	27.12	26.64	26.40	26.64	27.24
	1/6/99	27.06	26.61	26.40	26.61	27.27
14	7/30/97	26.43	26.01	25.62	26.13	26.64
	2/11/98	26.46	26.98	25.56	26.10	26.61
	6/24/98	26.49	26.01	25.62	26.10	26.64
	1/6/99	26.46	26.98	25.65	26.13	26.64

FIGURE 1

Sediment Gains or Losses (in centimeters) at selected Vegetative Barriers at the Study Site in Kenney, Texas



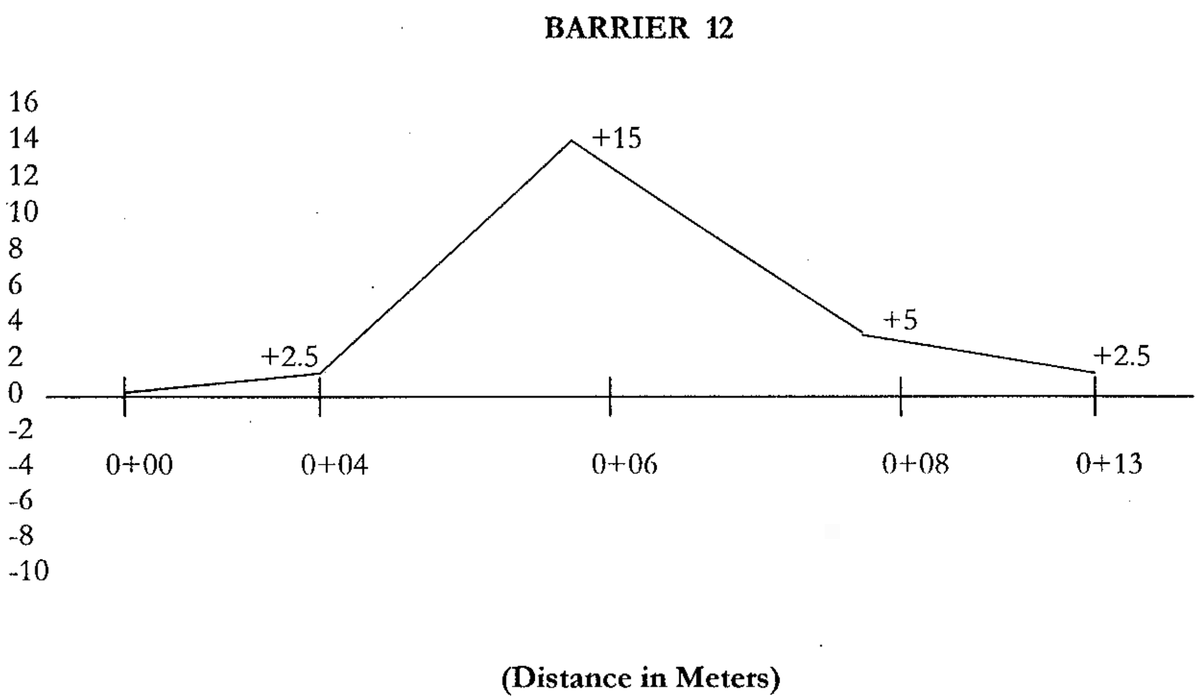
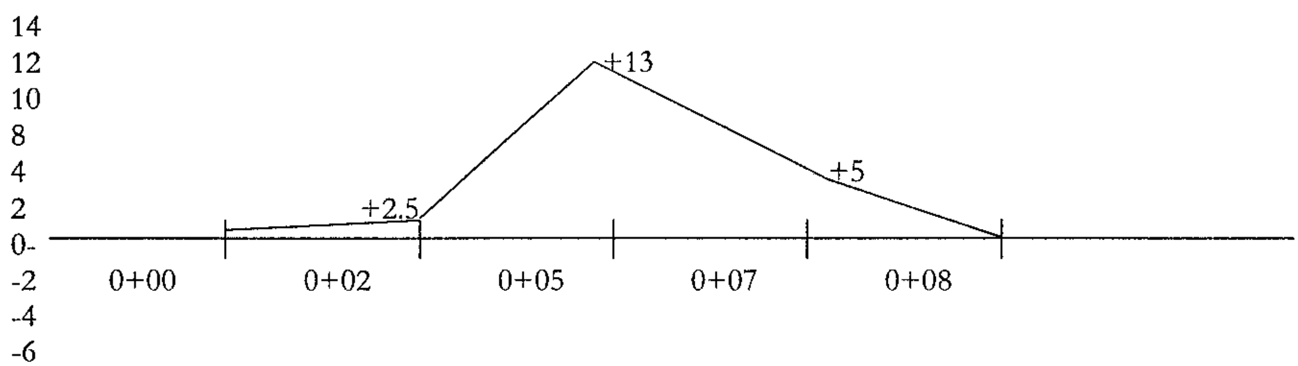


FIGURE 1 CONTINUED

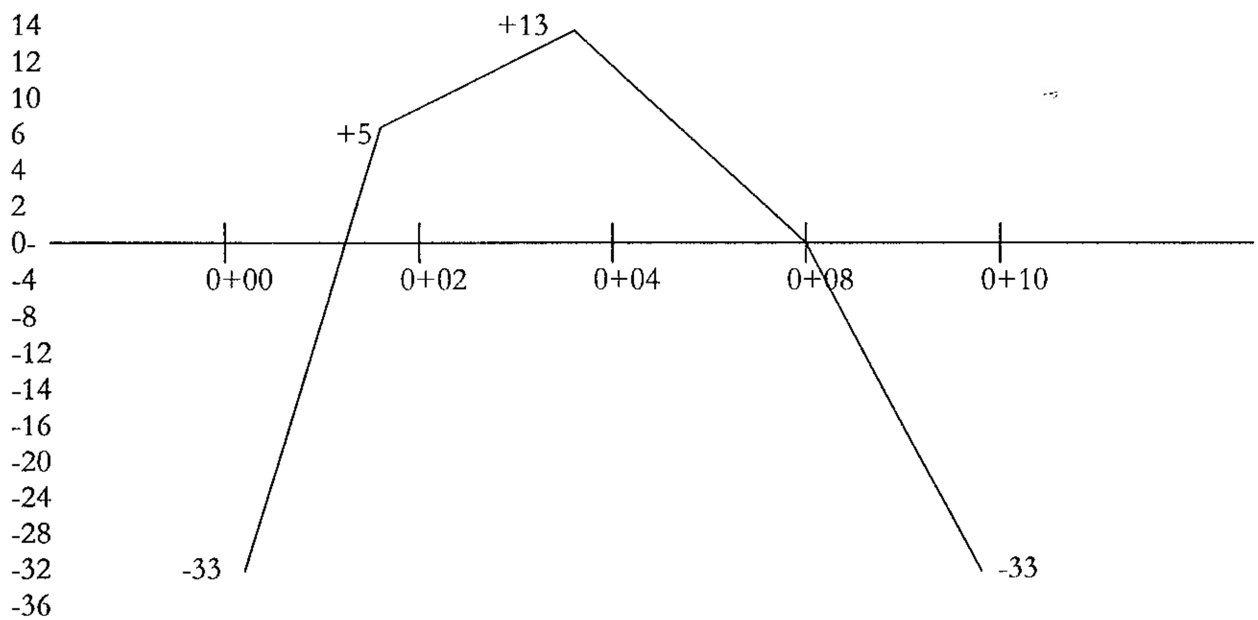
Sediment Gains or Losses (in centimeters) at selected Vegetative Barriers at the Study Site in Kenney, Texas

BARRIER 7



(Distance in Meters)

BARRIER 11



(Distance in Meters)

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SLIDE SHOW PRINTS
ENCLOSURE 4

Vegetative Barriers

A new upland buffer practice!

Vegetative Barriers also referred to as "grass hedges"

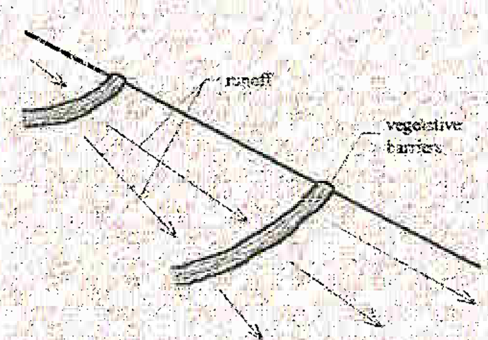
- Definition:
  - Narrow, parallel strips of stiff, erect, dense grass planted close to the contour (or)
  - across concentrated flow areas at convenient angles for farming (and)
  - are managed in such a way that any soil berms that develop are not smoothed out during maintenance

Purposes:

- Control erosion, trap sediment, and facilitate benching of sloping cropland
- Control ephemeral erosion and trap sediment in concentrated flow areas
- Trap sediment at the bottom of fields and at the end of furrows
- Improve the efficiency of other conservation practices

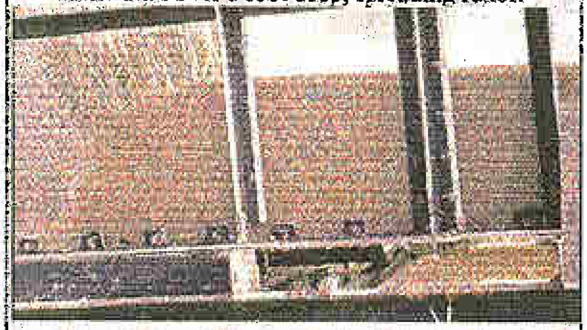
Additional Benefits:

- Retard and reduce surface runoff by promoting detention and infiltration
- Divert runoff to a stable outlet
- Entrap and transform sediment-borne and soluble contaminants
- Provide wildlife habitat



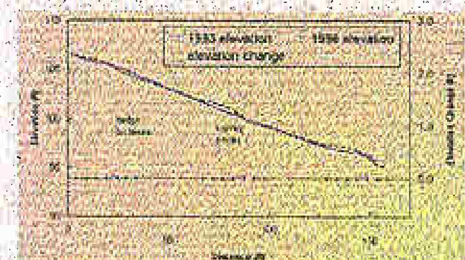
Parallel vegetative barriers divide field into short tilled strips making tillage impact greater

Narrow stiff-grass barriers can cause backwaters over a foot deep, spreading runoff



On standard USLE scale plots, 70% of silt loam sediment was trapped, runoff was reduced as much as by no-till management.

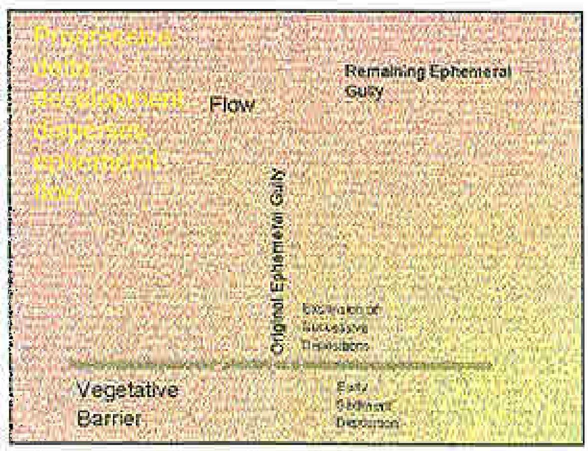
In swale areas, barriers caused 0.5 ft. of aggradation in 3 years of tilled fallow, Coffeeville, MS



Physical Effects
(How Vegetative Barriers Function)

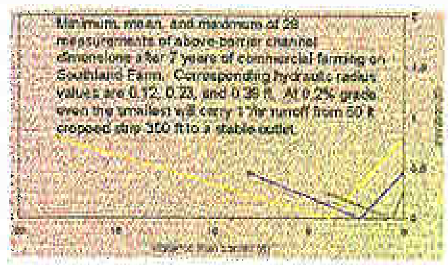
- Coarse, stiff, hedge-forming grasses can withstand high water flows and sediment.
- Concentrated flows are slowed and spread, scouring and head cuts are replaced by sediment deposition.
- Vegetative barriers disperse flows before runoff enters other conservation practices.

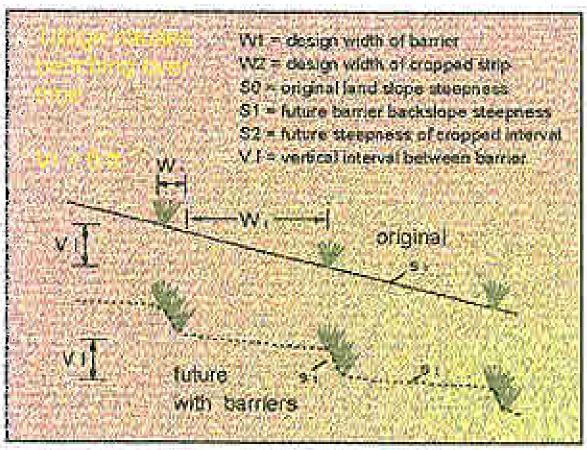
Sediment deposited upslope of barriers and soil moved from shoulders by tillage gradually level flow areas



Soil thrown into vegetative barriers by tillage gradually forms small terraces

Tillage-created berms act like mini-terraces to redirect runnoff and interrupt slope length





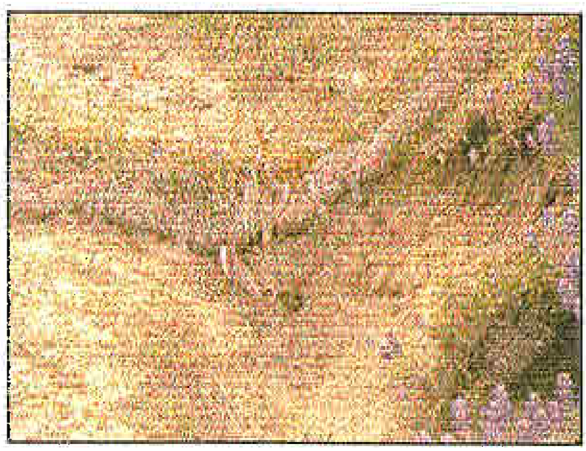


TABLE 7.

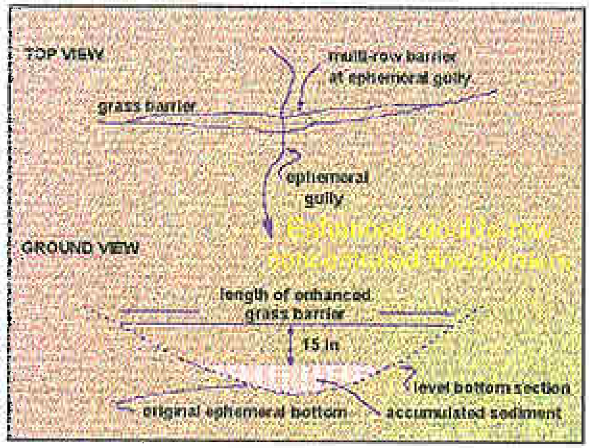
Permissible velocity for vegetated spillways[1]

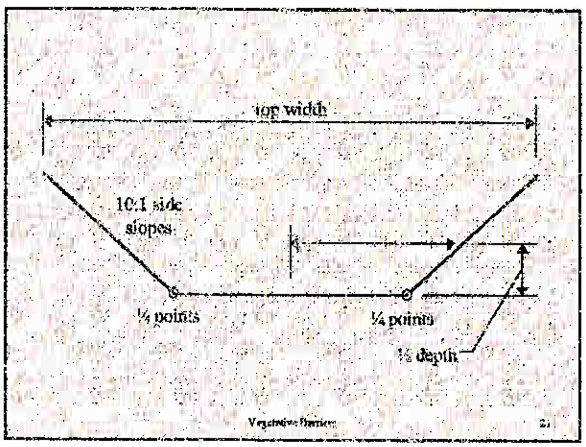
Vegetation	Permissible velocity[2]			
	Erosion-resistant soils[3]		Easily eroded soils[4]	
	Slope of exit channel		Slope of exit channel	
	pct 0-5 ft/s	pct 5-10 ft/s	pct 0-5 ft/s	pct 5-10 ft/s
Bermudagrass Bahiagrass	[illegible]	7	[illegible]	[illegible]
Buffalograss Kentucky bluegrass Smooth brome Tall fescue Reed canarygrass	7	[illegible]	[illegible]	[illegible]
Sod-forming grass-legume mixtures	5	4	4	3
Lespedeza sericea Weeping lovegrass Yellow bluestem Native grass mixtures	3.5	[illegible]	3.5	[illegible]

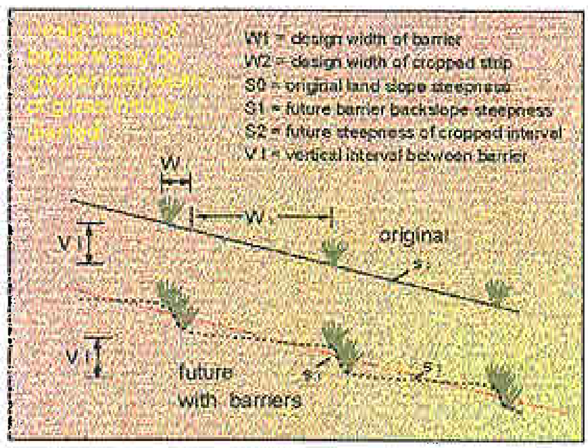
Rule of Thumb

Vegetative Barriers will be stable if the level length in __feet__ is equal to the contributing watershed area in __acres__.

(This is about equal to 1 cfs per foot of barrier when the runoff rate is 1 inch per hour)







Vegetative Guidelines

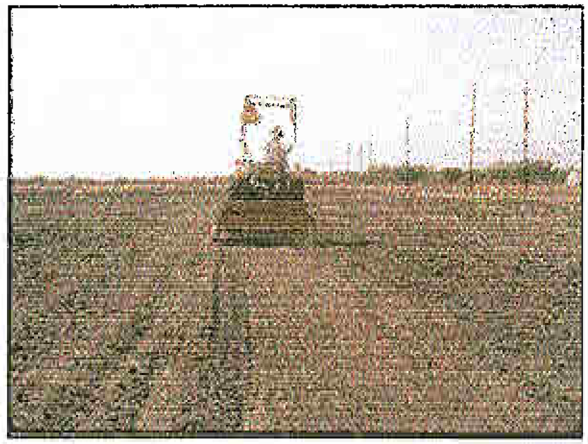
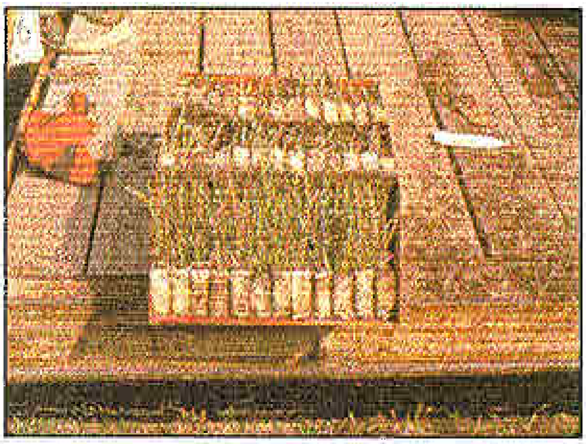
- 50 stems per square foot in all barriers
- $N \times D^4 > 0.1$ to resist concentrated runoff
- Example:
  - N=70 stems/ ft2
  - D = diameter of 0.2 inches
  - $70 \times 0.2^4 = 0.112$ (exceeds the 0.1 criteria)
- Mowing decreases average stem diameter

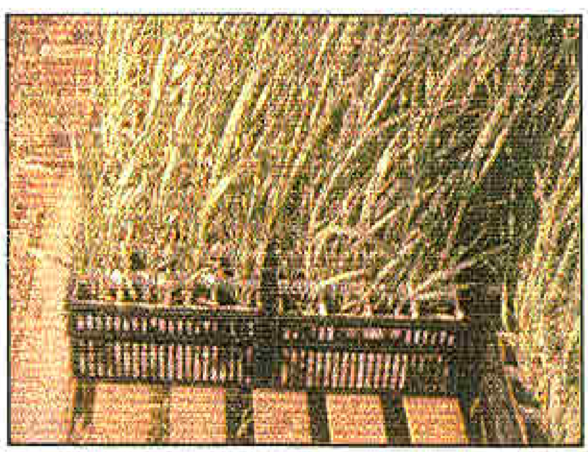
Grass species of adequate character include:

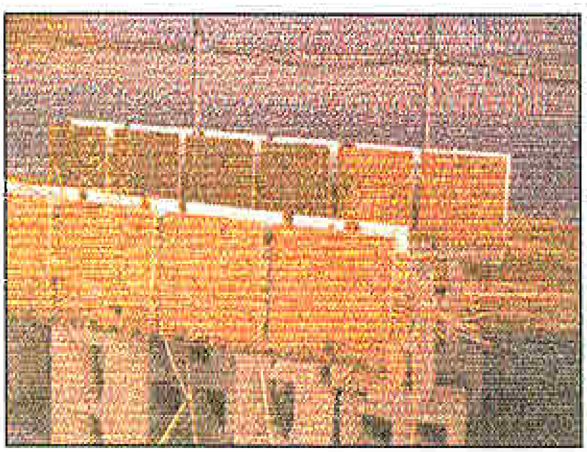
- Grasses Native to the Contiguous U.S.
  - switchgrass (Panicum virgatum)
  - eastern gamagrass (Tripsacum dactyloides)
  - big sacaton (Sporobolus wrightii)
- Exotic Grasses
  - vetivergrass (Vetiver zizanioides)

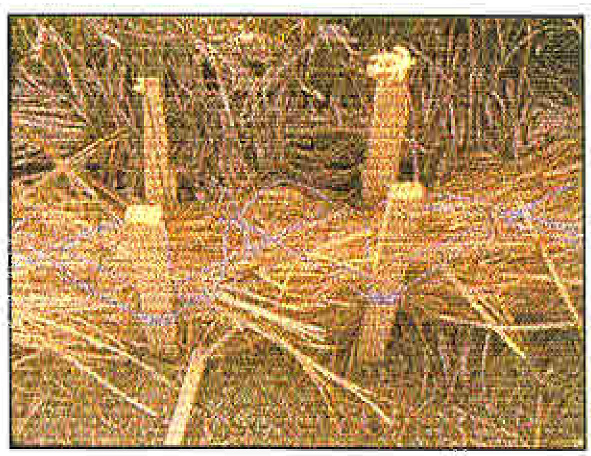
Vegetative Guidelines

- Barrier should be at least 3 feet wide
  - tall-growing barriers may be wider to accommodate available mowing equipment
  - stable backslope steepness (S1, Fig. 1) may also require wider barriers
- Barriers may be established from seed, but transplants are faster in critical areas.



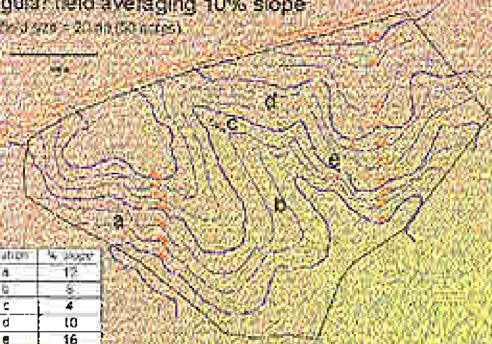


Ephemeral gullies can grow if unchecked, even in no-till fields with low sediment yield

Discrete hedge segments can trap residues and control ephemeral gullies in no-till fields

Design Example

Irregular field averaging 10% slope



location	% slope
a	12
b	8
c	4
d	10
e	16

Filter Strip Design (Dillaha and Hayes, 1992)

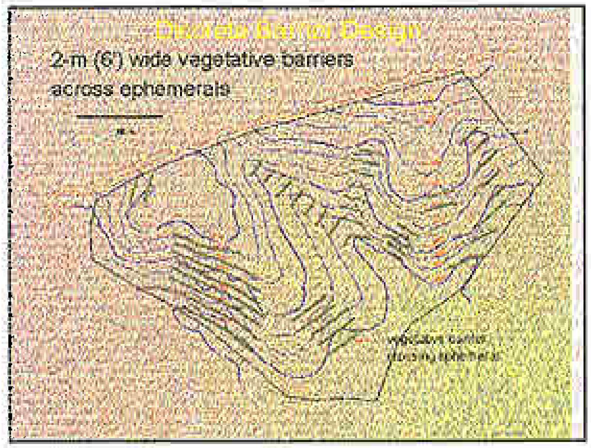
20-m (66 ft) wide filter strips on 1% grade on both side of drainage ways

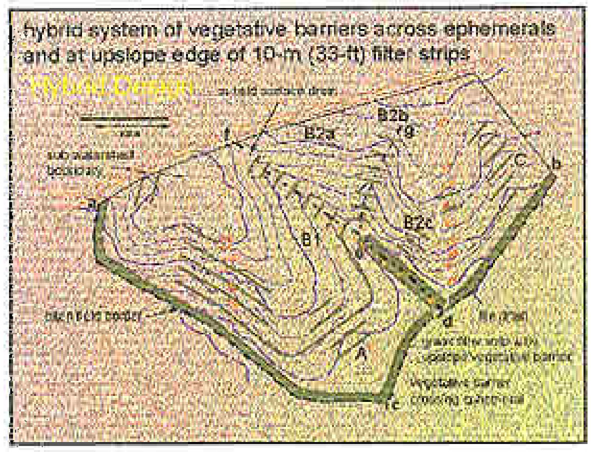
Buffer Strip Design

6-m (20') wide buffer strips alternating with 24 m (80') cropped strips

Parallel Contour Vegetative Barrier Design

2-m (6') vegetative barriers with15-m (50') cropped interval close to contour


Discrete Barrier Design
2-m (6') wide vegetative barriers
across ephemerals


hybrid system of vegetative barriers across ephemerals
and at upslope edge of 10-m (33-ft) filter strips
Hybrid Design
B2a
B2b
B2c
B1
A
C

POSTER/BROCHURE
ENCLOSURE 5

Advantages

There are numerous advantages to vegetative barriers. Seeded terraces are less expensive to construct than conventional earthen terraces. Vegetative barriers can revitalize and support waterways by capturing and spreading eroded sediment and enhancing nutrient uptake. These barriers can provide a cost-effective technique for water and sediment control basins. Furthermore, vegetative barriers can provide critical wildlife habitat when annual crops deteriorate.

This brochure is the result of a cooperative effort by the USDA-NRCS Kika de la Garza Plant Materials Center and the Texas Soil and Water Conservation Districts funded through the Texas Soil and Water Conservation Board and the U. S. EPA.

For More Information

Visit our Plant Materials Internet site at:
http://Plant-Materials.nrcs.usda.gov
to find more information on solving conservation problems using plants.

Contact

USDA NRCS
Kika de la Graza
Plant Materials Center
Rural Route 1, Box 608T
Kingsville, TX 78363
phone: (361) 595-1313

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Vegetative Barriers for Erosion Control

What is It?

Vegetative barriers are narrow strips (1 -3 feet wide) of stiff, erect, densely growing plants, usually grasses, planted across the slope perpendicular to the dominant slope. Vegetative barriers stair-step water down the hillside. These barriers retard surface runoff, slowing and ponding water and capturing and preventing sediment from flowing downhill.

Purpose

The main purpose of vegetative barriers is to:

1) Retard and reduce surface runoff by promoting detention and infiltration.

2) Disperse concentrated flow and prevent ephemeral gully development.

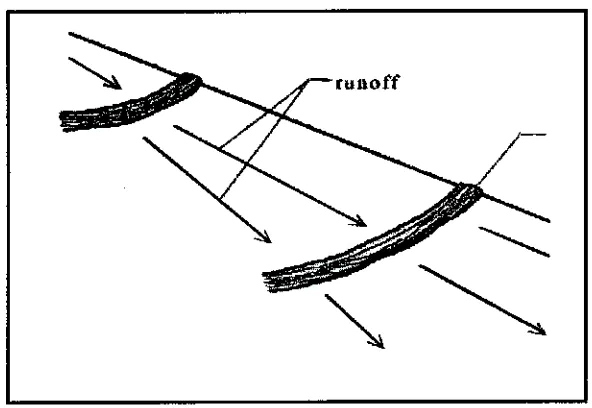
Secondary benefits that are sometimes realized:

1) Entrap sediment-borne and soluble contaminants and facilitate their transformation.

2) Reduce soil loss by causing deposition of eroded sediment on hill slopes.

3) Facilitate benching of sloping topography.

4) Provide valuable wildlife habitat.



Use

Vegetative barriers can be applied to eroding sites on areas of cropland, pastureland, field lots, mined land, gullies and ditches. Vegetative barriers have their greatest potential as vegetative terraces, as a method for controlling ephemeral gully development in concentrated flow areas, and as water detention barriers with buffer strips and filter strips to ensure more uniform entry of runoff and nutrient uptake.

VEGETATIVE BARRIER BOOKLET
ENCLOSURE 6

USDA NRCS
Natural Resources Conservation Service

United States Department
of Agriculture

Natural Resources
Conservation Service

Vegetative Barriers For Erosion Control

Plant Solutions for Conservation Needs

Kika de la Garza Plant Materials Center

Kingsville, Texas

This booklet is the result of work performed by the Kika de la Garza Plant Materials Center and funded through the Texas State Soil and Water Conservation Board and the United States Environmental Protection Agency.

CONTENTS

I. INTRODUCTION

Vegetative barriers or grass hedges are currently being evaluated as an alternative conservation practice. Vegetative barriers are narrow strips (1-3 feet wide) of stiff, erect densely growing plants, usually grasses, planted across the slope perpendicular to the dominant slope.

Over forty years ago, the USDA-Soil Conservation Service referenced the use of vegetative barriers in an agriculture handbook on conservation. (USDA-SCS, 1954) More recently, the World Bank has promoted the use of vetiver grass (Vetiveria zizanioides (L) Nash) as a hedge against erosion (NRC, 1993).

The main purpose of vegetative barriers is to:

1) Retard and reduce surface runoff by promoting detention and infiltration.

2) Disperse concentrated flow and prevent ephemeral gully development.

Secondary benefits that sometimes can be realized are:

1) Entrap sediment-borne and soluble contaminants and facilitate their transformations.

2) Reduce soil loss by causing deposition of eroded sediment on hill slopes.

3) Facilitate benching of sloping topography.

4) Provide valuable wildlife habitat.

II. CONCEPT OF USE

Erosion, whether caused by wind or water, accounts for the loss of tons of soil every year. Gully erosion is the most obvious form of erosion with the deep down-cutting of the soil profile. However, sheet erosion is the most insidious form of erosion. Raindrops pound the ground dislodging soil particles which are carried away by the surface runoff. Sheet erosion is a slow but steady form of erosion that covers vast amounts of acreage. It is difficult to see since it takes small amounts of soil over a long period of time.

Erosion can be controlled in two different ways. 1) The surface can be protected or reinforced by residue or through vegetation such as pastureland or a grass waterway. 2) The surface or slope can be flattened through benching or terracing. Earthen terraces or vegetative barriers stair-step water down the hillside. These barriers inhibit surface runoff, slowing and ponding water and capturing and preventing sediment from flowing downhill (figure 1).

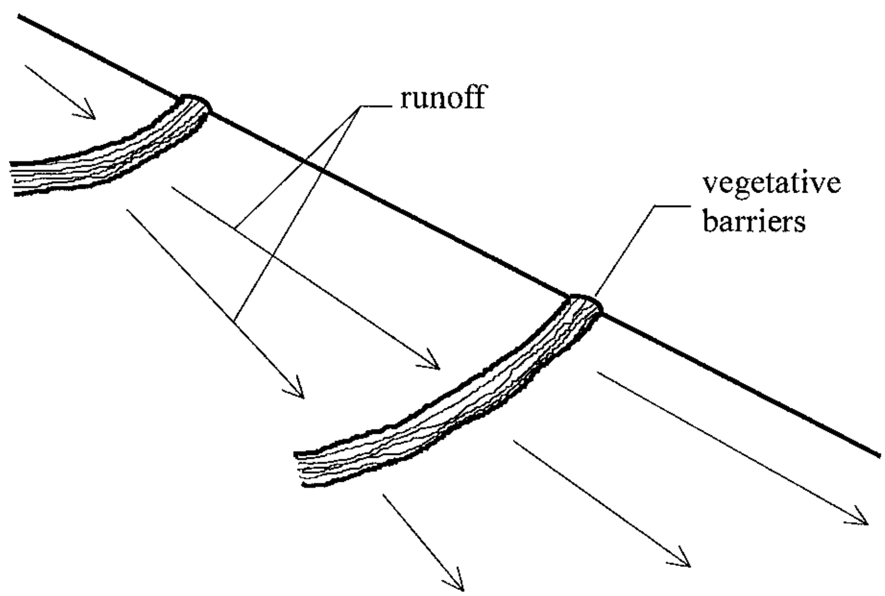


Figure 1

Vegetative barriers inhibit the flow of water because of their dense concentration of thick stems, thus slowing and ponding water and causing sediment to deposit in back of them (Meyers et al. 1994). Over time these deposits can develop into benched terraces (Aase and Pikul, 1995). These barriers function to diffuse and spread the water runoff so that it slowly flows through them without erosion. Vegetative barriers are resilient to failure because water passes over a broad area secured with perennial root reinforcement.

The vegetative barrier concept should not be confused with vegetative filter strips. Vegetative filter strips are a broad area of vegetation ranging from 15 to 30 feet wide whose purpose is to remove nutrients, pesticides and sediment from surface runoff. Vegetative barriers, on the other hand, are narrow strips of vegetation which are designed primarily to slow runoff, capture sediment and resist gully development. However, the two practices can be very complimentary. Research has reported that vegetated filter strips can be effective at nutrient removal and trapping sediment where water flows are shallow and uniform (Magette et al., 1989). Meyer et al., 1994 documented that stiff erect grasses such as vetiver (Vetiver zizanioides (L) Nash) and switchgrass (Panicum virgatum L.) can retard runoff and capture sediment from concentrated flow. Thus, as a vegetative barrier matures it reduces water velocities and establishes a broad uniform vegetative surface for the uptake of nutrients. Vegetative barriers have potential to not only reduce erosion but can enhance vegetated filter strips in the uptake of nutrients.

Practice Application

Vegetative barriers can be applied to eroding sites on areas of cropland, pastureland, feedlots, mined land, gullies, and ditches. This practice should be used in conjunction with other conservation practices in a conservation management system. Management practices such as conservation cropping rotation and residue management must be considered in designing the conservation management system on cropland. Associated structural practices such as water and sediment control basins, subsurface drainage, and underground outlets may need to be considered to adequately handle surface and subsurface water. This practice may improve the efficiency of other practices such as stripcropping, filter strips, riparian buffer zones, grassed waterways, diversions, and terraces.

Vegetative barriers have their greatest potential in use as a method for controlling ephemeral gully development in concentrated flow areas, and as water detention barriers with buffer strips and filter strips to ensure more uniform entry of runoff and nutrient uptake.

III. DESIGN CRITERIA:

According to the April 1997 NRCS Interim Practice Standard:

<u>For Controlling Sheet and Rill Erosion, Trapping Sediment, and Facilitating Leveling of Cropland:</u>

Figure 2 is a definition sketch of a system of vegetative barriers. The vertical interval (VI), or vertical fall between sequential barrier centers, limits barrier spacing. The maximum VI for this purpose is the lesser of 6 ft (2m) (USDA-Soil Conservation Service, 1954) or the spacing calculated by formulas for terraces (refer to Practice Standard 600-1, TERRACE). On slopes less than 5%, the terrace standard often results in a maximum VI less than 6 ft. A smaller VI than the maximum value may also be needed where subsoil conditions make the development of deep benches undesirable.

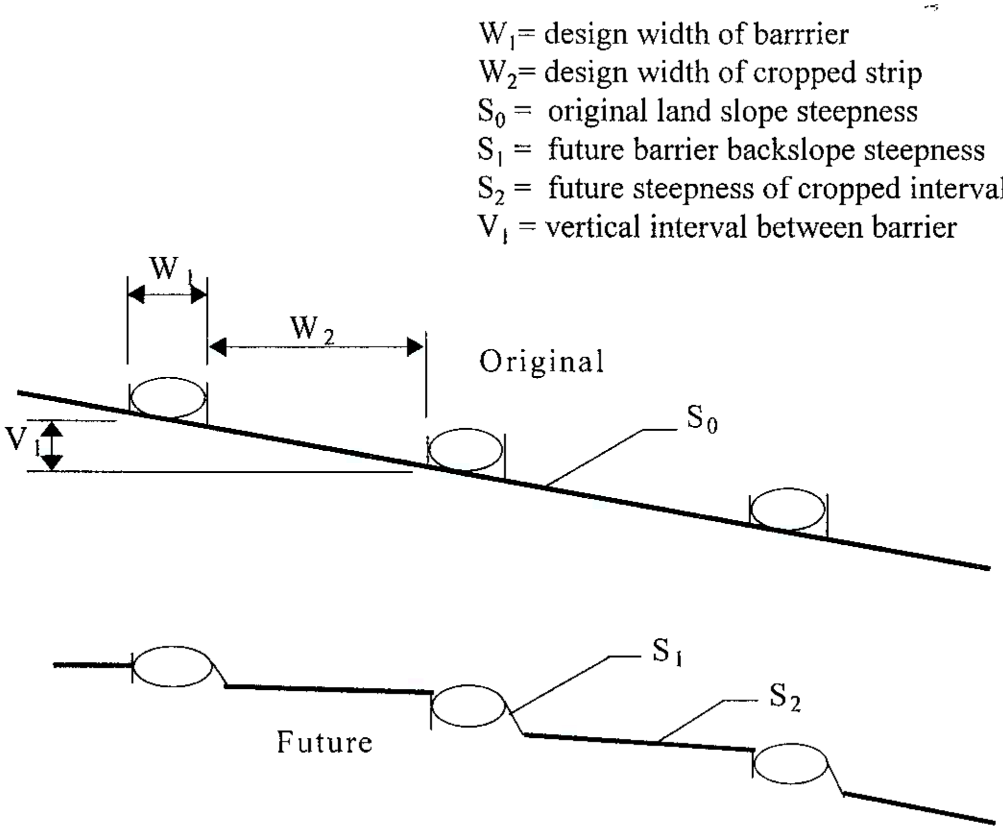


Figure 2

Vegetative barriers are arranged parallel to each other, on or near the contour, but across concentrated flow areas at angles convenient for farming. Over time, sediment and tillage will fill in the swale areas and contours will adjust to conform closer to barriers. All tillage will be done parallel to the vegetative barriers and will contribute significantly to the leveling and benching between vegetative barriers.

Gradients along barriers will be 0.6 percent or less except where the vegetative barrier crosses a concentrated flow area. Gradients entering a concentrated flow area may be 1 percent for 200 feet or 1.5 percent for 100 feet in order to get better row alignment. In designing barrier systems for variable fields, one approach is to select a constant hedge spacing based on the steepest 30% of the field that is a convenient multiple of the working width of the field equipment. Lay out barriers starting at midslope. Keep upslope and downslope barriers parallel to facilitate field operations. Where variable slopes cause excessive deviations from the contour, extra barriers can be included on the gentler slopes in order to keep barriers on steeper slopes close to the contour. For more local irregularities, a barrier's width may be altered, with subsequent barriers being parallel to the new line.

Vegetation must be established that has a density of at least 50 stems/ft^2 in all barriers. Barriers must be at least 3 feet wide. If barrier vegetation is so tall-growing that mowing is needed to minimize crop competition, barriers may be made wider to accommodate available mowing equipment. Mature barrier design width may also be wider than the amount of vegetation initially planted (Fig.2). The steepness of a stable backslope of the mature bench (S1, Fig.2), which depends on local soil and vegetation characteristics, will determine the required design barrier width. The final steepness of the cropped interval, (S2, Fig. 2) will be between 1 and 2%.

<u>Criteria for Controlling Rill and Gully Erosion and Trapping Sediment in Concentrated Flow Areas:</u>

Many fields have too much undulation to allow alignment on the contour without crossing a concentrated flow area with excessive slope for the criteria for contour vegetative barriers. In this case, or where sheet and rill erosion will be controlled with other practices such as residue management, discrete barrier sections may be installed across concentrated flow areas to control ephemeral gully development. When used to control only ephemeral erosion, barriers do not need to extend across the ridge tops but must be long enough to prevent bypass flow around the ends. At a minimum, each strip will extend far enough to provide 1.5 feet of elevation from the outer edge of the flow area to the end of the vegetative barrier. The amount of leveling anticipated as a result of tillage and sedimentation above the barrier should be considered when determining barrier length to avoid the necessity of extending barriers in the future.

In concentrated flow situations, vegetative barriers will be a minimum of 3 feet wide and consist of at least two rows of vegetation. The maximum VI for discontinuous barriers is reduced to 4 feet in order to minimize step heights. Vegetation must be maintained at a height of at least 15 inches throughout the year. Stem density must exceed 50 stems/ft2.

Criteria for Trapping Sediment as Field Borders at the Bottom of Fields and/or the Ends of Furrows:

Vegetative barriers may be used as field borders at the bottom of fields and/or the ends of furrows whether the furrows are aligned up and down the slope, across the slope, or on the contour. Barriers will be used as field borders only in fields already within soil loss tolerance and will not be credited with additional soil loss savings. They will effectively reduce sediment delivery to surface water downslope of the barrier, can prevent the development of headcuts into the field, and can ensure uniform over-bank flow into streams and ditches. A series of barriers spaced at a VI of 2 feet may also serve as an inexpensive alternative to small drop pipe structures. Vegetative barriers used as field borders will be a minimum of 3 feet wide. There is no maximum crop strip width or slope length.

Criteria for Increasing the Efficiency of Other Conservation Practices:

1. *Field Stripcropping or Contour buffer strips:*
Field strips are similar to vegetative barriers except they are wider, do not have as strict an alignment criteria, and require sediment accumulations to be periodically removed and redistributed on the land. Vegetative barriers established just upslope or in the upper 3 feet of the field strip where they cross concentrated flow areas could reduce the failure of field strips caused by concentrated flow.
2. *Filter Strips:* Filter strips are areas of vegetation located along field borders or above conservation practices such as terraces or diversions to improve water quality. Vegetative barriers incorporated into the upslope portion of filter strips will improve uniformity of runoff flows entering the filter and will increase filter strip longevity by promoting sediment deposition above the filter strip.

3. *Field Borders:* Field borders are areas of vegetation located along field borders to provide wildlife habitat or access to the field. Vegetative barriers incorporated into the upslope portion of field borders will increase field border longevity by promoting sediment deposition above the field border. Vegetative barriers will also provide additional wildlife cover in borders of predominantly sod-forming grasses.
4. *Riparian Forest Buffers:* Riparian forest buffers are similar to filter strips but include woody vegetation as well as herbaceous. Vegetative barriers could be used on the upslope edge of the vegetation zones.
5. *Grassed Waterways:* Waterways are designed to remove water from a field under controlled conditions. In many cases, waterways are difficult to stabilize. Vegetative barriers may help stabilize waterways by dispersing and slowing the concentrated flow.
6. *Diversions and Terraces:* Diversions and terraces are designed to intercept water flowing down a slope and direct it across the slope to a stable outlet such as a grassed waterway or underground outlet. Vegetative barriers established above the diversions and terraces will increase their longevity by promoting sediment deposition above the diversions and terraces, waterway or underground outlet. Barriers established on top of terraces may provide additional stability, but will not alter structure design specifications.

Local Experience:

It has been our experience at the Kika de la Garza PMC that a more strict design criteria is necessary for concentrated flow sites. It is extremely critical that you compute velocity of flow before constructing vegetative barriers.

The limiting factor on velocity should be the soil relationship. "Permissible velocities for channels lined with vegetation" and "Permissible velocity for vegetated spillways" in the SCS-TP-61 handbook provides a useful guide for this relationship (Table 1) and (Table 2). At this time, we would not recommend exceeding the velocities established for specified seed mixtures for newly constructed sites. As a repair or secondary treatment for existing vegetated sites, we probably can use Vegetative barriers at increased velocities of 1 to 2 ft./sec above these levels.

We believe barrier spacing should be set as close to 2 feet in vertical index as possible in order to prevent excessive erosion between barriers and to assist in water velocity reduction and improve sediment deposition.

The length of the barriers can be determined by the NRCS waterway calculation (WWCALC). In general it is important to have a consistent channel width above and below the barrier. Minimum length of the barriers are generally 20-30 feet with a minimum of $1^{1/2}$ to 2 feet in vertical height. Extending the height up to 2 feet allows for increased sediment capacity and helps prevent water flow around the barrier ends. Side slopes should be a minimum of 10:1 or gentler. The shape of the waterway for the vegetative barrier should be as close as possible to a trapezoid with a consistent flat bottom. (Figure 3)

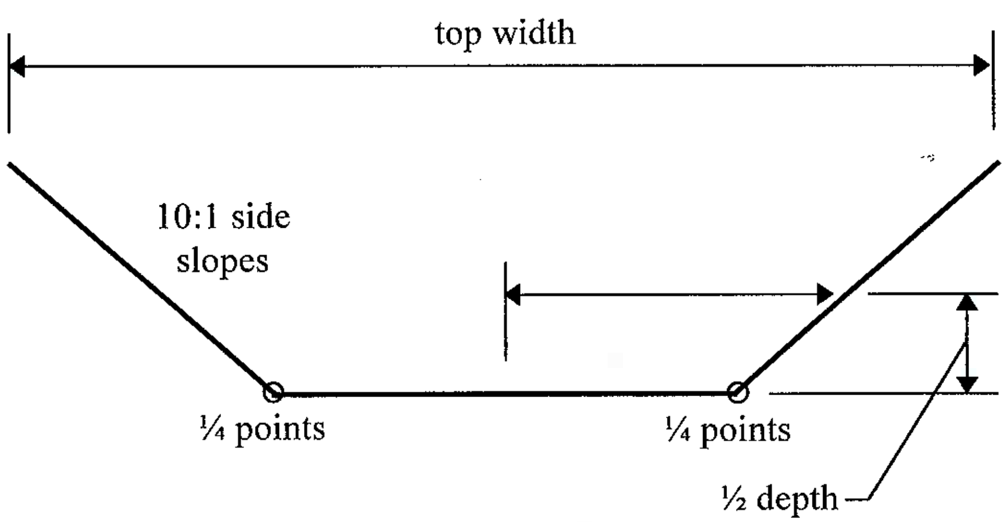


Figure 3

TABLE 1:

Permissible velocities for channels lined with vegetation[1]
The values apply to average, uniform stands of each type of cover.

COVER	SLOPE RANGE[2]	PERMISSIBLE VELOCITY EROSION RE-SISTANT SOILS	EASILY ERODED SOILS
	PERCENT	Ft. per. Sec.	Ft. Per. Sec.
Bermudagrass	0-5 5-10 Over 10	8 7 6	6 5 4
Buffalograss Kentucky bluegrass Smooth brome Blue grama	0-5 5-10 Over 10	7 6 5	5 4 3
Grass mixture	[2]0-5 5-10	5 4	4 3
Lespedeza sericea Weeping lovegrass Yellow bluestem Kudzu Alfalfa Crabgrass	[3]0-5	3.5	2.5
Common lespedeza[4] Sudangrass[2]	[5]0-5	3.5	2.5

[1]Use velocities exceeding 5 feet per second only where good covers and proper maintenance can be obtained.
[2]Do not use on slopes steeper than 10 percent, except for side slopes in a combination channel.
[3]Do not use on slopes steeper than 5 percent, except for side slopes in a combination channel.
[4]Annuals--used on mild slopes or as temporary protection until permanent covers are established.
[5]Use on slopes steeper than 5 percent is not recommended.

TABLE 2:

Permissible velocity for vegetated spillways[1]

Vegetation	Permissible velocity[2] Erosion-resistant soils[3] Slope of exit channel pct 0-5 ft/s	Permissible velocity[2] Erosion-resistant soils[3] Slope of exit channel pct 5-10 ft/s	Easily eroded soils[4] Slope of exit channel pct 0-5 ft/s	Easily eroded soils[4] Slope of exit channel pct 5-10 ft/s
Bermudagrass Bahiagrass	8	7	6	5
Buffalograss Kentucky bluegrass Smooth brome Tall fescue Reed canarygrass	7	6	5	4
Sod-forming grass-legume mixtures	5	4	4	3
Lespedeza sericea Weeping lovegrass Yellow buestem Native grass mixtures	3.5	3.5	2.5	2.5

[1]SCS-TP-61

[2]Increase values 10 percent when the anticipated average use if the spillway is not more frequent than once in 5 years, or 25 percent when the anticipated average use is not more frequent than once in 10 years.

[3]Those with a higher clay content and higher plasticity. Typical soil textures are silty clay, sandy clay, and clay.

[4]Those with a high content of fine sand or silt and lower plasticity, or non-plastic. Typical soil textures are fine sand, silt, sandy loam and silty loam.

IV PLANTING TECHNIQUES

Successful grass hedge plantings require the selection of the appropriate grass species, good land preparation, proper planting and sound management following establishment.

TERRACES

Seeding

The appropriate grass species for seeding vegetative barriers is a perennial species which produces an abundance of stiff erect stems that are resistant to water flow and tolerant of sediment deposition.
According to Dewald et al, (1996) suitable barrier plants must satisfy several criteria. They must be tolerant to the following:
(a) herbicides used on adjacent cultivated crops; (b) partial shading from cultivated crops; (c) inundation by sediment; (d) local climatic extremes (wetness, drought, freezing temperatures, etc); and, (e) easily established from available materials. They must also have the following characteristics: (a) long lived and manageable as a narrow strip; (b) non-weedy and not too competitive with adjacent cultivated crops; and (c) relatively tolerant to defoliation if crop residues are grazed.

Grass Selection

"Alamo" switchgrass (Panicum virgatum) has frequently been selected for vegetative barriers in Texas. Its seed characteristics make it easy and cost efficient to use. It produces a tall dense growing hedge and has good drought tolerance and range of adaptability. Good quality seed with a high germination rate should be purchased from a reputable dealer on a pure live seed (PLS) basis. Seeding rates for vegetative barriers must be considerably higher than for typical pasture plantings. It is necessary to establish a dense concentration of seedlings in order to quickly develop a solid vegetative barrier. However, since we are only planting narrow strips the total amount of seed is not very much. We recommend that seeding rates be between 10 and 20 pounds of PLS/acre.

Eastern gammagrass (*Tripsacum dactyloides*) is another grass that shows promise as a seeded grass for vegetative barriers. Its large seed gives it potential for good emergence especially on the heavier clay soils. It produces a tall, wide hedge with single plants growing 3 feet wide and 3 feet tall. We recommend that seeding rates be approximately 3-4 PLS per linear foot or approximately 25-30 pounds of PLS/acre.

Seed Bed Preparation

A major cause of seeding failures is poor seedbed preparation. Seedbed preparation needs to be initiated well ahead of the actual planting. Two types of seedbed preparation are generally used for vegetative barrier seedings, no-till and clean till.

A no-till seedbed will usually have had a prior seasons crop such as wheat or grain sorghum. This crop must be shredded and then shortly before seeding the field must be sprayed to kill any weed competition. A no-till seedbed can provide an ideal, firm seed bed.

A clean seedbed simply uses tillage to provide a clean, weed-free, smooth and firm seedbed. A disk followed by a cultivator is the most frequently used tillage operation to provide a clean, weed-free seedbed. However, a loose or rough seedbed will prevent accurate placement of the seed in the soil. Furthermore, it will prevent good seed to soil contact which is required for good germination, emergence and drought tolerance for the small grass seedling. Therefore, a cultipacker should follow cultivation to establish a smooth, firm seedbed surface.

It is our experience that switchgrass seedings on the heavy, shrink-swell clay soils of Texas tend to be extremely difficult. We recommend that switchgrass seedings be limited to the coarser textured loams and sands. An alternative planting method for heavy clay soils is the use of small transplants with a mechanical transplanter.

When To Seed

In south Texas, seeding can be done in either the spring or the fall. More important than the season of planting is the soil moisture. Good soil moisture is imperative to secure a good grass stand. If adequate soil moisture is available then seeding should be done in the spring as close thereafter to the 50% probability of the last frost as possible. In the fall, we recommend planting no later than two months before the 50% probability of the first frost.

Seeding Procedures

The width of the vegetative barriers should be a minimum of 3 feet wide. If planted with a brillion seeder the width is generally 5 feet wide. If planted with a no-till drill, it usually is seeded with the middle 6 rows of an 8 row drill at a ten inch spacing between rows. Switchgrass should be planted between one-quarter and one-half inch deep. Eastern gamagrass should be planted at approximately 1 inch deep. Eastern gamagrass is usually seeded using just 2 rows of a planter. Once the vegetative barrier is well established the barrier can be maintained at 3 feet wide with cultivation.

In a no-till operation, placement of seed is best attained with a no-till drill that is equipped with double disk openers and depth bands. A firm seedbed and appropriate tension on the disk openers should prevent the disk openers from submerging too far below the soil surface or running above the soil surface. The packer wheel on the drill will cover and firm the soil around the seed. In a clean-till operation, a brillion seeder can also provide a good seeding. Prior cultivation should provide a clean weed-free seedbed. The brillion seeder will then use its rollers to firm the soil, drop the seed, and then press the seed into the soil.

Transplanting

"Alamo" switchgrass has performed well as a transplant. It is easy and economical to produce 6" tall by 3" rooted transplants from seed for use in mechanical transplanters.

A clean, weed-free, but loose and friable soil is necessary for transplanting. It is preferable to form transplant beds at a maximum 3 foot spacing to improve transplant establishment. The beds improve the depth of loose friable soil and also act as small dams to capture runoff and reduce erosion. Generally two parallel beds about 4-6" in height are made with a disk-bedder following the terrace line. A mechanical transplanter is then used to plant the switchgrass transplants at a 7" interval. The transplanter uses a front coulter to break the soil, then has a shoe to set the transplant at the appropriate depth. The back of the transplanter has two press wheels to firm the soil around the transplant.

CONCENTRATED FLOW SITES

Grass Selection

"Alamo" switchgrass and Vetiver grass (*Vetiveria zizanioides*) are two grass species that have performed well as transplants in the concentrated flow zone.

Switchgrass transplants can be easily grown from seed. Transplants can range in size from 11/4" x 11/4" x 6" to 3" x 3" x 6". However, there is a balance between rapid growth and survival of the larger container versus the extra cost. It is important that the transplants have a minimum 6" rooting depth. It is also critical that the seedlings be at least 9" tall at planting to avoid sediment burial. Switchgrass is adaptive throughout Texas.

Vetiver is an introduced species from India. It has been used throughout Southeast Asia as an erosion control plant. It has excellent vegetative barrier characteristics with a deep root system, thick (3/4") stems, tall growth and dense tillering. Vetiver can not produce viable seed in Texas. Therefore, transplants have to be grown from splits. Furthermore, vetiver does not have good cold tolerance. We do not recommend that vetiver be planted north of Austin if being used for a long-term erosion control plant. If vetiver is being used as a short-term companion plant with switchgrass, it can be used throughout Texas.

Production of vetiver is best attained by planting splits on beds of a sandy loam soil. After a year of growth, the vetiver will have grown numerous tillers that are available for harvest. The vetiver is mowed at roughly a 12" height to remove most of the leaf material. Then a small blade or root plow that is roughly 3' wide and mounted on a tractor is driven down the rows to uplift the plants. Plants are then harvested and taken to a shed for processing. Plants are split with a hatchet and pruners to form a 3-4 stem clump with 4-6" roots and 9" tall stems. After splitting the vetiver, it is placed in containers of water. Vetiver can be maintained in these containers for at least a month. Vetiver is ready for planting once the clumps have developed new, young, white roots at 1/2" long. Waiting for new roots ensures that you are planting live healthy material. Vetiver splits can also be planted in transplant containers of 2" x 2" x 6" or 3" x 3" x 6". Vetiver transplants in containers cost more than bare-root material but have the advantage of a better root system for field survival. Containers also give a longer window for field planting. Plants can be maintained for over a year in 3" x 3" x 6" containers.

When To Plant

Planting of transplants in the concentrated flow zone is best done in spring. You want to plant after the threat of freezing temperatures but just before the spring rains. This is usually March through April. Spring plantings are desirable because this is the period of rapid growth for these warm-season grasses and it reduces the chance of sediment burial.

Planting Procedures

A planting area that is free of all plant competition is necessary. If planting in a crop field, bare-ground is necessary three feet to either side of the grass vegetative barriers. If planting in an existing waterway, grass should be killed either with a herbicide or tillage for ten feet on either side of the vegetative barrier. Two rows of transplants should be planted in the concentrated flow zone. The rows should be from 18" to 36" apart. Closer than 18" will result in plant competition and poor uniformity and functionality of the barrier.

We recommend that the down hill row be planted at a 3" spacing throughout the .5 foot depth of the concentrated flow basin. This should coincide with the half points of a grass waterway. The outside edges and the second row can be planted at a 6" interval. Transplant containers allow for accurate spacing. Bare-root vetiver clumps are planted four per foot for a 3" spacing and two per foot for a 6" spacing. Where adaptable, we prefer to plant the downhill row with vetiver and the uphill row to switchgrass. The vetiver provides quick erosion control effectiveness while the switchgrass provides good long-term control.

Planting is easiest with the use of a walk-behind ditcher. A trench six inches wide and nine inches deep can be dug with the trencher. A slow release fertilizer can then be sprinkled in the trench at a rate dictated by a soil test or at a rate of 120#/ac of nitrogen, phosphorus and potassium. Transplants are then placed in the trench and backfilled.

Where velocity will exceed 1.2 feet per second, we recommend that a straw bundle be secured abutting the downstream vegetative barrier. The bundle is made by tying switchgrass or vetiver stems to make a six foot long bundle. The width of the bundle should be around 4" - 6" in diameter. A taller bundle can be purchased commercially. However, the bundle's main function is to prevent the transplants from being dislodged and to help absorb the water velocity as it goes through the barrier. A taller bundle will capture more sediment which can bury the young transplants. The bundles are set across the vegetative barrier following the quarter points of the concentrated flow basin. The bundles must be adequately secured with baling twine to wooden stakes spaced every 2 feet following a weaving pattern (Figure 4). It must be tied in such a fashion that if one section fails the remaining section will stay secured. Once the bundles are tied down the stakes should be hammered to compress the bundles tightly to the ground.

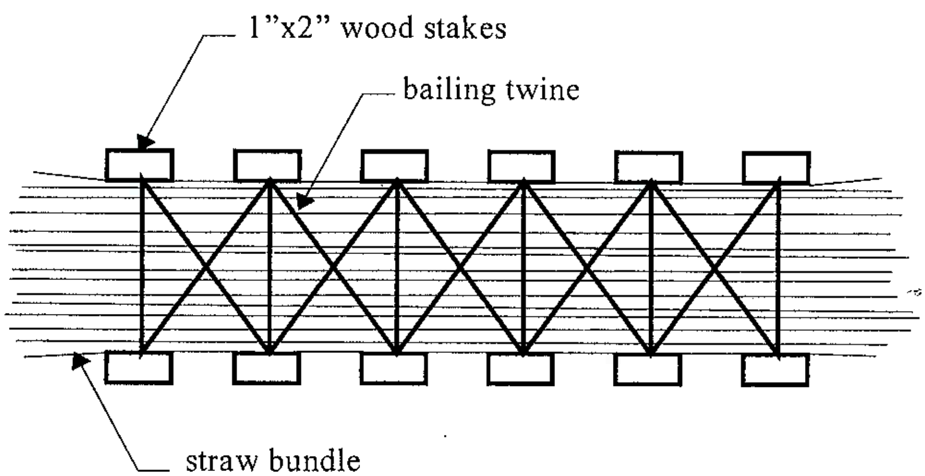


Figure 4

Once the transplanting and the placement of the bundles have been completed, all the transplants should be watered. This is done to eliminate any soil voids and give good soil moisture for rapid vegetative barrier establishment.

V MANAGEMENT

A newly installed barrier will require periodic inspection to ensure that there are no large gaps in the barrier. If gaps in the barrier are twelve inches or more, replanting will be necessary. Vegetative transplants should be planted in the gaps at a three inch interval and then watered. We also recommend that adjacent barriers be trimmed to twelve inches to reduce competition.

In the establishment year, be prepared if necessary to water your transplants. This may not be cost-effective for terraces, but watering plants in the concentrated flow zone is feasible. The landowner should be prepared to accept a travel lane in his crop field to facilitate watering of the vegetative barrier. In general, the transplants will need an average of 2" of rainfall or more per month in the initial growing season to survive and become established.

Cultivation of transplant rows in cropland is encouraged to reduce weed competition and to minimize soil cracking during drought years. Periodic cultivation as close to the vegetative barrier as possible may also be necessary to reduce and control downstream plunge pools in the concentrated flow zone.

Vegetative barriers should be mowed annually at a 12" height to maintain stem density and control tall weeds. Burning is not recommended for vegetative barriers unless the barrier has become decadent from many years of growth. Although burning stimulates grass growth, it also reduces the vegetative barrier effectiveness for controlling erosion.

Fertilization is generally not required for vegetative barriers on cropland. Mature vegetative barriers that are grown with a waterway may benefit from selective placement of fertilizer at a 60#/acre rate of nitrogen, phosphorus and potassium.

CONCLUSION

There are numerous advantages to vegetative barriers. Seeded terraces are less expensive to construct than conventional earthen terraces. There is less earth movement and soil compaction. Vegetative barriers can reduce concentrated water velocities. It can revitalize and support waterways by capturing and spreading eroded sediment. It can enhance nutrient uptake of filter areas. Vegetative barriers can provide a cost effective technique for water and sediment control basins. Furthermore, vegetative barriers can provide critical wildlife habitat when annual crops deteriorate.

However, there are several factors in Texas that must be resolved before vegetative barriers will reach full conservation use. Can vegetative barriers provide a cost effective alternative to conventional methods of conservation? Will there be adequate contractor and landowner interest to apply this alternative practice? The answers to these questions will come over the next few years as more land owners apply this conservation practice.

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Vegetative Barriers - Specifications Sheet

LANDOWNER________________________ DATE_____________ BY_____________________
TRACT NO. ______________ SECT.__________ T __________ R_________ CHECKED__________

Location and Layout	Strip/Basin 1	Strip/Basin 2	Strip/Basin 3	Strip/Basin 4
Barrier width (in)				
Rows per barrier				
Barrier length (ft)				
Barrier area (acres)				
Field slope (%)				
Channel velocity (f.s.)				
Barrier spacing (v.i.)				
Distance between barriers				
Basin depth (ft)				

Plant Materials Information

Species/cultivar by row number Strip #/Basin #	Plant spacing (plts/ft) Seeding rate (lb/acre)	Planting date	Grade Check Bundle (ft)	Recommend Amendments N-P_2O_5 -K_2O (lb/acre) or Lime (tons/acre)
1				
2				
3				
4				
Strip #/Basin #				
1				
2				
3				
4				
Strip #/Basin #				
1				
2				
3				
4				
Strip #/Basin #				
1				
2				
3				
4				

Site Preparation

Prepare weed-free seedbed. Apply lime and fertilizer according to recommendations. Shape basins according to engineering specifications.

Operation and Maintenance

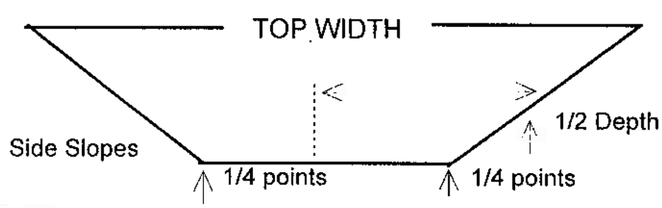
Vegetative barriers must be inspected periodically to assure no voids develop in the protective strips of vegetation. Shape and replant washouts and rills as necessary to maintain plant density. Control spreading of barrier plants into cropped areas. Control weeds and fertilize to maintain plant vigor. Control grazing and equipment traffic as necessary to protect barriers.

Vegetative Barriers - Job Sketch

Field sketch showing field boundaries, strip and basin locations, barrier widths, runoff direction arrow, and field layout. Other relevant information, such as adjacent field conditions including structures, crop types, and complementary practices, may also be included.

Scale 1" = _________ ft. (NA indicates sketch not to scale)

BASIN SHAPE



Additional Specifications and Notes: