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COOPERATIVE HIGHWAY RESEARCH PROGRAM

REPORT 81-4

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INVESTIGATION OF EROSION CONTROL MATERIALS FOR SLOPES IN HIGHWAY CORRIDORS IN MISSOURI

FINAL REPORT

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"INVESTIGATION OF EROSION CONTROL MATERIALS FOR SLOPES IN HIGHWAY CORRIDORS IN MISSOURI"

HPR Study #81-4

Final Report

DEPARTMENT OF TRANSPORTATION
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Prepared By

Missouri Highway and Transportation Department
Division of Materials and Research

June, 1983

In Cooperation With
U.S. Department of Transportation
Federal Highway Administration

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ABSTRACT

This study considered the use of ground fibers as a hydraulic mulch to replace Type 2 mulch (vegative mulch with emulsion as a tackifier) and the use of ground fibers, cooked fibers, and slick paper as mulch oversprays to replace emulsion as a tackifier, in Type 2 mulch.

Study results indicated ground fiber hydraulic mulch was not satisfactory as a replacement for Type 2 mulch. The oversprays were considered as the equivalent of emulsion as a tackifier over vegetative mulch and were recommended for use as an alternate to emulsion. Some cost savings are anticipated as a result of allowing the alternate.

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INTRODUCTION

Methods of erosion control for Missouri highway projects have been limited in variety and often entailed the use of a non-replaceable natural resource, asphalt emulsion. Recently, newer materials for erosion control of slopes have been developed which are reportedly economically competitive with the current Department method, primarily straw with SS-1 asphalt emulsion as a tackifier. A study was thus proposed to evaluate the newer materials for their applicability and cost-effectiveness.

The proposed objective of the study was to evaluate hydraulic mulches of virgin wood cellulose fibers of the ground and cooked variety, recycled wood cellulose from newsprint, slick paper, and cardboard, and both virgin and recycled wood cellulose fiber as a tack over straw.

Hydraulic mulches were applied at a rate of 1800 pounds per acre. The materials used as tack over straw, or oversprays, were applied at 750 pounds per acre. The rate of cooked fibers for either application was increased when the organic matter content was low as noted in Appendix A.

After initiation of the study, recycled newsprint and cardboard became unavailable. At the same time, Department funding for highway projects became critical resulting in a delay for many projects that were scheduled, including projects for this study. These resulted in the study being reduced substantially from the original proposal.

CONCLUSIONS AND RECOMMENDATIONS

Use of virgin ground fiber hydraulic mulch was only a limited success. If good growth can be obtained as is often the case in September, its use could be considered applicable. If immediate growth within 30 days is not expected, ground fiber hydraulic mulch is not recommended for use at the rate used for this study. It appears to be susceptible to rainfalls exceeding 1" in 24 hours. Its primary drawback appears to be the lack of protective bulk to dilute the rainfall force and slow down the eroding water.

The hydraulic mulch oversprays examined were generally a success. This included virgin wood fibers, ground and cooked, and slick paper. Admittedly, the straw is providing the erosion protection and the effectiveness of the oversprays apparently does not last long. Their primary effect is to hold the straw initially until it is packed by rainfall.

The oversprays, as well as the hydraulic mulches, were well liked by the contractors since they did not require the care and cleanup that emulsion does during application. Both types demonstrated economic competitiveness. The oversprays in particular appear to be economically advantageous.

The results of this study indicate that future erosion control materials should contain enough bulk to break the force of rainfall and should be tenacious enough to resist, at least to some extent, the lateral force of surface water. The apparent effect of the oversprays was to hold or "tack"

the straw until the weather settled and packed it somewhat. Following that, the oversprays are of minimal value.

On the basis of this study, it is recommended that ground fibers, cooked fibers, and slick paper oversprays be adopted as a standard specification option for emulsion in Type 2 mulches.

IMPLEMENTATION

As of November, 1982, the mulch overspray materials were tentatively recommended as a standard Job Special Provision in all contracts. Indications at that time were that overspray materials were less costly than SS-1 emulsion and were performing satisfactorily. Contractors were requesting change orders to mulch overspray in lieu of emulsion and in some instances were offering a reduction in contract price for their use. As a result, virgin ground fibers, cooked fibers, and slick paper were included as an option for emulsion starting in 1983.

Hydraulic mulches have been discontinued from future contracts.

SCOPE

The proposed method of study was to include the available materials in ten projects each, to be let to contract with statewide distribution to be achieved as near as possible. Predominant soils were to be sampled for pH and grain size classification, installation of materials was to be observed, daily high and low temperatures recorded, and rainfall monitored until vegetative growth was achieved or failure was identified. Each materials' success or failure was to be evaluated in relation to the degree and length of slope, weather, erodibility of the soil, application problems, and environmental effects and the economic feasibility of the products versus current standards was to be determined. The proposed materials for evaluation were virgin wood cellulose fibers of the ground and cooked variety, recycled wood cellulose fibers from newsprint, slick paper, and cardboard, and both virgin and recycled wood cellulose fiber as a tack over straw.

Specifications for various materials were prepared using manufacturer's recommendations and inserted in contracts in place of the standard mulching specification. The various hydraulic oversprays replaced the use of emulsion as a tackifier over a 2 1/2 tons/acre Type 2 straw mulch. Hydraulic mulch replaced Type 2 mulch. Typical specifications are included in Appendix A.

In addition to the projects specifying the experimental materials, occasional Change Orders to the experimental materials were allowed at the contractor's request after the projects had been contracted. These were included as a part of this study.

After awarding of the contracts, the field personnel in each of the ten Districts comprising the MHTD kept in touch with the project and tried to obtain the desired data as the experimental materials were placed. The reports were then sent to the Materials and Research Division for collection and analyzing. In addition, the Division personnel made occasional field checks on various installations.

The data collected generally included soil samples at the time of application for pH and grain size classification and samples two weeks after application for pH. Application procedures were checked when possible for problem areas. After installation, daily high and low temperatures and rainfall amounts were recorded using, typically, a max-min thermometer and a rainfall gauge. This was monitored for 30 days along with any notable occurrences such as high winds or intensive rainfall. At the end of 30 days, the observer noted the growth and filled out a report with the applicable data and comments. When possible, photographs were taken. Generally, data collection ceased after 30 days although a number of projects were checked thereafter for various effects.

The data and applicable field notes are tabulated in Tables I-V.

At a later date as a means of evaluating the projects, the vegetative growth at 30 days was ranked in varying degrees as none, minor, satisfactory, or good, on the basis of photographs and field reports. This information is also shown as data.

Prior to this report each of the projects was ranked in terms of the success of that particular overall installation at 30 days without regard to extenuating circumstances:

Failure (-) indicated the material did not provide erosion control and its use would not be recommended again under similar conditions.

Success (+) indicated the material worked well, erosion was very minor, a stand of vegetation was present at 30 days and the mulched area could be considered stable. The material would be specified again under similar conditions.

Zero (0) indicated the installation could not be classified as a failure or a success at 30 days. Lack of any growth but no erosion was typical of this rating. Also minor erosion with some growth was possible. Materials in this category could be considered as an alternate again under the same conditions.

These ratings were determined individually on each location by three individuals familiar with the materials and with field experience, using the field reports and any personal knowledge of the location. The rankings were fairly consistant between the individuals so the average was used as a means of eliminating possible field bias that might be present and thus placing the results in some quantifiable form.

The reduction of projects for this study due to material unavailability, critical Department funding during the study, and the many variables included in the original proposal precluded any statistical study of the data.

DISCUSSION

The success or failure of the erosion control materials examined was highly dependent upon quick vegetative growth. None of the products used were designed to have infinite life spans. They were designed to stabilize and protect a disturbed area for a finite period of time, after which, due to their nature, they decompose. Observations in this study indicated that after about 30 days, the weather elements began to take their toll on the experimental erosion materials although this was less evident for straw. The longer the period of time of no growth, the greater the probability was that erosion would occur. It would be unusual in Missouri to go 30 days and not have rainfall of some intensity and duration with some eroding potential, hence the desirability of controlling erosion for an optimum time span. There are also definite periods during which seed germination and growth establishment are difficult due to the lack of soil moisture and/ or ambient temperatures. For these reasons and the fact that, the finishing of a project which signals seeding and mulching time often falls at an inopportune time of the year for growth, observations were seldom taken beyond 30 days. Failure or erosion after that time could be expected and it was felt that this was a reasonable period of time to expect some growth.

Missouri Standard Specifications state that during the months of June, July, October and November only 50% of the required seed and 75% of the required fertilizer shall be applied with 100% of the lime and mulch. The remainder of the fertilizer and 75% of the required seed is to be applied by overseeding during August, September,

January, or February. Seeding was done primarily with Ky31 fescue (60-75%) using various mixtures containing white clover, birdsfoot trefoil, or crown vetch. There were quite a number of projects during the reduced rate application period. However, it did not appear that lack of growth was due to the reduction of seed and fertilizer applied, but more due to the climatic conditions.

Generally there were several factors that could not be tied down specifically due to the lack of projects. Soil pH samples taken before and after did not indicate any detrimental effects due to the low pH of the erosion materials although liming during the seeding applications likely confused the results. Length and degree of slopes varied within projects. Soil classifications did not provide any informative data. There were no application problems of any consequence noted. The hydraulic mulches are a one-application material whereas the oversprays require an applicator for the straw and one for the overspray.

Eleven projects were done with hydraulic mulch on fourteen occasions, all of which used virgin ground fibers with a tackifier either as a blend or as an additive to the mulch material. Review of the results indicate two of these were considered successes and eight were failures with the remaining four rated as zero. However, as shown graphically in Figure 1, the vegetative growth obtained was generally not very good, attributable to the fact that most of the applications were not done during the prime growing time of the year, either early spring or early fall.

The two successes were done in September and had good growth by 30 days. In fact, field notes for Project H indicated uniform growth by 15 days at which time it withstood a 3.8" rain.

The zero rated projects had either: (1) substantial intensive rain and satisfactory growth (Project R), or (2) no rainfall greater than 1" per day and minor or no growth (Projects T, U, and O).

The remaining projects considered as failures uniformly had minor or no growth with fairly substantial rains ranging from 1.3 to 3.1 inches in a 24 hour period, resulting in erosion of the mulched area.

The apparent conclusion is that the hydraulic mulches were satisfactory if vegetative growth was well established by 30 days. If growth was not established, the areas were vulnerable to rainfalls exceeding 1" in a 24 hour period.

Three different overspray materials were used over a straw mulch in lieu of the standard emulsion tackifier. Ground fibers were used on 9 projects on 11 occasions. Cooked fibers were used on 4 projects and slick paper was used on 2 projects. There was no obvious difference between the oversprays and no failures. Field reports indicated that the straw held well except in a few instances of extremely high winds. The cooked fibers were lower than specification limits for % organic matter on occasion. The applied quantity was raised to compensate for it. Only two

slick paper projects were done but field reports indicated a very sticky material and indeed one of the projects was still intact after 30 days and a 2.4" rain despite no vegetative growth. The oversprays did not generally get the concentrated rain that the hydraulic mulch did. Also the majority of them were done during a good growing season although it was dry on several of projects as reported by field reports and confirmed by the lack of growth. It is interesting to note that although growth was sometimes lacking at 30 days in September the materials were successful usually due to later growth when the surface moisture became adequate.

In general, the oversprays appear to be adequate up to at least a 3" rainfall and all except extremely high wind conditions. Erosion protection was generally provided for at least 30 days.

Economically there appears to be a savings with all of the materials, as shown in Table VI, although hydraulic mulch was close to a breakeven point compared to straw and emulsion. The oversprays appear to be more economical and the switch to an over-spray - straw, emulsion option in 1983 has continued to show a price drop as the materials increase in familiarity. The 1983 option prices cannot compare directly to the 1982 straw plus emulsion prices due to the quantities involved and the nature of the jobs, however, mulching prices are approaching those of several years ago when quantities were large.

There are many more factors which contribute to slope erosion than those briefly considered in this report. The variability of conditions within projects and from project to project statewide would imply exhaustive studies and extensive expenditures to engineer each individual condition and tailor fit a proper erosion control material. The intent of this study was to determine if available materials would generally work statewide under existing conditions, if so, were they economical.

TABLES

TABLE I

Hydraulic Mulch (Ground Fibers)
Field Data

Project	State District	Installed	30 Day Avg. Temp. Hi	Lo	Avg.	30 Day Rain Hi	Avg.	Growth At 30 Days	Area (Acres)	Success
A	1	11/13/81	47	30	39	1.54	.075	None	2.0	-
	Approximately 50% of mulch washed away after 1.54" rain. Also considerable erosion. Applied well. Erodable soil. 3:1 slope.									
C	1	9/2/81	78	53	66	2.50	.187	Good	1.7	+
	Heavy rain at 3 weeks.									
C	1	10/27/81	58	36	47	2.25	.092	Minor	1.6	-
	Applied well. 2.25" rain washed away 50% of mulch. Highly erodable soil, 2.5:1 slope.									
D	1	7/5/81	85	69	77	3.10	.343	Minor	22.8	-
	Washed out in heavy rain. Considerable erosion. 2:1 slope.									
D	1	7/14/81	85	66	76	3.10	.349	Minor	22.8	-
	Considerable erosion. 2:1 slope.									
G	4	11/25/81	44	21	33	1.3	.061	None	14.2	-
	Numerous rills at 30 days.									
H	4	9/24/81	67	40	54	3.8	.163	Good	4.5	+
	Heavy rain at 2 weeks. Uniform growth at 15 days. Minor erosion.									
R	6	5/30/81	83	64	74	2.6	.197	Satis.	1.5	o
	Non-uniform application. Some erosion.									

TABLE I (Cont.)

Hydraulic Mulch (Ground Fibers)
Field Data

Project	State District	Installed	30 Day Avg. Temp. Hi	Lo	Avg.	30 Day Rain Hi	Avg.	Growth At 30 Days	Area (Acres)	Success
S	6	7/15/81	86	71	78	2.4	.291	Minor	15.8	-
	Hard rains washed mulch. Severe channeling.									
S	6	8/15/81	83	64	74	2.4	.238	Minor	13.8	-
	Hard rain washed mulch. Severe channeling.									
T	6	11/10/80	48	34	41	.8	.168	None	5.0	o
	Applied well.									
U	6	10/15/82	62	43	53	.6	.073	Minor	27.5	o
	Did not stay well on slopes steeper than 4:1.									
W	7	8/14/81	82	61	72	1.87	.152	None	35.2	-
	Some erosion and loss of mulch. Change ordered in lieu of T-2 mulch.									
O	6	12/14/81	32	9	21	.58	.095	None	23.6	o
	Applied well. Minor erosion.									

TABLE II

Hydraulic mulch Overspray (Ground Fibers)
Field Data

Project	State District	Installed	30 Day Avg. Temp. Hi	Lo	Avg.	30 Day Rain Hi	Avg.	Growth At 30 Days	Area (Acres)	Success
I	4	9/16/81	77	51	64	1.45	.062	Satis.	6.4	o
	Change ordered in lieu of emulsion. Dry conditions.									
J	4	9/15/80	82	48	65	.7	.048	Minor	55.4	+
	Change ordered in lieu of emulsion.									
K	4	4/29/82	74	56	65	1.5	.270	Good	65.0	+
	Very little erosion. Excellent growth.									
L	4	10/4/82	66	45	55	1.16	.073	Minor	57.1	o
	Some sheet erosion.									
M	5	9/9/81	76	55	66	0	0	None	33.6	+
	Held well. Uniform growth at 48 days.									
V	7	9/8/82	83	56	70	.6	.110	Good	49.0	+
	Extremely high winds. One small area of mulch lost due to wind tunnel effect after completion. Some areas lost straw before overspray could be applied.									
Y	8	9/8/82	78	57	68	1.51	.116	Satis.	21.9	+
	Some difficulty during application with wind.									
Y	8	11/4/82	66	39	53	.69	.056	None	21.9	o
	Some difficulty during application with wind.									

TABLE II (Cont.)

Hydraulic Mulch Overspray (Ground Fibers)
Field Data

Project	State District	Installed	30 Day Avg. Temp. Hi	Lo	Avg.	30 Day Rain Hi	Avg.	Growth At 30 Days	Area (Acres)	Success
Z	9	10/7/81	68	48	58	3.2	.343	Good	7.1	+
	Good application. Fairly high winds. Heavy rains.									
A-1	10	9/15/81	78	51	65	.95	.060	Satis.	24.6	o
	No difficulty.									
A-1	10	9/21/82	80	50	65	.80	.060	Satis.	24.6	+
	Worked well.									

TABLE III

Hydraulic Mulch Overspray (Slick Paper)
Field Data

Project	State District	Installed	30 Day Avg. Temp. Hi	30 Day Avg. Temp. Lo	30 Day Avg. Temp. Avg.	30 Day Rain Hi	30 Day Rain Avg.	Growth At 30 Days	Area (Acres)	Success
F	4	11/4/82	51	35	45	1.25	.112	None	65.2	o
	Applied well. Some sheet erosion. Still performing well after 60 days and no growth. Very sticky.									
P	6	11/12/82	52	37	45	2.4	.286	None	6.9	o
	Appeared equal to emulsion.									

TABLE IV

Hydraulic Mulch Overspray (Cooked Fibers)
Field Data

Project	State District	Installed	30 Day Avg. Temp. Hi	Lo	Avg.	30 Day Rain Hi	Avg.	Growth At 30 Days	Area (Acres)	Success
B	1	10/6/80	70	37	54	.50	.042	Minor	14.3	+
Applied well. Change ordered in lieu of emulsion. Required 1000#/A instead of 750#/A due to low organic matter.										
E	4	5/4/82	72	58	65	2+	.463	Good	4.1	+
Minor erosion. Non-uniform coverage due to high winds. Change ordered in lieu of emulsion.										
N	5	11/21/80	47	30	39	.85	.065	None	13.3	o
Application difficulty due to high winds. Change ordered in lieu of emulsion. Required 1000 #/A instead of 750#/A due to low organic matter. Contractor voluntarily crimped straw with disk										
X	8	8/20/82	85	64	75	1.45	.109	Satis.	45.5	+
Application difficulty due to high wind.										

TABLE V

Soil Test
Field Data

Project	Installed	Soil pH Before	Soil pH After	Soil Classification ASTM	Soil Classification AASHTO
A	11/13/81	7.8	7.6	ML	A-4-(8)
B	10/6/80	6.8	7.1	--	--
		7.1	7.9	--	--
C	9/2/81	7.3	7.9	--	--
C	10/27/81	6.8	7.5	CL	A-7-6-(12)
D	7/5/81	6.1	6.4	CH	A-7-6-(19)
D	7/14/81	6.2	6.9	CL	A-4-(8)
E	5/4/82	6.4	6.6	CL	A-7-6-(15)
F	11/4/82	7.2	7.5	CL	A-7-6-(13)
G	11/25/81	7.7	7.1	--	--
		6.5	7.5	--	--
H	9/24/81	7.9	7.5	CL	A-6-(10)
I	9/16/81	8.1	7.7	CL	A-6-(12)
		7.9	7.9	CL	A-7-6-(15)
J	9/15/80	7.8	8.2	--	--
		7.5	8.0	--	--
K	4/29/82	6.2	6.6	CL	A-6-(10)
L	10/4/82	5.8	6.1	CL-ML	A-4-(8)
M	9/9/81	6.8	7.2	CL	A-7-6-(13)
		4.9	6.8	CL	A-7-6-(14)
N	11/21/80	7.0	6.2	--	--
		7.4	7.1	--	--
O	12/14/81	5.1	7.1	CL	A-6-(5)
		3.9	7.2	CL	A-6-(9)
P	11/12/82	6.4	6.3	--	--
R	5/30/81	7.1	5.6	--	--
S	8/15/81	---	---	--	--
S	11/15/81	6.9	7.4	--	--
T	11/10/80	5.7	6.0	--	--
U	10/15/82	5.7	6.0	--	--
		7.4	7.1	--	--
V	9/8/82	5.8	---	CL	A-6-(10)
		---	4.5	MH	A-7-5-(20)
W	8/14/81	8.2	---	CL	A-6-(9)
		---	8.0	GC-CL	A-6-(7)
		7.5	---	CH	A-7-6-(14)
		---	7.9	CL-CH	A-7-6-(13)
X	8/20/82	4.4	5.8	--	--
		7.2	7.7	--	--
Y	9/8/82	7.5	7.7	--	--
Y	11/4/82	7.2	7.8	CL	A-7-6-(14)
Z	10/7/81	7.0	7.2	CH	A-7-6(18)
		5.0	5.1	GC	A-7-6(9)
A-1	9/15/81	5.8	4.9	CL	A-6-(10)
A-1	9/21/81	6.8	7.0	GC	A-6-(2)

TABLE VI

Economic Results

Year	Straw + SS-1 Emulsion		Straw + Overspray		Hydraulic Mulch		Straw + Overspray or SS-1	
	Acres	$/Acre	Acres	$/Acre	Acres	$/Acre	Acres	$/Acre
1975	2418	542	---	---	---	---	---	---
1976	3119	530	---	---	---	---	---	---
1977	2870	512	---	---	---	---	---	---
1978	2097	563	---	---	---	---	---	---
1979	959	636	---	---	---	---	---	---
1980	254	789	90	720	130	566	---	---
1981	298	738	285	606	58	786	---	---
1982	102	1041	272	531	97	579	41	626
1983	(To Date)	---	---	---	---	---	497	542

FIGURES

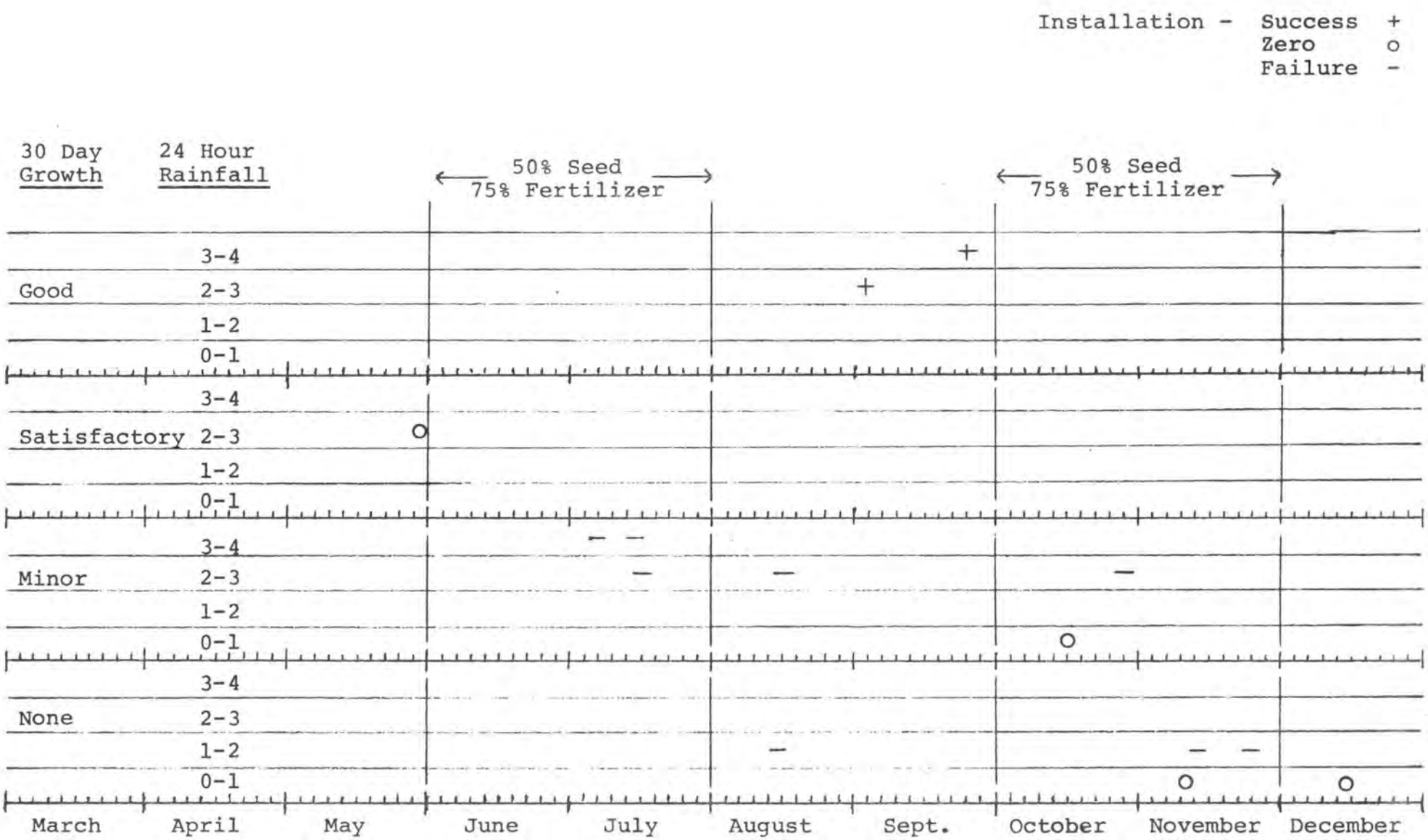


Figure 1
Hydraulic Mulch (Ground Fiber)

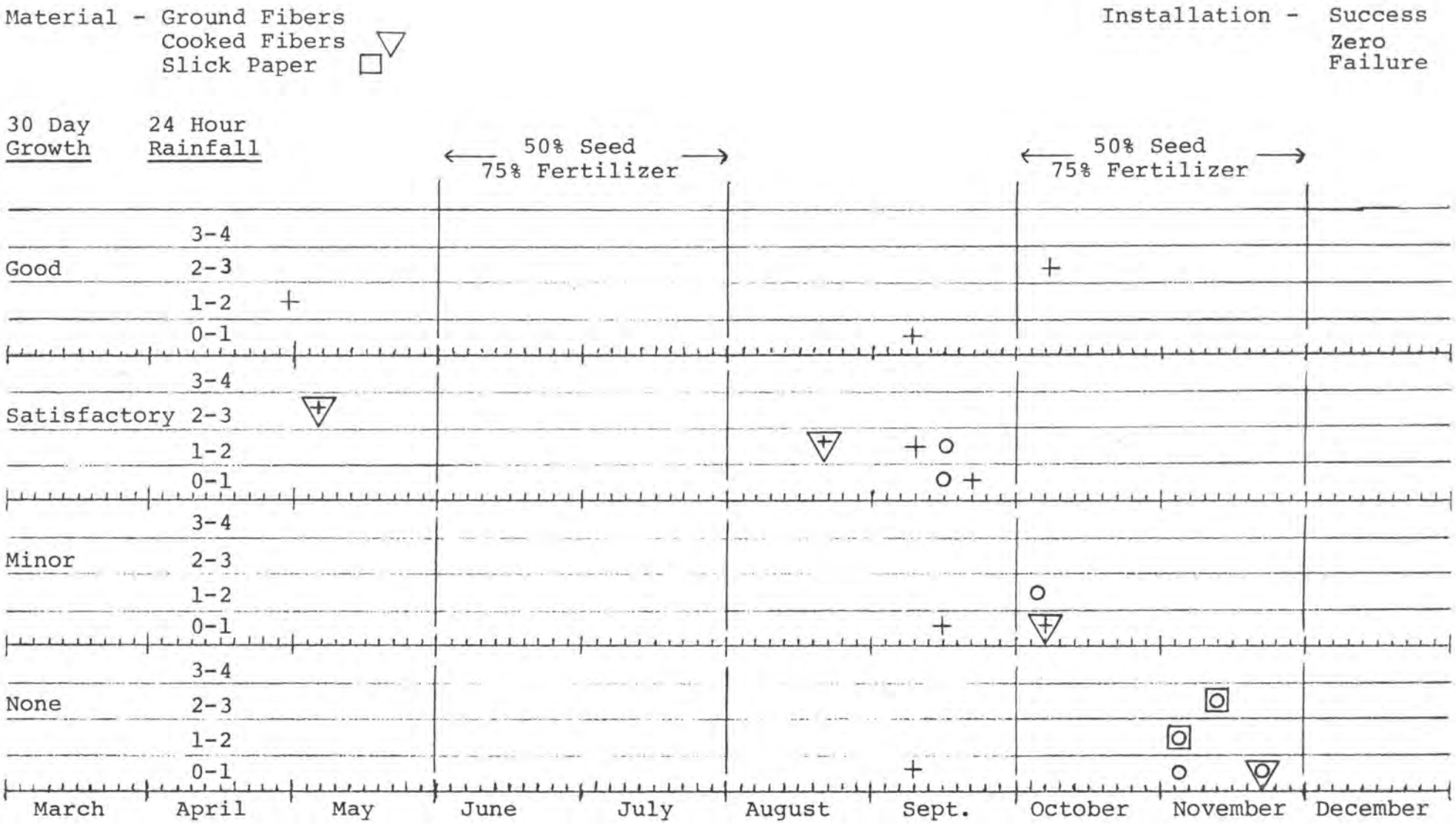


Figure 2
Hydraulic Mulch Overspray

LEGEND

○ LET TO CONTRACT AND COMPLETED DURING THIS STUDY.

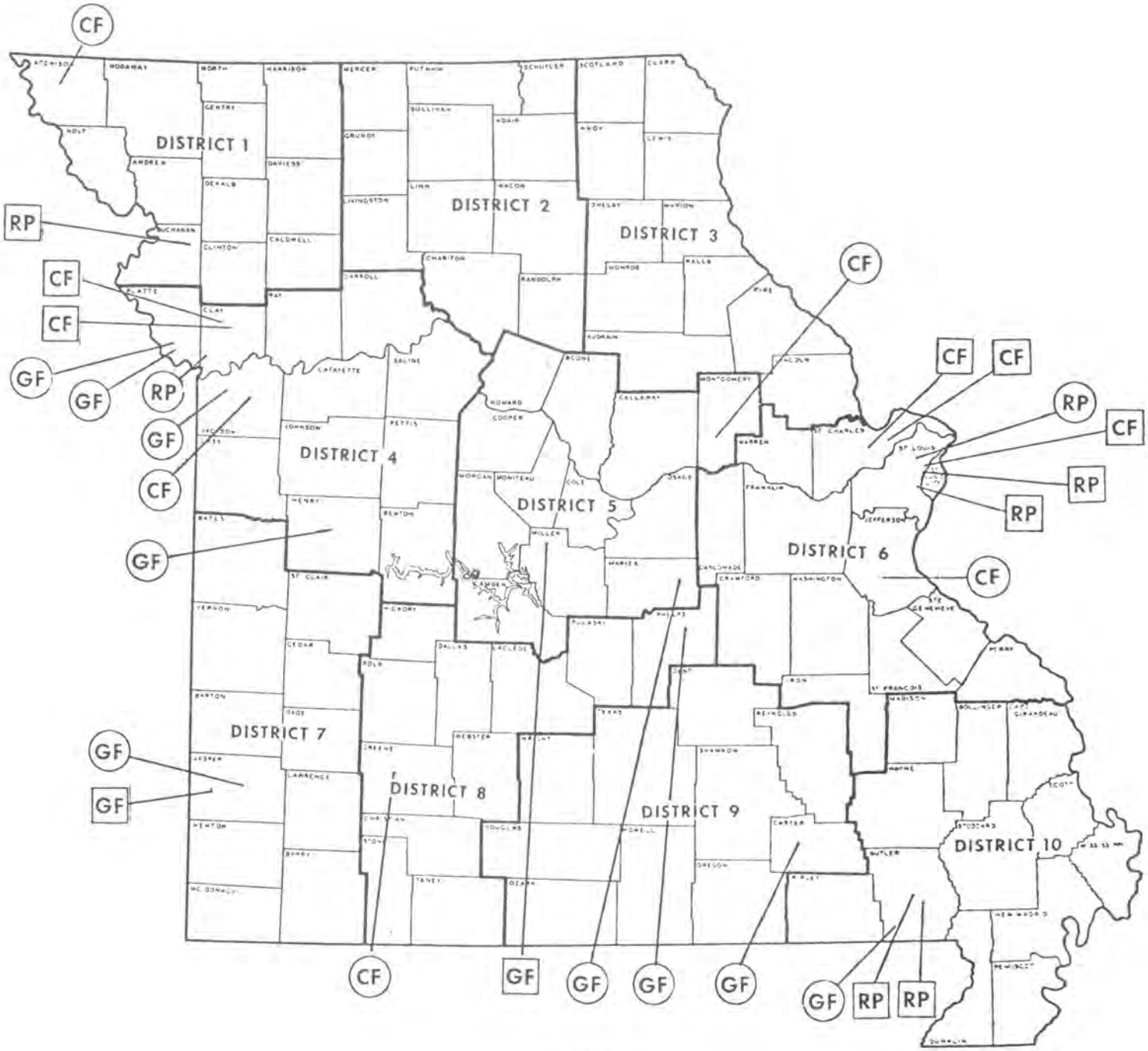
□ LET TO CONTRACT BUT NOT COMPLETED DURING THIS STUDY.

GF VIRGIN, GROUND WOOD FIBERS.

CF VIRGIN, COOKED WOOD FIBERS.

RP RECYCLED SLICK PAPER.

Figure 3. Location of Hydraulic Mulch Projects.



LEGEND

○ LET TO CONTRACT AND COMPLETED DURING THIS STUDY.

□ LET TO CONTRACT BUT NOT COMPLETED DURING THIS STUDY.

GF VIRGIN, GROUND WOOD FIBERS.

CF VIRGIN, COOKED WOOD FIBERS.

RP RECYCLED SLICK PAPER.

Figure 4. Location of Hydraulic Mulch Overspray Projects.

APPENDIX A

Specifications for Hydraulic Mulches And Hydraulic Mulch Oversprays

HYDRAULIC MULCH, GROUND WOOD FIBERS

1.0 Hydraulic Mulch shall consist of the furnishing and application of wood cellulose fibers mixed with water to form a homogeneous slurry. A tackifier shall be used either as an integral part of the hydraulic mulch or as an overspray.

2.0 Materials. Wood cellulose fibers shall be virgin wood cellulose fibers and shall be of the "ground" variety. The fibers shall not be produced from recycled material and shall contain no germination or growth-inhibiting factors. They shall be colored green and shall have the property to be evenly dispersed and suspended when agitated in water. When they are sprayed uniformly on the surface of the soil, the fibers shall form an absorbent cover, allowing percolation of water to the underlying soil. The fibers shall be packaged in moisture resistant bags with the net weight of the packaged material plainly shown on each bag. The wood fibers shall not be water soluble and shall comply with the following properties:

Moisture Content, percent, maximum	15
Organic Matter-Wood Fiber (Oven Dried Basis) percent, minimum	90
pH	4.3 - 8.5

The tackifier shall be insoluble in water after curing. Bituminous material may not be used as a tackifier.

3.0 Application. Wood cellulose fibers shall be applied at rate of 1800 pounds per acre. The wood fibers shall be mixed with water in a manner to provide a homogeneous slurry. Equipment for mixing and applying the slurry shall be capable of applying a uniform mixture over the entire area to be mulched. The slurry mixture

shall be agitated during application to keep the ingredients thoroughly mixed.

4.0 Certification and Acceptance. The contractor shall furnish a manufacturer's certification in triplicate certifying that the wood cellulose fibers comply with these specifications and shall include or have attached typical results of tests performed during production. Acceptance will be based upon a satisfactory certification and results of any tests deemed necessary by the eingineer.

5.0 Method of Measurement. Measurement of Hydraulic Mulch will be made to the nearest 1/10 acre of the area mulched.

6.0 Basis of Payment. Hydraulic Mulching will be paid for at the contract unit price per acre for hydraulic mulch, pay item number 802-99.92. No direct payment will be made for the water used in the slurry.

JOB SPECIAL PROVISION

HYDRAULIC MULCH, COOKED FIBERS

1.0 Hydraulic Mulch shall consist of the furnishing and application of wood cellulose fibers mixed with water to form a homogeneous slurry. A tackifier shall be used either as an integral part of the hydraulic mulch or as an overspray.

2.0 Materials. Wood cellulose fibers shall be virgin wood cellulose fibers and shall be of the "cooked" variety. The fibers shall not be produced from recycled material and shall contain no germination or growth-inhibiting factors. They shall be colored green and shall have the property to be evenly dispersed and suspended when agitated in water. When they are sprayed uniformly on the surface of the soil, the fibers shall form an absorbent cover, allowing percolation of water to the underlying soil. The fibers shall be packaged in moisture resistant bags with the net weight of the packaged material plainly shown on each bag. The wood fibers shall not be water soluble and shall comply with the following properties:

Moisture Content, percent, maximum	15
Organic Matter-Wood Fiber (Oven Dried Basis)	(Refer to Paragraph 3.1)
pH	4.3 - 8.5

The tackifier shall be insoluble in water after curing. Bituminous material may not be used as a tackifier.

3.0 Application.

3.1 Wood cellulose fiber mulch containing 90 percent or greater, organic matter shall be applied at the rate of 1800 pounds per acre. Mulch containing 80 to 89 percent organic matter shall be applied at a rate calculated as follows:

$$\left[\frac{100}{\text{Actual Percent Organic}}\right] 1800 \text{ pounds per acre}$$

Material with less than 80 percent organic matter will be rejected.

3.2 The wood fibers shall be mixed with water in a manner to provide a homogeneous slurry. Equipment for mixing and applying the slurry shall be capable of applying a uniform mixture over the entire area to be mulched. The slurry mixture shall be agitated during application to keep the ingredients thoroughly mixed.

4.0 Certification and Acceptance. The contractor shall furnish a manufacturer's certification in triplicate certifying that the wood cellulose fibers comply with these specifications and shall include or have attached typical results of tests performed during production. Acceptance will be based upon a satisfactory certification and results of any tests deemed necessary by the engineer.

5.0 Method of Measurement. Measurement of Hydraulic Mulch will be made to the nearest 1/10 acre of the area mulched.

6.0 Basis of Payment. Hydraulic Mulching will be paid for at the contract unit price per acre for hydraulic mulch, pay item number 802-99.91. No direct payment will be made for the water used in the slurry.

HYDRAULIC MULCH, RECYCLED "SLICK" PAPER

1.0 Hydraulic mulch shall consist of the furnishing and application of recycled "slick" paper mixed with water to form a homogeneous slurry.

2.0 Materials. This material shall be produced from printers slick paper containing wood cellulose and kaolin clay. Recycled newspaper or recycled cardboard will not be allowed. The mulch shall not contain any germination or growth-inhibiting factors. The mulch shall be green in color after application and shall have the property to be evenly dispersed and suspended when agitated in water. When sprayed uniformly on the surface of the soil, the mulch fibers shall form an absorbent cover, allowing percolation of water to the underlying soil. The mulch shall be packaged in moisture resistant bags with the net weight of the packaged material plainly shown on each bag. The mulch fibers shall not be water soluble and shall comply with the following properties:

Moisture Content, air dried basis, percent, maximum..... 8

pH ..... 4.5 - 6.5

3.0 Application. The recycled "slick" paper mulch shall be hydraulically applied at the rate of 1800 pounds per acre. The mulch shall be mixed with water in a manner to provide a homogeneous slurry. Equipment for mixing and applying the slurry shall be capable of applying a uniform mixture over the entire mulched area. The slurry mixture shall be agitated during application to keep the ingredients thoroughly mixed.

4.0 Certification and Acceptance. The contractor shall furnish a manufacturer's certification in triplicate certifying that the mulch complies with these specifications and shall include or have attached typical results of tests performed during production. The engineer will sample and test these materials prior to approval or use. Acceptance will be based upon a satisfactory certification and results of any tests deemed necessary by the engineer.

5.0 Method of Measurement. Measurement of hydraulic mulch will be made to the nearest 1/10 acre of the area mulched.

6.0 Basis of Payment. Hydraulic mulching will be paid for at the contract unit price per acre for hydraulic mulch, pay item number 802.99.89. No direct payment will be made for the water used in the slurry.

MULCH OVERSPRAY, GROUND WOOD FIBERS

1.0 Hydraulically applied wood cellulose fibers shall be used as an overspray for Type 2 mulch in lieu of SS-1 emulsion.

2.0 Materials. Wood cellulose fibers shall be virgin wood cellulose fibers and shall be of the "ground" variety. The fibers shall not be produced from recycled material and shall contain no germination or growth-inhibiting factors. They shall be colored green and shall have the property to be evenly dispersed and suspended when agitated in water. When they are sprayed uniformly over the straw mulch, the fibers shall form an absorbent cover, allowing percolation of water to the underlying soil. The fibers shall be packaged in moisture resistant bags with the net weight of the packaged material plainly shown on each bag. The wood fibers shall not be water soluble and shall comply with the following properties:

Moisture Content, percent, maximum	15
Organic Matter-Wood Fiber (Oven Dried Basis) percent, minimum	90
pH	4.3 - 8.5

3.0 Application. Wood cellulose fibers shall be hydraulically applied over the required straw mulch at a rate of 750 pounds per acre. The wood fibers shall be mixed with water in a manner to provide a homogeneous slurry. Equipment for mixing and applying the slurry shall be capable of applying a uniform mixture over the entire mulched area. The slurry mixture shall be agitated during application to keep the ingredients thoroughly mixed.

4.0 Certification and Acceptange. The contractor shall furnish a manufacturer's certification in triplicate certifying that the wood cellulose fibers comply with these specifications and shall include or have attached typical results of tests performed during production.

The engineer will sample and test these materials prior to approval or use. Acceptance will be based upon a satisfactory certification and results of any tests deemed necessary by the engineer.

5.0 Method of Measurement. Measurement of mulch overspray will be made to the nearest 1/10 acre of the area mulched.

6.0 Basis of Payment. Mulch overspray complete in place, will be paid for at the contract unit price per acre for mulch overspray, pay item number 802.99.95. No direct payment will be made for the water used in the slurry.

JOB SPECIAL PROVISION

MULCH OVERSPRAY, COOKED FIBERS

1.0 Hydraulically applied wood cellulose fibers shall be used as an overspray for Type 2 mulch in lieu of SS-1 emulsion.

2.0 Materials. Wood cellulose fibers shall be virgin wood cellulose fibers and shall be of the "cooked" variety. The fibers shall not be produced from recycled material and shall contain no germination or growth-inhibiting factors. They shall be colored green and shall have the property to be evenly dispersed and suspended when agitated in water. When they are sprayed uniformly over the straw mulch, the fibers shall form an absorbent cover, allowing percolation of water to the underlying soil. The fibers shall be packaged in moisture resistant bags with the net weight of the packaged material plainly shown on each bag. The wood fibers shall not be water soluble and shall comply with the following properties:

Moisture Content, percent, maximum	15
Organic Matter-Wood Fiber (Oven Dried Basis)	(Refer to Paragraph 3.1)
pH	4.3 - 8.5

3.0 Application.

3.1 Wood cellulose fiber mulch containing 90 percent or greater, organic matter shall be applied over the required straw mulch at the rate of 750 pounds per acre. Mulch containing 80 to 89 percent organic matter shall be applied at a rate calculated as follows:

$$\left[\frac{100}{\text{Actual Percent Organic}}\right] \quad 750 \text{ pounds per acre}$$

Material with less than 80 percent organic matter will be rejected.

3.2 The wood fibers shall be mixed with water in a manner to provide a homogeneous slurry. Equipment for mixing and applying the slurry shall be capable of applying a uniform mixture over the entire mulched area. The slurry mixture shall be agitated during application to keep the ingredients thoroughly mixed.

4.0 Certification and Acceptance. The contractor shall furnish a manufacturer's certification in triplicate certifying that the wood cellulose fibers comply with these specifications and shall include or have attached typical results of tests performed during production. The engineer will sample and test these materials prior to approval or use. Acceptance will be based upon a satisfactory certification and results of any tests deemed necessary by the engineer.

5.0 Method of Measurement. Measurement of mulch overspray will be made to the nearest 1/10 acre of the area mulched.

6.0 Basis of Payment. Mulch overspray complete in place, will be paid for at the contract unit price per acre for mulch overspray, pay item number 802.99.90. No direct payment will be made for the water used in the slurry.

MULCH OVERSPRAY - RECYCLED "SLICK" PAPER

1.0 Hydraulically applied recycled paper meeting the requirements herein specified shall be used as an overspray for Type 2 mulch in lieu of SS-1 emulsion.

2.0 Materials. This material shall be produced from printers slick paper containing wood cellulose and kaolin clay. Recycled newspaper or recycled cardboard will not be allowed. The mulch shall not contain any germination or growth-inhibiting factors. The mulch shall be green in color after application and shall have the property to be evenly dispersed and suspended when agitated in water. When sprayed uniformly over straw, the mulch fibers shall form an absorbent cover, allowing percolation of water to the underlying soil. The mulch shall be packaged in moisture resistant bags with the net weight of the packaged material plainly shown on each bag. The mulch fibers shall not be water soluble and shall comply with the following properties:

Moisture Content, air dried basis, percent, maximum..... 8

pH ..... 4.5 - 6.5

3.0 Application. The recycled "slick" paper mulch shall be hydraulically applied over the required straw at the rate of 750 pounds per acre. The mulch shall be mixed with water in a manner to provide a homogeneous slurry. Equipment for mixing and applying the slurry shall be capable of applying a uniform mixture over the entire mulched area. The slurry mixture shall be agitated during application to keep the ingredients thoroughly mixed.

4.0 Certification and Acceptance. The contractor shall furnish a manufacturer's certification in triplicate certifying that the mulch complies with these specifications and shall include or have attached typical results of tests performed during production. The engineer will sample and test these materials prior to approval or use. Acceptance will be based upon a satisfactory certification and results of any tests deemed necessary by the engineer.

5.0 Method of Measurement. Measurement of mulch overspray will be made to the nearest 1/10 acre of the area mulched.

6.0 Basis of Payment. Mulch overspray complete in place, will be paid for at the contract unit price per acre for mulch overspray, pay item number 802.99.95. No direct payment will be made for the water used in the slurry.

JOB SPECIAL PROVISION

MULCH OVERSPRAY

1.0 This specification covers mulch to be applied over straw. At the contractor's option, SS-1 emulsion meeting material and application requirements for Type 2 Mulch, Sec 802, Missouri Standard Specifications for Highway Construction, 1981 Edition, may be used in lieu of the mulch overspray material herein specified.

2.0 Materials. The overspray mulch material shall not contain any germination or growth inhibiting substances. Recycled newspaper or cardboard will not be allowed. The mulch overspray shall be green in color after application and shall have the property to be evenly dispersed and suspended when agitated in water. When sprayed uniformly over straw, the mulch fibers shall form an absorbent cover, allowing percolation of water to the underlying soil. The mulch shall be packaged in moisture resistant bags with the net weight of the packaged material plainly shown on each bag. The mulch fibers shall not be water soluble and shall comply with one of the following materials.

2.1 Virgin wood cellulose fibers shall be produced by either the ground or cooked fiber process and have the following properties.

Moisture Content, percent, maximum 15

Organic Matter-Wood Fiber (Oven Dried Basis) ..... See Paragraph 3.1

pH ..... 4.3 - 8.5

2.2 Recycled slick paper mulch shall be produced from printers slick paper containing wood cellulose and kaolin clay. The material shall be free of other material or fillers and shall have the following properties.

Moisture Content, percent, maximum 8

pH .-..... 4.5 - 6.5

3.0 Application.

3.1 Virgin wood cellulose fiber mulch containing 90 percent or greater organic matter shall be hydraulically applied over the required straw mulch at the rate of 750 pounds per acre. Mulch containing 80 to 89 percent organic matter shall be applied at a rate calculated as follows:

$$\text{Rate, lb./acre} = \frac{100}{\text{Actual Percent Organic}} \times 750 \text{ lb./acre}$$

Material with less than 80 percent organic matter will be rejected.

3.2 Recycled slick paper mulch shall be applied at the rate of 750 pounds per acre.

3.3 The mulch overspray material shall be mixed with water in a manner to provide a homogeneous slurry. Equipment for mixing and applying the slurry shall be capable of applying a uniform mixture over the entire mulched area. The slurry mixture shall be agitated during application to keep the ingredients thoroughly mixed.

4.0 Certification and Acceptance. The contractor shall furnish a manufacturer's certification in triplicate certifying that the overspray mulch material complies with these specifications and shall include or have attached typical results of tests performed during production. The engineer will sample and test these materials prior to approval or use. Acceptance will be based upon a satisfactory certification and results of any tests deemed necessary by the engineer.

5.0 Method of Measurement. Measurement of mulch overspray will be made to the nearest 1/10 acre of the area mulched.

6.0 Basis of Payment. Mulch overspray complete in place, will be paid for at the contract unit price per acre for mulch overspray, pay item number 802.99.88. No direct payment will be made for the water used in the slurry.

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