FIELD GUIDE

SOIL STABILIZATION FOR TEMPORARY SLOPES

CONTRACT NO. 43A0004C, TASK ORDER NO. 17

Prepared for

State of California – Business, Transportation and Housing Agency
Department of Transportation
Environmental Programs (MS-27)
1120 N Street
PO Box 942874
Sacramento, CA 94274-0001

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URS Greiner Woodward Clyde

1615 Murray Canyon Road, Suite 1000
San Diego, CA 92108-4314
619-294-9400 Fax: 619-293-7920

The purpose of this document is to provide information to construction staff on the selection of appropriate products and techniques for soil stabilization for temporary slopes (SSTS) at construction sites. This *Field Guide* is comprised of this introduction and three tables. The tables separate the products and techniques, first by general category then by type within each category.

With known field conditions, the Category Checklist (Table 1) may be used to identify which category or categories of products or techniques may be used at the site based on time until stabilization required, soil type, slope steepness and available equipment and labor. Once the appropriate category or categories have been identified, then the Criteria Matrix (Table 2) may be used to select among the types of products or techniques within the identified categories. The selection criteria in Table 2 include items such as cost, effectiveness, and drying time, which are pertinent to making a selection. Table 3 is a guide to the criteria rating system that is used in the Criteria Matrix.

Separate from this *Field Guide* is a supporting *Guidance Document* that provides more detailed information, including material descriptions, detailed criteria descriptions, and product trade names.

Example

If soil stabilization is required at a site within 3 days, then based on Table 1, Temporary Seeding (TS) would not be an option. If the site has sandy soils, then no other options would be eliminated. If all slopes are flatter than 1:1, then no options are eliminated. If the DSA is larger than 0.1 Ha, then Impervious Covers (IC) are eliminated. If manual labor as well as a hydroseeding contractor is available (on-site or under contract) within the three days, then the most appropriate options would be short lived Hydraulic Soil Stabilizers (HSS) and Standard Biodegradable Mulches (SBM). Using these two categories, the Criteria Matrix would be used next to select the most appropriate products/techniques based on the detailed criteria, such as cost, effectiveness, drying time, etc.

TABLE 1
TEMPORARY SOIL STABILIZATION CATEGORY CHECKLIST[(1)]

There are five categories of temporary soil stabilization techniques, and within each category there are various classes and types of products and/or techniques. The five categories are:

- **Standard biodegradable mulches (SBM)**
- **Rolled erosion control products (RECP)**
- **Impervious covers (IC)**
- **Temporary seeding (TS)**
- **Hydraulic soil stabilizers (HSS)**

The first step in selecting a temporary soil stabilization technique is to determine the factors at the project site that may limit the use of a particular category, based on the following criteria:

Minimum Time Until Soil Stabilization Is Required –

- Less than 28 days – cannot use TS.

Soil Type –

- Very gravelly or rocky soil – cannot use RECP.

Slope –

- Slope 1:1 or steeper – cannot apply blown straw (SBM straw mulch).

Disturbed Soil Area (DSA) Size –

- Greater than 0.1Ha – should not use IC.

Installation –

- Hand labor is required for installation of RECP and IC; TS and SBM (straw mulch) may also be applied by hand.
- Hydroseeding equipment is required for application of TS and most HSS and SBM types.
- Water truck can be used to apply certain HSS types.

(1)This checklist serves as a guide to selecting temporary soil stabilization categories. Detailed criteria for each category are provided in Table 2. Implementation should be adjusted to meet field conditions as necessary.

Table 2
TEMPORARY SOIL STABILIZATION CRITERIA MATRIX

CLASS	TYPE	TEMPORARY SOIL STABILIZATION CONTROL CRITERIA													
		Antecedent Moisture	Availability	Ease of Clean-Up	Installed Cost Per Ha	EC Effectiveness (%)	Degradability	Length of Drying Time (hrs)	Time to Effectiveness (days)	Longevity	Mode of Application	Residual Impact	Native	Runoff Effect	Water Quality Impact
CATEGORY: STANDARD BIODEGRADABLE MULCHES (SBM)															
Straw Mulch	Wheat Straw	D	S	H	$5,200	90-95	B	0	1	M	L/M	M		+	*
	Rice Straw	D	S	H	$5,200	90-95	B	0	1	M	L/M	M		+	*
Wood Fiber Mulch	Wood Fiber	D	S	H	$2,200	50-60	B	0-4	1	M	H	L		+	*
Recycled Paper Mulch	Cellulose Fiber	D	S	H	$2,100	50-60	B	0-4	1	S	H	L		+	*
Bonded Fiber Matrix	Biodegradable	D	S	H	$13,600	90-95	B	12-18	1	M	H	M		+	*
CATEGORY: ROLLED EROSION CONTROL PRODUCTS (RECP)															
Biodegradable	Jute Mesh	D	S	H	$16,000	65-70	B		1	M	L	M		+	*
	Curled Wood Fiber	D	S	H	$26,000	85-90	P/B		1	M	L	M		+	*
	Straw	D	S	H	$22,000	85-90	P/B		1	M	L	M		+	*
	Wood Fiber	D	S	H	$22,000	85-90	P/B		1	M	L	M		+	*
	Coconut Fiber	D	S	H	$32,000	90-95	P/B		1	L	L	M		+	*
	Coconut Fiber Mesh	D	S	H	$77,000	85-90	B		1	L	L	M		+	*
	Straw Coconut Fiber	D	S	H	$27,000	90-95	P/B		1	L	L	M		+	*
Non-Biodegradable	Plastic Netting	D	M	H	$5,000	<50	P		1	L	L	H		+	UNK
	Plastic Mesh	D	M	H	$8,000	75-80	P		1	L	L	H		+	UNK
	Synthetic Fiber with Netting	D	M	H	$86,000	90-95	P		1	L	L	H		+	UNK
	Bonded Synthetic Fibers	D	M	H	$121,000	90-95	P		1	L	L	H		+	UNK
	Combination with Biodegradable	D	M	H	$79,000	85-90	P		1	L	L	H		+	UNK
CATEGORY: TEMPORARY SEEDING (TS)															
High-Density	Ornamentals		S-M	H	$1000 - $4000	50-60			28	M-L	H	L-M	N/E	+	UNK
	Turf species		S	H	$900	50-60			28	L	H	M-H	N/E	+	UNK
	Bunch grasses		S-M	H	$750 - $3200	50-60			28	L	H	L-M	N	+	UNK
Fast-Growing	Annual		S	H	$900 - $1,600	50-60			28	L	H	L-H	N/E	+	UNK
	Perennial		S	H	$800 - $2000	50-60			28	L	H	M	N/E	+	UNK
Non-Competing	Native		S-M	H	$700 - $4000	50-60			28	L	H	L-M	N	+	UNK
	Non-Native		S-M	H	$1000 - $1200	50-60			28	L	H	L-H	E	+	UNK
Sterile	Cereal Grain		S	H	$1,200	50-60			28	L	H	L	E	+	UNK
CATEGORY: IMPERVIOUS COVERS (IC)															
Plastic	Rolled Plastic Sheeting		S		$17,000	100	P		1	M	L	H		-	UNK
	Geotextile (Woven)		S		$14,800	90-95	P		1	M	L	H		-	UNK
CATEGORY: HYDRAULIC SOIL STABILIZERS (HSS)															
(PBS) Plant Material Based- Short Lived	Guar	D	S	H	$1,000	80-85	B	12-18	Same as Length of Drying Time.	S	B	L		0/+	M/L
	Psyllium	P	S	H	$1,000	25-35	B	12-18		M	B	L		0	L/H
	Starches	D	S	H	$1,000	25-30	B	9-12		S	H	L		0	L
(PBL) Plant Material Based- Long Lived	Pitch/ Rosin Emulsion	D	S	M	$3,000	60-75	B	19-24		M	B	M		-	H
(PEB) Polymeric Emulsion Blends	Acrylic polymers and copolymers	D	S	M	$3,000	35-70	P/C	19-24		L	B	M		+/-	L/M
	Methacrylates and acrylates	D	M	M	$1,000	35-40	P/C	12-18		S	W	L		0/+	L
	Sodium acrylates and acrylamides	D	M	M	$1,000	20-70	P/C	12-18		S	H	L		+/-	L/M
	Polyacrylamide	D	M	M	$1,000	55-65	P/C	4-8		M	H	L		0/+	L
	Hydro-colloid polymers	D	M	H	$1,000	25-40	P/C	0-4		M	H	L		0/+	L/M
(PRB) Petroleum/ Resin-Based Emulsions	Emulsified Petroleum Resin	D	M	L	$3,000	10-50	P/C	0-4		M	B	M		0/-	H
(CBB) Cementitious Based Binders	Gypsum	D	S	M	$2,000	75-85	P/C	4-8		M	H	L		-	M/H

= not applicable for category, class or type
UNK = unknown
* = currently being evaluated in the D7 Erosion Control Pilot Study (ECPS)

Table 3
CRITERIA RATING SYSTEM

Antecedent Moisture	**D**	Soil should be relatively dry prior to application
	P	Soil should be pre-wetted prior to application
Availability	**S**	A short turn-around time between order and delivery, usually 3-5 days
	M	A moderate turnaround time, between 1-2 weeks
Ease of Clean-Up	**L**	Require pressure washing, a strong alkali solution, or solvent to clean up
	M	Requires cleanup with water while wet; more difficult to clean up once dry
	H	May be easily removed from equipment and overspray areas by a strong stream of water
Installed Cost		Dollars per hectare
Degradability	**C**	Chemically degradable
	P	Photodegradable
	B	Biodegradable
Length of Drying Time		Estimated hours
Time to Effectiveness		Estimated days
Erosion Control Effectiveness		Percent reduction in soil loss over bare soil condition.
Longevity	**S**	1 - 3 months
	M	3 – 12 months
	L	> than 12 months
Application Mode	**L**	Applied by hand labor
	W	Applied by water truck
	H	Applied by hydraulic mulcher
	B	Applied by either water truck or hydraulic mulcher
	M	Applied by a mechanical method other than those listed above (e.g., straw blower)
Residual Impact	**L**	Projected to have a low impact on future construction activities
	M	Projected to have a moderate impact on future construction activities
	H	Projected to have a significant impact on future construction activities
Native	**N**	Plant or plant material native to the State of California
	E	Exotic plant not native to the State of California
Runoff Effect	**+**	Runoff is decreased over baseline (bare soil)
	0	No change in runoff from baseline
	-	Runoff is increased over baseline
Water Quality Impact	**L**	Low potential to impact water quality
	M	Moderate potential to impact water quality
	H	Higher potential to impact water quality

GUIDANCE DOCUMENT

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URS Greiner Woodward Clyde

Pacific Center II, Suite 1000
1615 Murray Canyon Road
San Diego, CA 92108
(619) 294-9400 Fax (619) 293-7920

TABLE OF CONTENTS

Tables

The purpose of this document is to provide supporting information to construction staff on appropriate products and techniques for soil stabilization of temporary slopes at construction sites. Products and techniques are separated first by general category, and then by type within each category.

Provided in this section are two tables to be used in the selection process. With known field conditions, the Category Checklist (Table 1-1) may be used to identify which category (or categories) of products or techniques may be used at the site. Once the appropriate category or categories have been identified, then the Criteria Matrix (Table 1-2) may be used to select among the types of products or techniques within the identified categories. The selection criteria include items such as cost, effectiveness, and drying time, which are pertinent to making a selection. For each product type, product trade names are provided in Table 1-3.

Section 2 of this document provides a detailed description of the rating criteria used in the tables, and Section 3 provides material descriptions.

Separate from this *Guidance Document* is a *Field Guide* that provides the selection tables in condensed format for field use.

TABLE 1-1
TEMPORARY SOIL STABILIZATION CATEGORY CHECKLIST[1]

There are five categories of temporary soil stabilization techniques, and within each category there are various classes and types of products and/or techniques. The five categories are:

- **Standard biodegradable mulches (SBM)**
- **Rolled erosion control products (RECP)**
- **Impervious covers (IC)**
- **Temporary seeding (TS)**
- **Hydraulic soil stabilizers (HSS)**

The first step in selecting a temporary soil stabilization technique is to determine the factors at the project site that may limit the use of a particular category, based on the following criteria:

Minimum Time Until Soil Stabilization Is Required –

- Less than 28 days – cannot use TS.

Soil Type –

- Very gravelly or rocky soil – cannot use RECP.

Slope –

- Slope 1:1 or steeper – cannot apply blown straw (SBM straw mulch).

Disturbed Soil Area (DSA) Size –

- Greater than 0.1Ha – should not use IC.

Installation –

- Hand labor is required for installation of RECP and IC; TS and SBM (straw mulch) may also be applied by hand.
- Hydroseeding equipment is required for application of TS and most HSS and SBM types.
- Water truck can be used to apply certain HSS types.

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[1]This checklist serves as a guide to selecting temporary soil stabilization categories. Detailed criteria for each category are provided in Table 2. Implementation should be adjusted to meet field conditions as necessary.

Table 1-2
TEMPORARY SOIL STABILIZATION CRITERIA MATRIX

CLASS	TYPE	TEMPORARY SOIL STABILIZATION CONTROL CRITERIA													
		Antecedent Moisture	Availability	Ease of Clean-Up	Installed Cost Per Ha	EC Effectiveness (%)	Degradability	Length of Drying Time (hrs)	Time to Effectiveness (days)	Longevity	Mode of Application	Residual Impact	Native	Runoff Effect	Water Quality Impact
CATEGORY: STANDARD BIODEGRADABLE MULCHES (SBM)															
Straw Mulch	Wheat Straw	D	S	H	$5,200	90-95	B	0	1	M	L/M	M		+	*
	Rice Straw	D	S	H	$5,200	90-95	B	0	1	M	L/M	M		+	*
Wood Fiber Mulch	Wood Fiber	D	S	H	$2,200	50-60	B	0-4	1	M	H	L		+	*
Recycled Paper Mulch	Cellulose Fiber	D	S	H	$2,100	50-60	B	0-4	1	S	H	L		+	*
Bonded Fiber Matrix	Biodegradable	D	S	H	$13,600	90-95	B	12-18	1	M	H	M		+	*
CATEGORY: ROLLED EROSION CONTROL PRODUCTS (RECP)															
Biodegradable	Jute Mesh	D	S	H	$16,000	65-70	B		1	M	L	M		+	*
	Curled Wood Fiber	D	S	H	$26,000	85-90	P/B		1	M	L	M		+	*
	Straw	D	S	H	$22,000	85-90	P/B		1	M	L	M		+	*
	Wood Fiber	D	S	H	$22,000	85-90	P/B		1	M	L	M		+	*
	Coconut Fiber	D	S	H	$32,000	90-95	P/B		1	L	L	M		+	*
	Coconut Fiber Mesh	D	S	H	$77,000	85-90	B		1	L	L	M		+	*
	Straw Coconut Fiber	D	S	H	$27,000	90-95	P/B		1	L	L	M		+	*
Non-Biodegradable	Plastic Netting	D	M	H	$5,000	<50	P		1	L	L	H		+	UNK
	Plastic Mesh	D	M	H	$8,000	75-80	P		1	L	L	H		+	UNK
	Synthetic Fiber with Netting	D	M	H	$86,000	90-95	P		1	L	L	H		+	UNK
	Bonded Synthetic Fibers	D	M	H	$121,000	90-95	P		1	L	L	H		+	UNK
	Combination with Biodegradable	D	M	H	$79,000	85-90	P		1	L	L	H		+	UNK
CATEGORY: TEMPORARY SEEDING (TS)															
High-Density	Ornamentals		S-M	H	$1000 - $4000	50-60			28	M-L	H	L-M	N/E	+	UNK
	Turf species		S	H	$900	50-60			28	L	H	M-H	N/E	+	UNK
	Bunch grasses		S-M	H	$750 - $3200	50-60			28	L	H	L-M	N	+	UNK
Fast-Growing	Annual		S	H	$900 - $1,600	50-60			28	L	H	L-H	N/E	+	UNK
	Perennial		S	H	$800 - $2000	50-60			28	L	H	M	N/E	+	UNK
Non-Competing	Native		S-M	H	$700 - $4000	50-60			28	L	H	L-M	N	+	UNK
	Non-Native		S-M	H	$1000 - $1200	50-60			28	L	H	L-H	E	+	UNK
Sterile	Cereal Grain		S	H	$1,200	50-60			28	L	H	L	E	+	UNK
CATEGORY: IMPERVIOUS COVERS (IC)															
Plastic	Rolled Plastic Sheeting		S		$17,000	100	P		1	M	L	H		-	UNK
	Geotextile (Woven)		S		$14,800	90-95	P		1	M	L	H		-	UNK
CATEGORY: HYDRAULIC SOIL STABILIZERS (HSS)															
(PBS) Plant Material Based- Short Lived	Guar	D	S	H	$1,000	80-85	B	12-18	Same as Length of Drying Time.	S	B	L		0/+	M/L
	Psyllium	P	S	H	$1,000	25-35	B	12-18		M	B	L		0	L/H
	Starches	D	S	H	$1,000	25-30	B	9-12		S	H	L		0	L
(PBL) Plant Material Based- Long Lived	Pitch/ Rosin Emulsion	D	S	M	$3,000	60-75	B	19-24		M	B	M		-	H
(PEB) Polymeric Emulsion Blends	Acrylic polymers and copolymers	D	S	M	$3,000	35-70	P/C	19-24		L	B	M		+/-	L/M
	Methacrylates and acrylates	D	M	M	$1,000	35-40	P/C	12-18		S	W	L		0/+	L
	Sodium acrylates and acrylamides	D	M	M	$1,000	20-70	P/C	12-18		S	H	L		+/-	L/M
	Polyacrylamide	D	M	M	$1,000	55-65	P/C	4-8		M	H	L		0/+	L
	Hydro-colloid polymers	D	M	H	$1,000	25-40	P/C	0-4		M	H	L		0/+	L/M
(PRB) Petroleum/ Resin-Based Emulsions	Emulsified Petroleum Resin	D	M	L	$3,000	10-50	P/C	0-4		M	B	M		0/-	H
(CBB) Cementitious Based Binders	Gypsum	D	S	M	$2,000	75-85	P/C	4-8		M	H	L		-	M/H

= not applicable for category, class or type
UNK = unknown
* = currently being evaluated in the D7 Erosion Control Pilot Study (ECPS)

Table 1-3
SOME PRODUCT TRADE NAMES FOR TEMPORARY SOIL STABILIZATION CONTROLS

CLASS	TYPE	Trade Names		
		Option No. 1	Option No. 2	Option No. 3
Category: Standard Biodegradable Mulches (SBM)				
Straw Mulch	Wheat Straw	Wheat		
	Rice Straw	Rice		
Wood Fiber Mulch	Wood fiber	Silva-Fiber	Hydro-Mulch 2000	EcoFiber
Recycled Paper Mulch	Cellulose fiber	Second Nature	Terra Mulch	ReFiber Cellulose
Bonded Fiber Matrix	Biodegradable	Soil Guard	EcoAegis	Conwed 3000
Category: Rolled Erosion Control Products (RECP)				
Biodegradable	Jute Mesh	GeoJute	Soil Saver	Jute Mesh
	Curled Wood Fiber	XCEL	Curlex	Verdyol
	Straw	S75	WS05	Ero-Mat
	Wood Fiber	Futerra		
	Coconut Fiber	C125	CFB2	CF072B
	Coconut Fiber Mesh	Koir Mat 700	Coir Mesh	BioD Mesh
	Straw Coconut	SC150	CSF072B	SCFB2
Non-Biodegradable	Plastic Netting	Conwed	Tenax Radix	AET Strongnet
	Plastic Mesh	Polyjute		
	Synthetic Fiber with Netting	P300	TechMat12	C-Jute
	Bonded Synthetic Fibers	Enkamat	Landlok	Miramat
	Combination with Biodegradable	P350	TechMat CTRI	CFO72RR
Category: Temporary Seeding (TS) - Not Applicable				
Category: Impervious Covers (IC)				
Plastic	Rolled Plastic Sheeting	Plastic Sheeting		
	Woven Geotextile	500X	AMOCO 2006	EXXON GTF-300
Category: Hydraulic Soil Stabilizers (HSS)				
(PBS) Plant Material Based- Short Lived	Guar	SuperTak	TacPac GT	Fibre-Tak
	Psyllium	Plantago	EcoBinder	EcoTak
	Starches	Fisch-Stik	Con-TackAT	
(PBL) Plant Material Based- Long Lived	Pitch/ Rosin	Road Oyl		
(PEB) Polymeric Emulsion Blends	Acrylic polymers and copolymers	Soil Seal	Soil Master WR	Copolymer Gel
	Methacrylates	Pro40dc		
	Na acrylates	Atlas SoiLok	C:tak	Hydropam
	Polyacrylamide	Fisch-Bond	APS600 Series	Silt Stop
	Hydro-colloid polymers	Tacking Agent III		
(PRB) Petroleum/ Resin- Based	Petroleum Resin	Pennzsuppress	Seal	Soil-Sement
(CBB) Cementitious Binder- Based	Gypsum	Airtrol		

2.1 INTRODUCTION

For the purpose of evaluating different soil stabilization techniques for temporary slopes (SSTS), two groups of criteria were developed, one group to differentiate among SSTS categories, and another group to allow direct comparison of material and performance attributes among the types of products/techniques in each category. The Category Checklist (Table 1-1) is the first step in a two-step selection process, and the Criteria Matrix (Table 1-2) is the second step. The use of these tables is described below. Table 1-3 provides some product trade names for temporary soil stabilization controls.

2.2 USING THE CATEGORY CHECKLIST

The Category Checklist is designed to be used to identify which SSTS categories (or category) would be appropriate to use at a site given the specific conditions present.

Example:

If soil stabilization is required at a site within 3 days, then using Table 1-1 Temporary Seeding (TS) would not be an option. If the site has sandy soils, then no other options would be eliminated. If all slopes are flatter than 1:1, no options are eliminated. If the DSA is larger than 0.1 Ha, then Impervious Covers (IC) are eliminated. If manual labor as well as a hydroseeding contractor is available (on site or under contract) within the three days, then the most appropriate options would be short lived Hydraulic Soil Stabilizers (HSS) and Standard Biodegradable Mulches (SBM). Using these two categories, the Criteria Matrix (Table 1-2) would be used next to select the most appropriate products/techniques based on the detailed criteria, such as cost, effectiveness, drying time, etc.

2.3 USING THE CRITERIA MATRIX

In this two-step selection process, the first step is to use the Category Checklist to select the category (or categories) of practice that is appropriate for the site conditions, which considerably reduces the number of choices. The second and final step is the use of the Criteria Matrix.

A group of criteria were developed to allow for comparison and differentiation among the product types that are available. These criteria include installed cost, erosion control effectiveness, drying time, and others. For some criteria, values have been assigned by characteristics: an example would be mode of application where H = hydraulic seeder, W = water truck, and L = hand labor. For other criteria, actual numeric values are provided based on available data, such as drying time in hours. All numeric and letter values are defined herein.

The Criteria Matrix is best employed as a tool to establish a shorter list of criteria – i.e., the ones that are most important to the site or project (e.g., drying time, mode of application, etc.). There is usually enough of a difference in performance attributes within a criteria to aid in selection – e.g., a drying time of 4 hours versus a drying time of 24 hours.

2.4 DEFINITION OF CRITERIA

Antecedent Moisture

This criterion relates to the effect of existing soil moisture on the effectiveness of a SSTS. In the tests conducted at the SDSU Soil Erosion Research Laboratory, antecedent soil moisture was measured prior to the application of each hydraulic soil stabilizer. Through test bed preparation procedures, additional applications of water and by closely watching drying times, soil moisture was kept constant throughout the testing program.

While antecedent soil moisture conditions can have an effect on the performance of some SSTSs, (e.g., hydraulic soil stabilizers, temporary seeding) other SSTSs, such as erosion control blankets or impervious covers, are not affected – except perhaps in their ease of installation.

Suppliers of manufactured SSTSs affected by antecedent soil moisture specify the conditions under which their products are to be applied. For example, some products clearly benefit from having the soil "pre-wetted" before application of the hydraulic soil stabilizer and as a result, some manufacturers recommend application of water by itself as a first step. Conversely, the binding action of some adhesives on soil particles (and thereby their erosion control effectiveness) can be affected by excessive soil moisture. Therefore, some manufacturers recommend that their products not be applied when the soil is visibly saturated or when standing water is present.

In determining the antecedent soil moisture condition most favored by a particular approach, the following definitions were used:

D	Soil should be relatively dry prior to application
P	Soil should be pre-wetted prior to application

Availability

A critical aspect of product specification and use is whether or not an SSTS is readily available. While local sources may be preferable, the seasonal nature of soil stabilization work can create localized shortages of materials. In these cases, usually the material that can be delivered to the job more quickly is the material that is selected for application.

For the purpose of assigning a value to this criterion, the following definitions were used:

S	A short turn-around time between order and delivery, usually 3-5 days
M	A moderate turnaround time, between 1-2 weeks

Ease of Clean-Up

This criterion applies primarily to the hydraulically-applied soil stabilization materials, but there may be clean-up issues associated with some of the other categories as well (e.g., packaging materials, disposal of excess product, etc).

All of the hydraulic SSTSs included in this study are typically applied using water as a carrier, and to varying degrees, these SSTSs can be removed from application machinery and overspray areas with the application of clean water as well. However, cleaning must occur before the material sets or dries, otherwise stronger cleaning solutions of detergent, a strong alkali solution, or a petrochemical solvent must be used. A prudent contractor will take precautions when working with hydraulic SSTSs that have some clean-up limitations, and must follow the BMPs in the SWPPP or WPCP for cleaning of equipment on site.

Regardless of which approach is used for temporary soil stabilization, site clean-up can be problematic due to the following:

- Added time to dispose of waste materials
- Added time to clean hydraulic equipment before material sets or dries
- Additional quantities of water needed for cleaning operations
- Impact of quick-setting materials on overspray areas such as sidewalks, roads, vehicles
- Contractor resistance to products that require excessive clean-up
- Additional operation and maintenance costs included in contractor's bid.

The values for ease of clean-up are as follows:

L	May require pressure washing, a strong alkali solution, or solvent; additional operation and maintenance costs increases cost of practice
M	Readily removed by water while still wet, but may require more aggressive measures once dry; added time required to dispose of waste materials
H	Easily removed from equipment and overspray areas by a strong stream of water; disposal of excess product or packaging materials not significant

Installed Cost

In the Criteria Matrix, the estimated installed cost (the cost of the SSTS material itself, plus the cost associated with its installation) is given a value that corresponds to cost in dollars per hectare, as are used for estimating and bidding. This kind of presentation allows for the direct comparison of approaches regardless of Category, Class or Type.

Degradability

Degradability relates to the method by which the chemical components of an SSTS are degraded over time. As might be expected, the way in which an SSTS degrades is related to longevity, which is another selection criterion. Both degradability and longevity are sometimes key issues in temporary soil stabilization and long term erosion and sediment control planning.

Soil properties, climate, existing vegetation as well as slope aspect contribute to the degradation of SSTS materials. Knowing something about the physical and chemical properties of an SSTS and how these characteristics might interact with site conditions is important when selecting a particular material.

As the emphasis of this study is on temporary measures, a short-lived, biodegradable SSTS would seem to have the edge if all other criteria were equal. Letters assigned in the Criteria Matrix to differentiate degradability are as follows:

C	Chemically degradable
P	Photo-degradable
B	Biodegradable

Length of Drying Time

Not all SSTS materials require drying time, and the drying criterion may be used to differentiate categorical approaches as well as a final screen for the various types of materials within a class of approaches.

Determining when an SSTS material is dry or completely cured is an interesting but currently subjective exercise that relies a great deal on manufacturer-published information. In setting standards for this criteria, where drying or curing time is necessary for a particular method to become erosion control effective, manufacturers' recommendations have been followed. For example, when the hydraulic soil stabilizers were tested at the SDSU Soil Erosion Research Laboratory, they each were applied to the soil bed and allowed to dry for the manufacturer's recommended time period before the rainfall/test period commenced.

Ranges of "0 – 8 hours depending on soil temperature" and "24 – 48 hours depending on ambient air temperature" do not do much to narrow the application window of opportunity. For engineers to have confidence in designing and specifying SSTSs in times of the year when rain is imminent, more independent research needs to be conducted on the time it takes for various hydraulically-applied SSTSs to cure, dry, or otherwise reach the maximum strength to resist erosion.

For the purposes of the Criteria Matrix, estimated drying time is presented in the matrix based on the manufacturer's recommended time.

Time to Effectiveness

Not all SSTSs are immediately effective in controlling erosion: some take time to dry (e.g., hydraulic soil stabilizers) and others take time to grow (e.g., temporary seeding). However, when some treatments are applied (e.g., rolled erosion control products, plastic sheeting, and straw mulch) they are immediately effective. The estimated time to effectiveness is given in days in the Criteria Matrix, except for Hydraulic Soil Stabilizers, which are provided in hours.

Erosion Control Effectiveness

This criterion measures the ability of a particular SSTS to reduce soil erosion relative to the amount of erosion measured for bare soil. Erosion control effectiveness is presented in the matrix as a percentage the erosion would be reduced as compared to an untreated, or control, condition.

For example, two side-by-side soil conditions are subjected to the same storm intensity and duration:

1. The bare soil, or control condition yields measured soil losses of 20 kilograms.
2. The second plot, treated with a surface mulch, yields measured soil losses of 10 kilograms.

In this example the surface mulch has an erosion control effectiveness of 50%.

Effectiveness of a particular practice to control erosion is generally determined by use of a rainfall simulation protocol like that developed for testing hydraulic soil stabilizers at the SDSU Soil Erosion Research Laboratory. In the SDSU procedure, runoff water and sediment resulting from a specific storm is collected from a bare soil plot. The dry weight of the soil (kilograms) as well as the total volume of runoff water (liters) are recorded. Subsequent surface treatments using different soil stabilizers are subjected to the same storm event and for each soil stabilizer, runoff water and sediment are collected and compared against the data from the bare soil. This comparison is presented as a percentage reduction of the bare soil condition.

Longevity

The values presented for this criterion are simply a function of the time that an SSTS maintains its erosion control effectiveness:

S	1 - 3 months
M	3 – 12 months
L	> than 12 months

Mode of Application

The mode of application criterion refers to the type of labor or equipment that is required to install the product or technique. The letter codes for this criterion are as follows:

L	Applied by hand labor
W	Applied by water truck
H	Applied by hydraulic mulcher
B	Applied by either water truck or hydraulic mulcher
M	Applied by some mechanical method other than those listed above (e.g., straw blower)

Residual Impact

This criterion relates to the impact that a particular practice might have on construction activities once they are resumed on the area that was temporarily stabilized. Some examples include:

- Temporary vegetation covers or standard biodegradable mulches might create problems with achieving final slope stability or compaction due to their organic content, and therefore would require removal and disposal.

- Applications of straw or hay fibers might keep soil from drying out as quickly as it might if it was bare.
- Plastic sheeting, netting or materials used in the construction of an SSTS might persist longer than needed on or in the soil.

For the purpose of assigning a value to this criterion, residual impacts are described as:

L	Will have a low impact on future construction activities
M	Will have a moderate impact on future construction activities
H	Will have a high impact on future construction activities

Native

This criterion relates primarily to selection of plant materials and is important from the standpoint of environmental compatibility and competitiveness. Definitions for this category include:

N	Plant or plant material native to California
E	Exotic species not native to North America

Runoff Effect

This criterion measures the effect that a particular SSTS has on the production of storm water runoff. Similar to the erosion control effectiveness criterion, runoff from an SSTS is compared to the amount of runoff measured for bare soil and is presented in the matrix as a percentage of the runoff that would occur in an untreated, or control, condition.

For example, two side-by-side soil conditions are subjected to the same storm intensity and duration:

1. The bare soil, or control condition, yields a measured runoff value of 100 liters.
2. The second plot, treated with a surface mulch, yields a measured runoff volume of 50 liters.

In this example the surface mulch has reduced runoff by 50%. However, it is also important to remember that some practices, such as plastic sheeting, increase runoff above the bare soil condition. This may not be desirable in some locations.

As previously described, one method that can be used to evaluate the effect of a particular practice on runoff volumes is the use of a rainfall simulator. Using the simulator, the runoff from a specific storm is collected from a bare soil plot and recorded. Subsequent surface treatments using different hydraulic soil stabilizers are subjected to the same storm event and for each hydraulic soil stabilizer, the runoff is collected and compared against the data from the bare soil. This comparison is presented as an increase, decrease, or no change in runoff compared to the bare soil condition as follows:

+	Positive effect, i.e., runoff is decreased over baseline (bare) soil condition
0	No change in runoff
-	Negative effect, i.e., runoff is increased from bare soil condition

Water Quality Impact

In order to develop a method for comparing the relative impacts of the Hydraulic Soil Stabilizers on water quality in the runoff water, data from each product were compared to each other in terms of the number of exceedances of the standards against which they were evaluated. Samples that had more than two constituents present at concentrations above both the background level and levels typical of urban runoff were assigned a "High" value (meaning that they have relatively higher potential to impact water quality, based on the results in this study). Samples that had one or two such exceedances were assigned a rating of "Moderate," while samples with no notable differences from the background sample (which was generally within the range of normal urban runoff levels) were assigned a rating of "Low."

The water quality impact of other SSTS categories, particularly Standard Biodegradable Mulches (SBM) and biodegradable Rolled Erosion Control Products (RECP) are currently being evaluated in the District 7 Erosion Control Pilot Study.

Water quality impact values are as follows:

L	Lower potential to impact water quality
M	Moderate potential to impact water quality
H	Higher potential to impact water quality

3.1 CATEGORY: STANDARD BIODEGRADABLE MULCHES (SBM)

Class: Straw Mulch

Loose straw is the most common mulch material used in conjunction with direct seeding of soil. Straw mulching is generally the second part of multi-step process where seed and fertilizer is first applied, then straw mulch applied as the second step. The final step of the process involves holding the loose straw in place by a) utilizing netting, b) applying a liquid tackifier, or c) punching it into the soil by a process known as "crimping" or "incorporating."

Type: Wheat or Rice Straw

Straw can be hand applied or machine applied. The maximum fiber length of the straw should be typically greater than 150 mm.

Class: Wood Fiber Mulch

Wood fiber mulch is a component of hydraulic applications. It is usually used in combination with seed and fertilizer and is typically applied at the rate of 2,250 to 4,500 kilograms per hectare (kg/Ha).

Type: Wood Fiber

This type of mulch is manufactured from wood or wood waste from lumber mills or from urban sources. Wood fiber mulch can be specified with or without a tackifier and previous work has shown that wood fiber mulches with tackifiers have better erosion control performance.

Specifications for wood fiber mulch can be found in Caltrans Standard Specifications, Sections 20-2.07 and 2.08.

Class: Recycled Paper Mulch

Recycled paper mulch is a component of hydraulic applications. It is usually used in combination with seed and fertilizer and is typically applied at the rate of 2,250 to 4,500 kg/Ha.

Type: Cellulose Fiber

Cellulose fiber mulch contains fibers of shorter length than wood fiber mulches and is typically made from recycled newsprint, magazine, or other waste paper sources. It can be specified with or without a tackifier.

Specifications for cellulose fiber mulch can be found in Caltrans Standard Specifications, Sections 20-2.07 and 2.08.

Class: Bonded Fiber Matrix

A bonded fiber matrix (BFM) is a hydraulically-applied system of fibers and adhesives that upon drying forms an erosion-resistant blanket that promotes vegetation, and prevents soil erosion. BFMs are typically applied at rates from 3,400 kg/ha to 4,500 kg/ha based on the manufacturer's recommendation.

Type: Biodegradable

The biodegradable BFM is comprised of materials that are 100% biodegradable. The binder in the BFM should also be biodegradable and should not dissolve or disperse upon re-wetting. Typically, biodegradable BFMs should not be applied immediately before, during or immediately after rainfall so that the matrix will have an opportunity to dry for 24 hours after application.

3.2 CATEGORY: ROLLED EROSION CONTROL PRODUCTS (RECP)

This class of products includes manufactured mulch materials that are produced in a roll configuration that is placed on the ground and held in place by stakes, metal staples, geotextile pins or other fastening systems. The mulch within the blanket can be held in place by netting, sewing, adhesives or a combination of these methods.

Class: Biodegradable

Biodegradable RECPs are typically composed of jute fibers, curled wood fibers, straw, coconut fiber, or a combination of these materials. In order for an RECP to be considered 100% biodegradable, the netting, sewing or adhesive system that hold the biodegradable mulch fibers together must also be biodegradable.

Type: Jute Mesh

Jute is a natural fiber that is made into a yarn which is loosely woven into a biodegradable mesh. It is designed to be used in conjunction with vegetation and has longevity of approximately one year. The material is supplied in rolled strips, which should be secured to the soil with U-shaped staples or stakes in accordance with manufacturers' recommendations.

Type: Curled Wood Fiber

Excelsior (curled wood fiber) blanket material should consist of machine produced mats of curled wood excelsior with 80 percent of the fiber 150 mm or longer. The excelsior blanket should be of consistent thickness. The wood fiber should be evenly distributed over the entire area of the blanket. The top surface of the blanket should be covered with a photodegradable extruded plastic mesh. The blanket should be smolder resistant without the use of chemical additives and shall be non-toxic and non-injurious to plant and animal life. Excelsior blanket should be furnished in rolled strips, a minimum of 1220 mm wide, and should have an average weight of 0.5

kg/m^2, ±10 percent, at the time of manufacture. Excelsior blankets should be secured in place with wire staples. Staples should be made of 3.05-mm steel wire and should be U-shaped with 200-mm legs and 50-mm crown.

Type: Straw

Straw blanket should be machine-produced mats of straw with a lightweight biodegradable netting top layer. The straw should be attached to the netting with biodegradable thread or glue strips. The straw blanket should be of consistent thickness. The straw should be evenly distributed over the entire area of the blanket. Straw blanket should be furnished in rolled strips a minimum of 2 m wide, a minimum of 25 m long and a minimum of 0.27 kg/m^2. Straw blankets should be secured in place with wire staples. Staples should be made of 3.05-mm steel wire and should be U-shaped with 200-mm legs and 50-mm crown.

Type: Wood Fiber

Wood fiber blanket is comprised of biodegradable fiber mulch with extruded plastic netting held together with adhesives. The material is designed to enhance revegetation. The material is furnished in rolled strips, which should be secured to the ground with U-shaped staples or stakes in accordance with manufacturers' recommendations.

Type: Coconut Fiber

Coconut fiber blanket should be machine-produced mats of 100 percent coconut fiber with biodegradable netting on the top and bottom. The coconut fiber should be attached to the netting with biodegradable thread or glue strips. The coconut fiber blanket should be of consistent thickness. The coconut fiber should be evenly distributed over the entire area of the blanket. Coconut fiber blanket should be furnished in rolled strips with a minimum of 2 m wide, a minimum of 25 m long and a minimum of 0.27-kg/m^2. Coconut fiber blankets should be secured in place with wire staples. Staples should be made of 3.05-mm steel wire and should be U-shaped with 200-mm legs and 50-mm crown.

Type: Coconut Fiber Mesh

Coconut fiber mesh is a thin permeable membrane made from coconut or corn fiber that is spun into a yarn and woven into a biodegradable mat. It is designed to be used in conjunction with vegetation and typically has longevity of several years. The material is supplied in rolled strips, which should be secured to the soil with U-shaped staples or stakes in accordance with manufacturers' recommendations.

Type: Straw Coconut Fiber

Straw coconut fiber blanket should be machine-produced mats of 70 percent straw and 30 percent coconut fiber with a biodegradable netting top layer and a

biodegradable bottom net. The straw and coconut fiber should be attached to the netting with biodegradable thread or glue strips. The straw coconut fiber blanket should be of consistent thickness. The straw and coconut fiber should be evenly distributed over the entire area of the blanket. Straw coconut fiber blanket should be furnished in rolled strips a minimum of 2 m wide, a minimum of 25 m long and a minimum of 0.27 kg/m^2. Straw coconut fiber blankets should be secured in place with wire staples. Staples should be made of 3.05-mm steel wire and should be U-shaped with 200-mm legs and 50-mm crown.

Class: Non-Biodegradable

Non-biodegradable RECPs are typically composed of polypropylene, polyethylene, nylon or other synthetic fibers. In some cases, a combination of biodegradable and synthetic fibers is used to construct the RECP. Netting used to hold these fibers together is typically non-biodegradable as well.

Type: Plastic Netting

Plastic netting is a lightweight biaxially-oriented netting designed for securing loose mulches like straw or paper to soil surfaces to establish vegetation. The netting is photodegradable. The netting is supplied in rolled strips, which should be secured with U-shaped staples or stakes in accordance with manufacturers' recommendations.

Type: Plastic Mesh

Plastic mesh is an open-weave geotextile that is comprised of an extruded synthetic fiber woven into a mesh with an opening size of less than 0.5 cm. It is used with revegetation or may be used to secure loose fiber such as straw to the ground. The material is supplied in rolled strips, which should be secured to the soil with U-shaped staples or stakes in accordance with manufacturers' recommendations.

Type: Synthetic Fiber with Netting

Synthetic fiber with netting is a mat that is comprised of durable synthetic fibers treated to resist chemicals and ultraviolet light. The mat is a dense, three-dimensional mesh of synthetic (typically polyolefin) fibers stitched between two polypropylene nets. The mats are designed to be revegetated and provide a permanent composite system of soil, roots, and geomatrix. The material is furnished in rolled strips, which should be secured with U-shaped staples or stakes in accordance with manufacturers' recommendations.

Type: Bonded Synthetic Fibers

This type of product consists of a three-dimensional geomatrix nylon (or other synthetic) matting. Typically it has more than ninety percent open area, which facilitates root growth. Its tough root-reinforcing system anchors vegetation and protects against hydraulic lift and shear forces created by high volume discharges. It

can be installed over prepared soil, followed by seeding into the mat. Once vegetated, it becomes an invisible composite system of soil, roots, and geomatrix.

The material is furnished in rolled strips that should be secured with U-shaped staples or stakes in accordance with manufacturers' recommendations.

Type: Combination Synthetic and Biodegradable

Combination synthetic and biodegradable RECPs consist of biodegradable fibers, such as wood fiber or coconut fiber, with a heavy polypropylene net stitched to the top and a high-strength continuous-filament geomatrix or net stitched to the bottom. The material is designed to enhance revegetation. The material is furnished in rolled strips, which should be secured with U-shaped staples or stakes in accordance with manufacturers' recommendations.

3.3 CATEGORY: TEMPORARY SEEDING

The following ratings are used in the tables below:

Native: y = native to California; n = not native to California

Availability: S = 3-5 days; M = 1-2 weeks

Erosion control effectiveness: M = moderate; H = high.

Longevity: M = 3-12 months; L = > 12 months.

Residual Impact: L = low; M = moderate; H = high.

District: District the species will thrive in, or if indicated, will NOT thrive in. However, all species listed can be used in all Districts if DSA irrigated.

Rate: Approximate seeding rate in kg/Ha. Rate of application depends on seed viability (i.e., purity and percent germination).

Pls/Germ: Pure live seed and percent germination that were used as the basis for the seeding rate provided. The seed supplier can provide seed viability information.

Cost: Cost of seed in $/kg. Installed cost will vary with proximity of project to seed source or supplier.

Class: High Density Plantings

Type: Ornamentals

Name	Native (y/n)	Availability	Erosion Control Effectiveness	Longevity	Residual Impact	District	Rate (kg/Ha)	Pls/Germ	Seed Cost ($/kg)
Aristida purpurea (Purple-three-awn)	y	M	M	L	L	All	34	60/45	$66
Aristida ternipes (Hook three-awn)	y	M	M	L	L	Not 8,11	34	50/60	$66
Bouteloua gracilis (Blue grama)	y	M	M	L	L	All	17	60/60	$26
Buchloe dactyloides (Buffalo grass)	n	M	H	L	L	Not 9	17	95/85	$21
Deschampsia elongata (Slender hairgrass)	y	M	M	M	L	Not 9	22	90/60	$53
Eragrostis curvula (Weeping lovegrass)	n	M	M	L	L	All	28	98/65	$9
Leymus condensatus (Giant wildrye)	y	M	H	L	M	Not 9	11	70/80	$88
Muhlenbergia rigens (Deergrass)	y	S	M	L	L	All	13	60/60	$240

Type: Turf Species

Name	Native (y/n)	Availability	Erosion Control Effectiveness	Longevity	Residual Impact	District	Rate (kg/Ha)	Pls/Germ	Seed Cost ($/kg)
Festuca rubra 'Molate' (California native red fescue)	y	S	H	L	M	Not 9	34	95/80	$3.50
Festuca spp. many species available	--	S	H	L	H	All	34	95/80	$4.40

Note: Many ryegrass species are available. Please DO NOT use *Lolium multiflorum, Lolium perenne, or Tetrazoid*, as these tend to become invasive and will have high residual impact.

Type: Bunch Grasses

Name	Native (y/n)	Availability	Erosion Control Effectiveness	Longevity	Residual Impact	District	Rate (kg/Ha)	Pls/Germ	Seed Cost ($/kg)
Achnatherum coronata (Giant stipa)	y	M	M	L	M	Not 1,2,3,10	22	70/40	call
Elymus elymoides (Bottlebrush squirreltail)	y	S	H	L	M	All	22	90/80	$24
Elymus glaucus (Blue wildrye)	y	S	H	L	M	Not 8	22	90/80	$24
Leymus triticoides (Creeping wildrye)	y	M	H	L	M	Not 8, 11	22	90/80	$66
Poa secunda (Pine bluegrass)	y	M	M	L	L	All	22	80/40	$66
Nasella cernua (Nodding stipa)	y	S	M	L	L	Not 1,4	17	80/50	$93
Nasella lepida (Foothill needlegrass)	y	S	M	L	L	Not 8,9,11	11	60/60	$221
Nasella pulchra (Purple needlegrass)	y	S	M	L	L	Not 8,9	22	70/60	$93

Class: Fast Growing

Type: Annual

Name	Native (y/n)	Availability	Erosion Control Effectiveness	Longevity	Residual Impact	District	Rate (kg/Ha)	Pls/Germ	Seed Cost ($/kg)
Vulpia microstachys (Small fescue)	y	S	H	L	L	All	22	90/60	$18
Bromus carinatus 'Cucamonga' (Arizona brome)	y	S	H	L	M	Not 8	50	95/80	$9
Bromus carinatus (California brome)	y	S	H	L	M	Not 8	50	95/80	$8.80
Lupinus succulentus (Arroyo lupine)	y	S	H	L	L	All	22	95/85	$40
Trifolium incarnatum (Crimson clover)	n	S	H	L	L	All	28	98/85	$4.40

Note: Many brome species are available. Please DO NOT use *Bromus hordeaceus* or *Bromus rubens* as these tend to become invasive and will have a high residual impact.

Type: Perennial

Name	Native (y/n)	Availability	Erosion Control Effectiveness	Longevity	Residual Impact	District	Rate (kg/Ha)	Pls/Germ	Seed Cost ($/kg)
Hordeum brachyantherum (Meadow barley)	y	S	H	L	M	Not 8, 9, 11	112	90/80	$0.51
Hordeum californicum (California barley)	y	S	H	L	M	2,3,6,8,10, 11	112	90/80	$0.51
Bromus carinatus (California brome)	y	S	H	L	M	Not 8, 9, 11	50	95/80	$6.60
Elymus glaucus (Blue wildrye)	y	S	H	L	M	Not 8, 9, 11	22	90/80	$24
Festuca idahoensis (Idaho fescue)	y	S	H	L	M	Not 8, 9, 11	34	90/75	$29
Festuca ovina (Sheep fescue)	n	S	H	L	M	All	56	95/80	$9
Deschampsia elongata (Slender hairgrass)	y	S	H	L	M	Not 8, 9, 11	22	90/60	$53

Class: Non-Competing

Type: Native

None of the native species listed are overly competitive. Refer to species listed previously by seed type.

Type: Non-Native

Most of the species listed are natives. The species that are not native that are listed are not highly competitive, with the exception of the species listed below. Please be advised that these species could have High Residual Impact if allowed to seed.

- *Bromus hordeaceus* (see annuals)
- *Bromus rubens* (see annuals)
- Several ryegrass species, including *Lolium multiflorum, Lolium perenne*, and *Tetrazoid* (see turf species)

Class: Sterile

Type: Cereal Grain

Name	Native (y/n)	Availability	Erosion Control Effectiveness	Longevity	Residual Impact	District	Rate (kg/Ha)	Pls/Germ	Seed Cost ($/kg)
Wheat Wheatgrass *Regreen*	n	S	H	L	L	All	56	95/90	$9

3.4 CATEGORY: IMPERVIOUS COVERS

Class: Plastic

Type: Rolled Plastic Sheeting

Plastic sheeting should have a minimum thickness of 6 mm, and should be firmly held in place with sandbags or other weights placed no more than 3 m apart. Seams are typically taped or weighted down their entire length, and there should be at least a 300 mm to 600 mm overlap of all seams. Edges should be embedded a minimum of 150 mm in native soil.

All sheeting should be inspected periodically after installation and after significant rainstorms to check for erosion and undermining. Any failures shall be repaired immediately. If washout or breakages occurs, the material should be re-installed after repairing the damage to the slope.

Type: Geotextile (Woven)

Woven geotextile material should be a woven polypropylene fabric with a minimum thickness of 15 mm, a minimum of 3.7 m wide and should have a minimum tensile strength of 0.67 kN (warp) 0.36 kN (fill) in conformance with the requirements in ASTM Designation: D 4632. The permittivity of the fabric shall be approximately 0.07 sec^{-1} in conformance with the requirements in ASTM Designation: D 4491. The fabric should have an ultraviolet (UV) stability of 70 percent in conformance with the requirements in ASTM designation: D 4355. Geotextile blankets should be secured in place with wire staples or sandbags and by keying into tops of slopes and edges to prevent infiltration of surface waters under geotextile. Staples should be made of 3.05-mm steel wire and shall be U-shaped with 200-mm legs and 50-mm crown.

3.5 CATEGORY: HYDRAULIC SOIL STABILIZERS

Class: Plant-Material Based (Short Lived)

Type: Guar

Guar is a non-toxic, biodegradable, natural galactomannan-based hydrocolloid treated with dispersent agents for easy field mixing. It should be applied at the rate of 1.2 to 1.8 kg per 1,000 liters of water, depending on application machine capacity. Recommended minimum application rates are as follows:

Application Rates for Guar Soil Stabilizer

Slope (V:H):	Flat	1:4	1:3	1:2	1:1
Kg/Ha:	45	50	56	67	78

Type: Psyllium

Psyllium is comprised of the finely ground muciloid coating of plantago seeds that is applied as a dry powder or in a wet slurry to the surface of the soil. It dries to form a firm but rewettable membrane that binds soil particles together but permits germination and growth of seed. Psyllium requires 12 to 18 hours drying time. Application rates are generally 90 to 225 kg/Ha, with enough water in solution to allow for a uniform slurry flow.

Type: Starch

Starch is non-ionic, cold-water soluble (pre-gelatinized) granular cornstarch. The material is mixed with water and applied at the rate of 170 kg/Ha. Approximate drying time is 9 to 12 hours.

Class: Plant-Material Based (Long Lived)

Type: Pitch and Rosin Emulsion

Generally, a non-ionic pitch and rosin emulsion has a minimum solids content of 48%. The rosin should be a minimum of 26% of the total solids content. The soil stabilizer should be non-corrosive, water-dilutable emulsion that upon application cures to a water insoluble binding and cementing agent. For soil erosion control applications, the emulsion is diluted as follows:

For clayey soil: 5 parts water to 1 part emulsion
For sandy soil: 10 parts water to 1 part emulsion

Application can be by water truck or hydraulic seeder with the emulsion/product mixture applied at the rate specified by the manufacturer.

Class: Polymeric Emulsion Blends

Type: Acrylic Copolymers and Polymers

Polymeric soil stabilizers should consist of a liquid or solid polymer or copolymer with an acrylic base that contains a minimum of 55 percent solids. The polymeric compound should be handled and mixed in a manner that will not cause foaming or should contain an anti-foaming agent. The polymeric emulsion should have a minimum shelf life of one year. Polymeric soil stabilizer should be readily miscible in water, non-injurious to seed or animal life, non-flammable, should provide surface

soil stabilization for various soil types without totally inhibiting water infiltration, and should not re-emulsify when cured. The applied compound should air cure within a maximum of 36 to 48 hours. Liquid copolymer should be diluted at a rate of 10 parts water to 1 part polymer and applied to soil at a rate of 11,000 liters/hectare.

Type: Liquid Polymers of Methacrylates and Acrylates

This material consists of a tackifier/sealer that is a liquid polymer of methacrylates and acrylates. It is an aqueous 100% acrylic emulsion blend of 40% solids by volume that is free from styrene, acetate, vinyl, ethoxylated surfactants or silicates. For soil stabilization applications, it is diluted with water and applied with a hydraulic seeder at the rate of 190 liters per hectare. Drying time is 12 to 18 hours after application.

Type: Copolymers of Sodium Acrylates and Acrylamides

These materials are non-toxic, dry powders that are copolymers of sodium acrylate and acrylamide. They are mixed with water and applied to the soil surface for erosion control at rates that are determined by slope gradient:

Slope Gradient (V:H)	Kg/Ha
Flat to 1:5	3.4 – 5.6
1:5 to 1:3	5.6 – 11.2
1:2 to 1:1	11.2 – 22.4

Type: Poly-Acrylamide and Copolymer of Acrylamide

Linear copolymer polyacrylamide is packaged as a dry-flowable solid. When used as a stand-alone stabilizer, it is diluted at a rate of 1.2 kg/1,000 liters of water and applied at the rate of 5.6 kg/Ha.

Type: Hydro-Colloid Polymers

Hydro-Colloid Polymers are various combinations of dry-flowable poly-acrylamides, copolymers and hydro-colloid polymers that are mixed with water and applied to the soil surface at rates of 60 to 70 kg/Ha. Drying times are 0 to 4 hours.

Class: Petroleum or Resin-Based Emulsions

Type: Emulsified Petroleum Resin

This material is a concentrated petroleum hydrocarbon emulsion that is mixed with water and applied to the soil surface at a rate of 23,000 liters per hectare. Dilution rates vary with the type of soil and other site conditions, and should be provided by the manufacturer. They typically range from 12:1 to 20:1 parts water to emulsion.

Class: Cementitious-Based Binders

Type: Gypsum

This is a formulated gypsum-based product that readily mixes with water and mulch to form a thin protective crust on the soil surface. It is comprised of high purity gypsum that is ground, calcined and processed into calcium sulfate hemihydrate with a minimum purity of 86%. It is mixed in a hydraulic seeder and applied at rates 4,500 to 13,500 kg/Ha. Drying time is 4 to 8 hours.