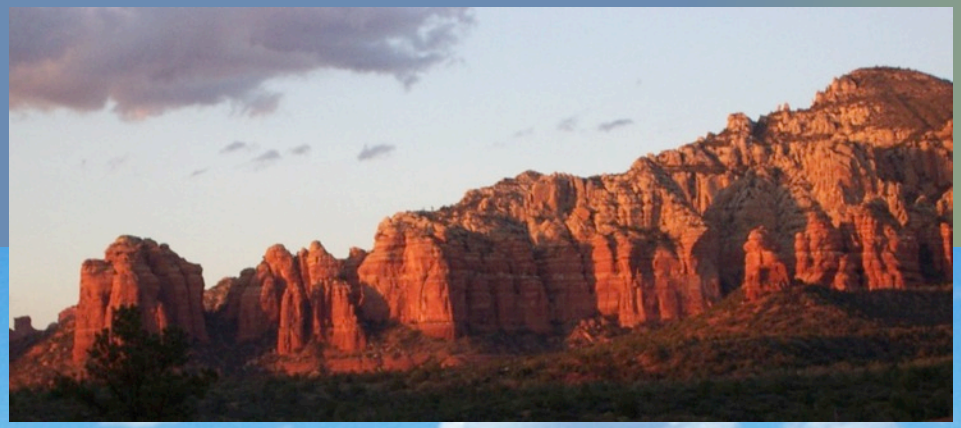
Module 2

1. Erosion Theory -
2. Planning for Effective Erosion and Sediment Control
3. Selecting the Correct BMP

Erosion Can Be Beautiful…….



But not on your project site !

Definitions

- ✓ Erosion
- ✓ Sediment
- ✓ Sedimentation
- ✓ Turbidity

Turbidity entering Sulphur Creek from Union Pacific Railroad, Redding, CA

Erosion

- Soil erosion is the physical process by which soil particles become detached by water, wind, or gravity

Sediment

- Is the Product of erosion
  - Sediment can be suspended or moved as bedload

Seditmentation

Deposition of eroded material

Turbidity

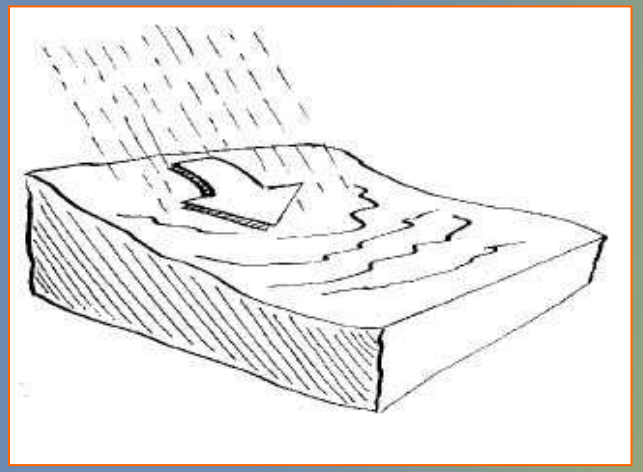
- Turbidity is a measure of the degree to which the water looses its transparency due to the presence of suspended particulates
- The more total suspended solids in the water, the murkier it seems and the higher the turbidity

Turbidity

- Turbidity is measured in Nephelometric Turbidity Units (NTUs)
- The instrument used for measuring it is called nephelometer or turbidimeter.

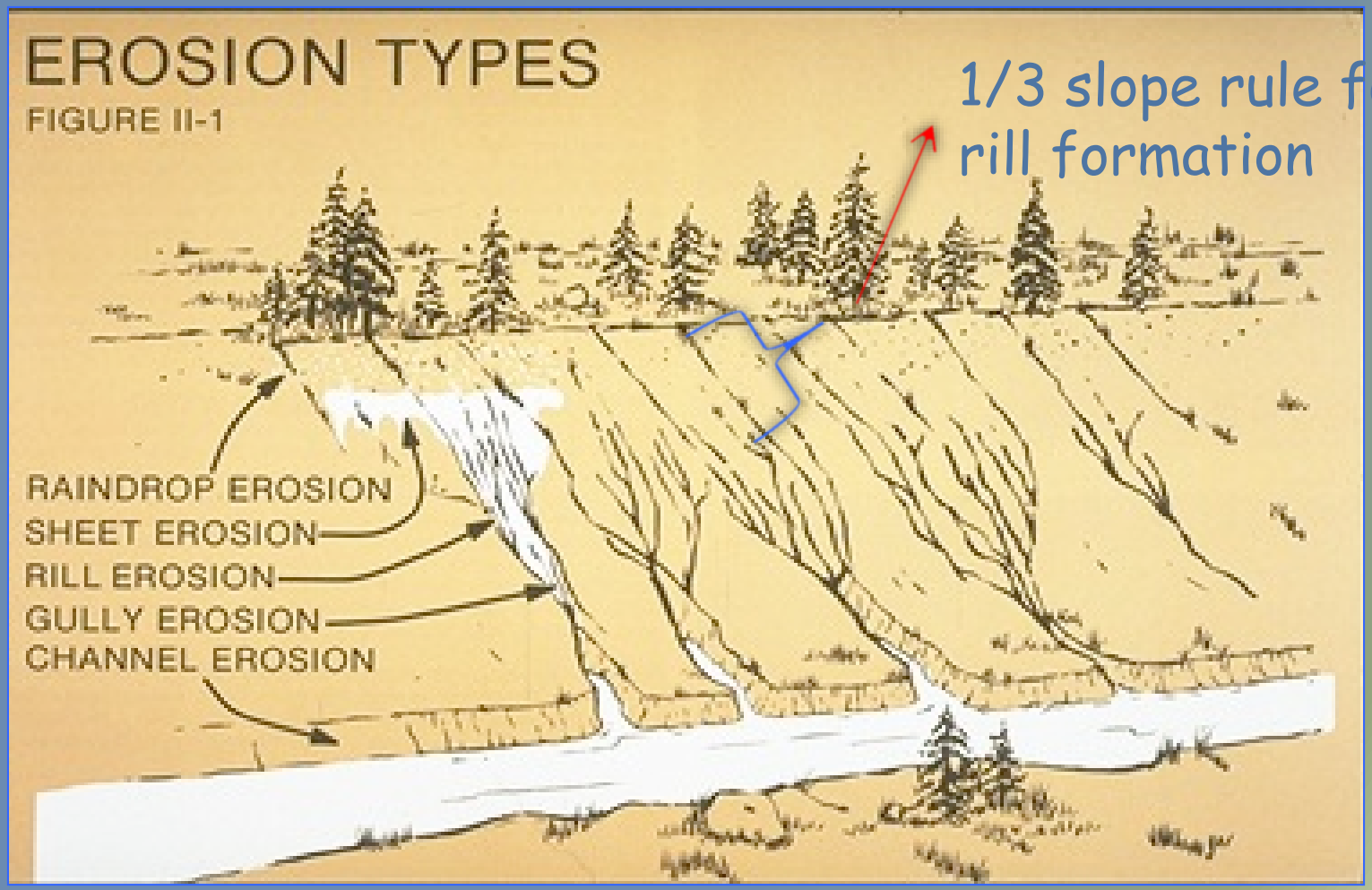
Types of Erosion

- Raindrop (Splash) Erosion
- Sheet Erosion (Overland Flow)
- Rill Erosion
- Gully Erosion
- Channel Erosion
- Wind Erosion



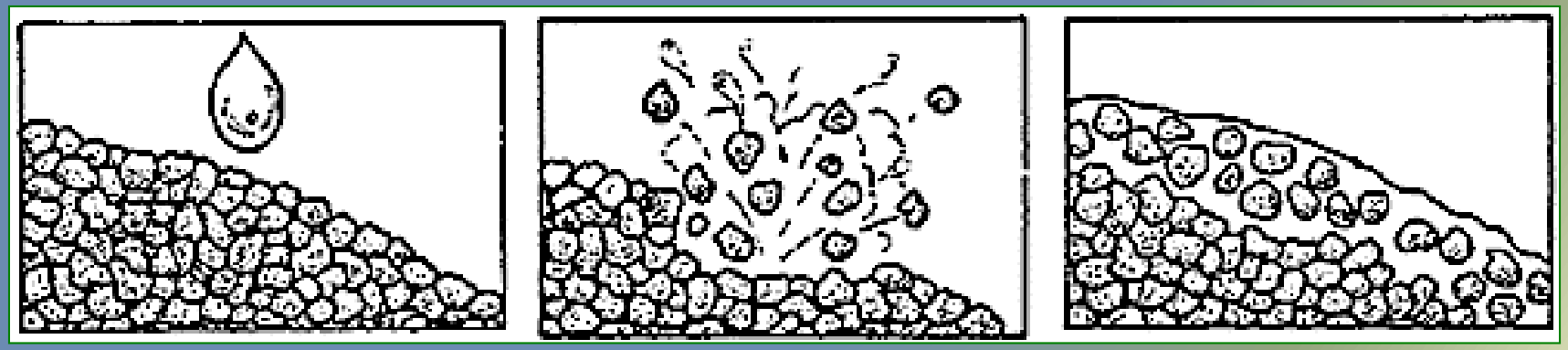
Concentrated Flow

Types of Erosion

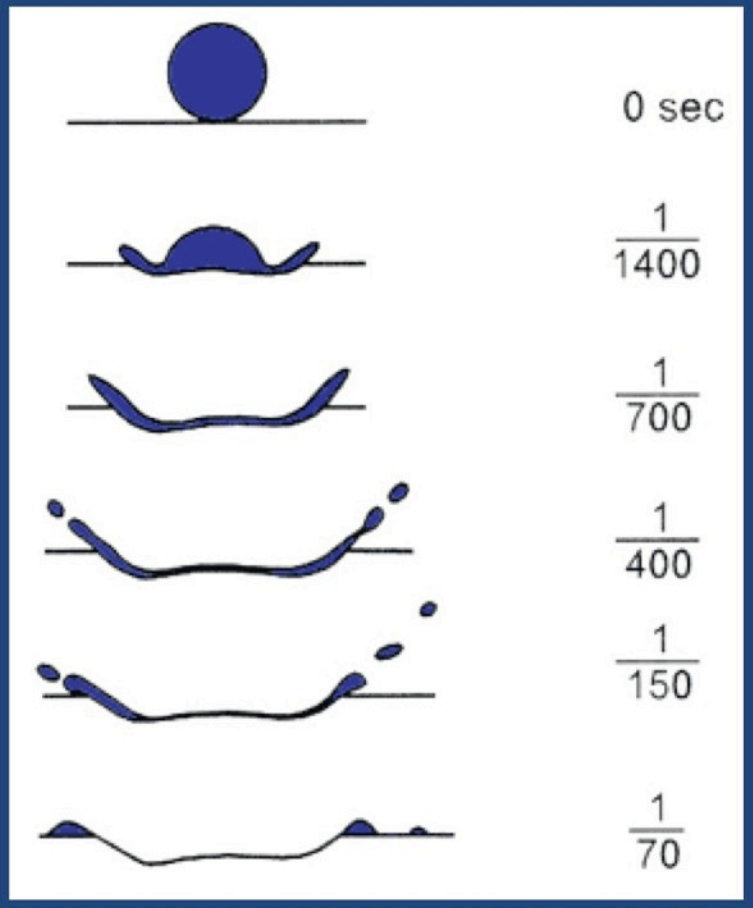


Raindrop Erosion

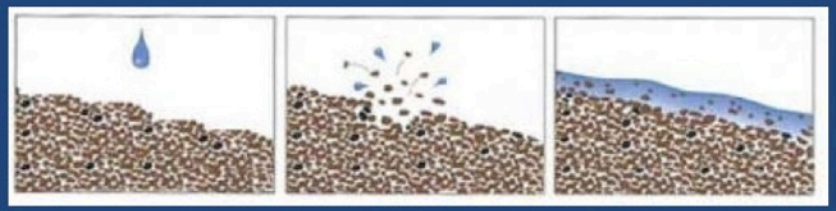
- Also called Splash erosion
- Rain drops striking bare soil directly
  - Detaches soil particles
  - Particles can then be transported by the action of water and/or wind



Raindrop Impact



+ Surfaces become "puddled"
+ Lower infiltration rates
+ Increased runoff
= Increased Turbidity

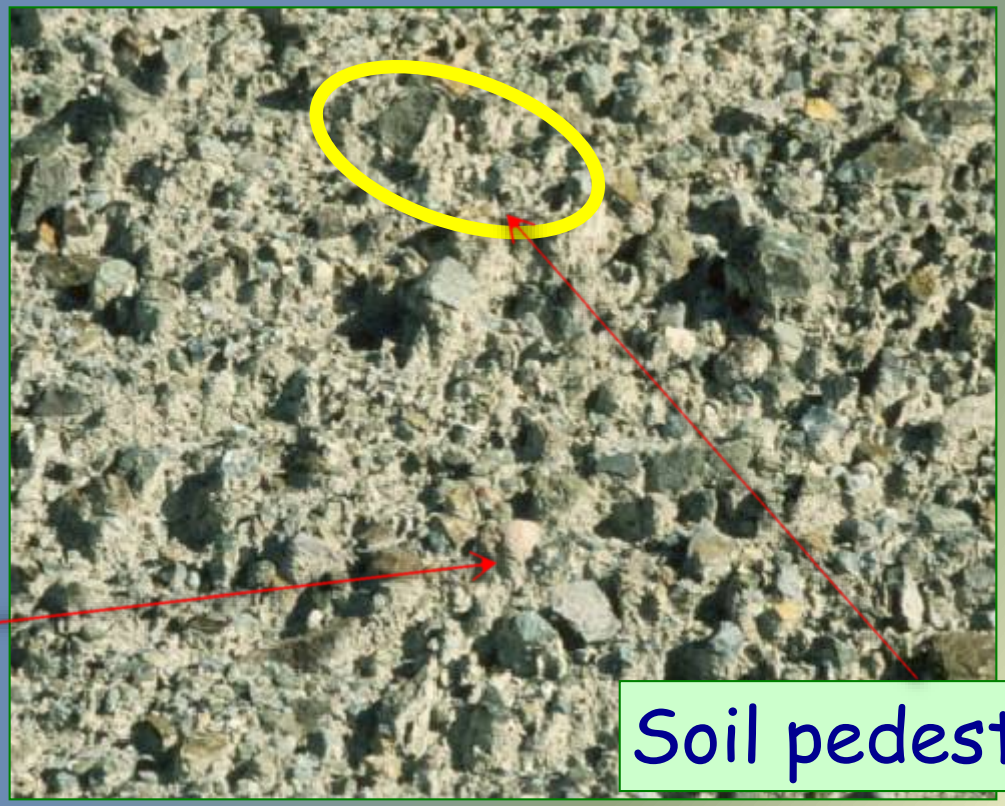


Source: *Environmental Soil Physics*, Hillel

Raindrop Erosion

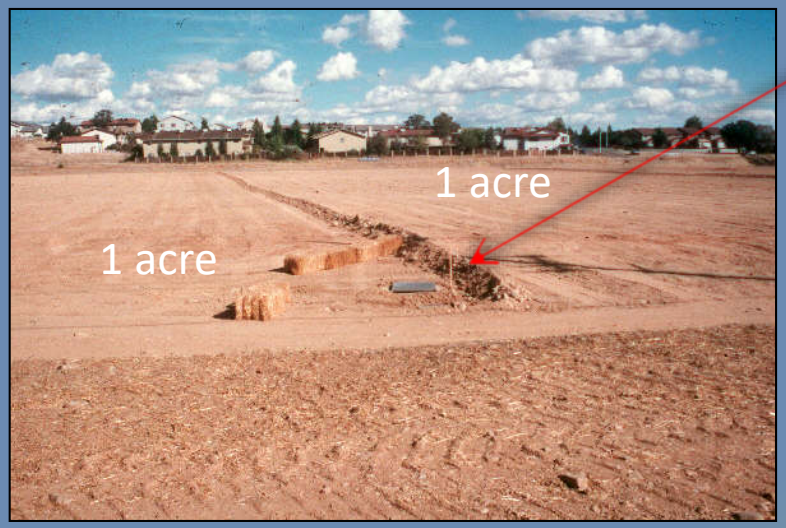
Factoid - The loss of 1/2" soil over 1 acre ≅ 90T !

- Raindrop Erosion - Primary source of erosion energy
  - Raindrop erosion is often imperceptible
  - Indicators are
    - Pedestals
    - Stains
    - Gravelling or Lag

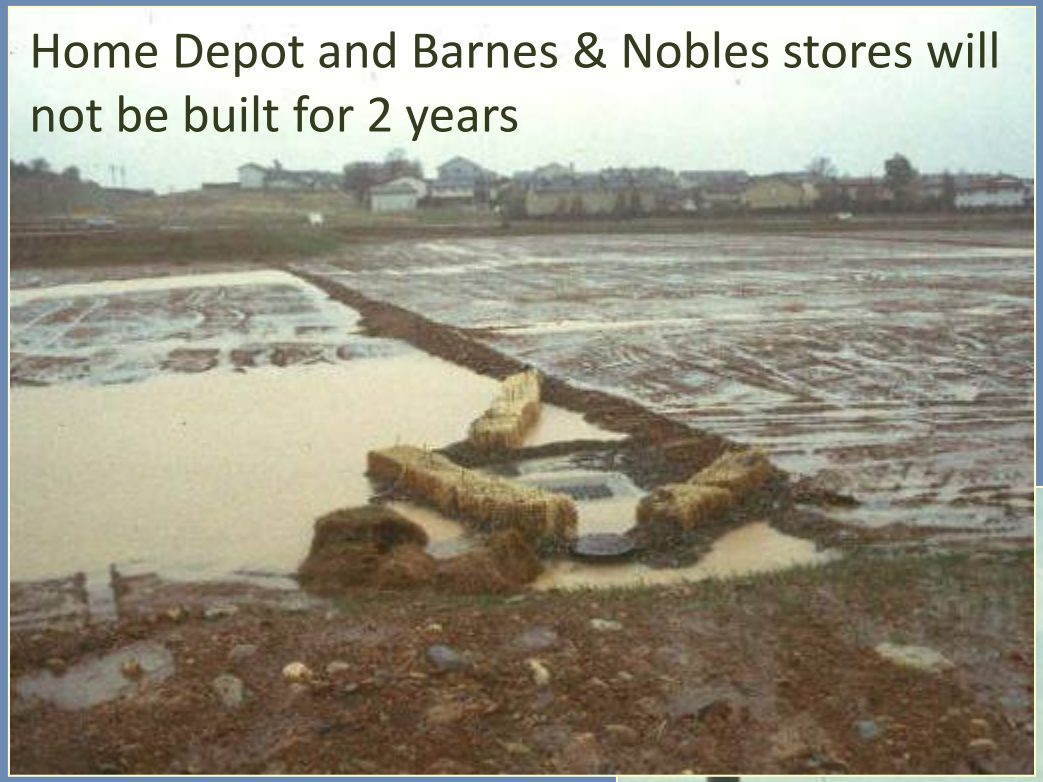


Sheet Erosion

- The removal of a uniform thin layer of soil by raindrop splash and sheet erosion
- Surface film of water 2-3 mm deep

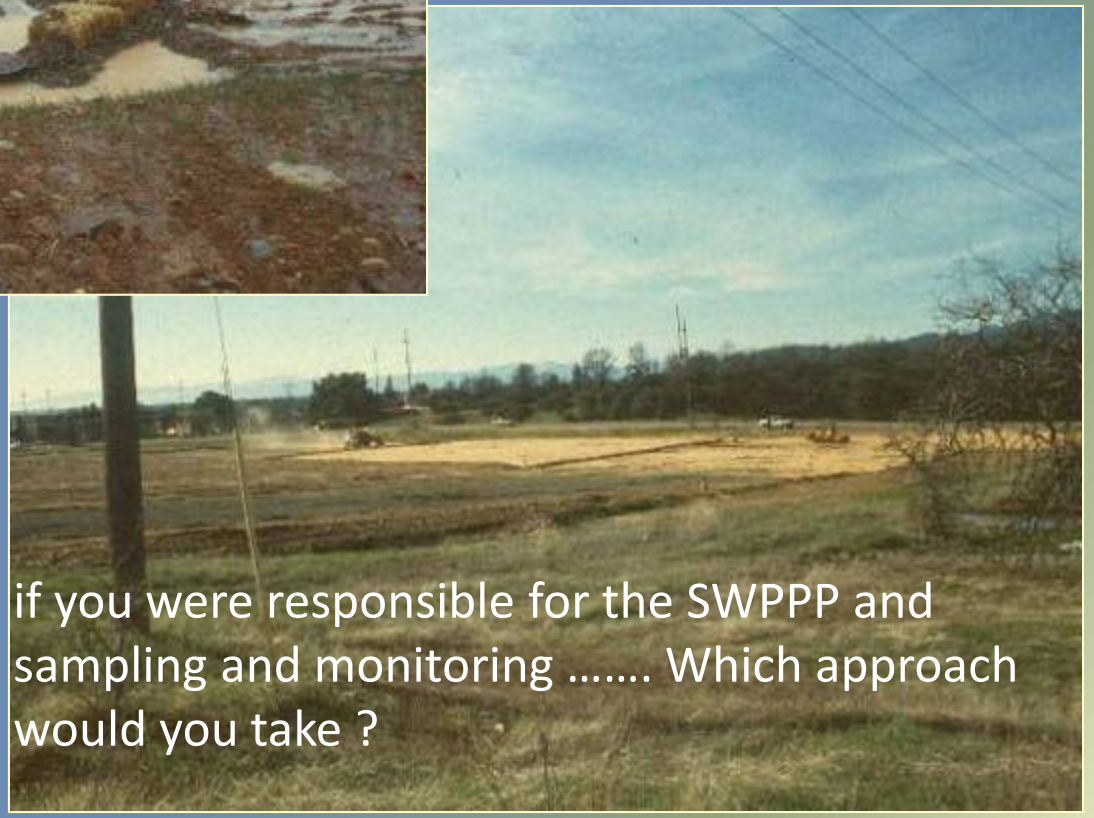


A Real Redding Experience

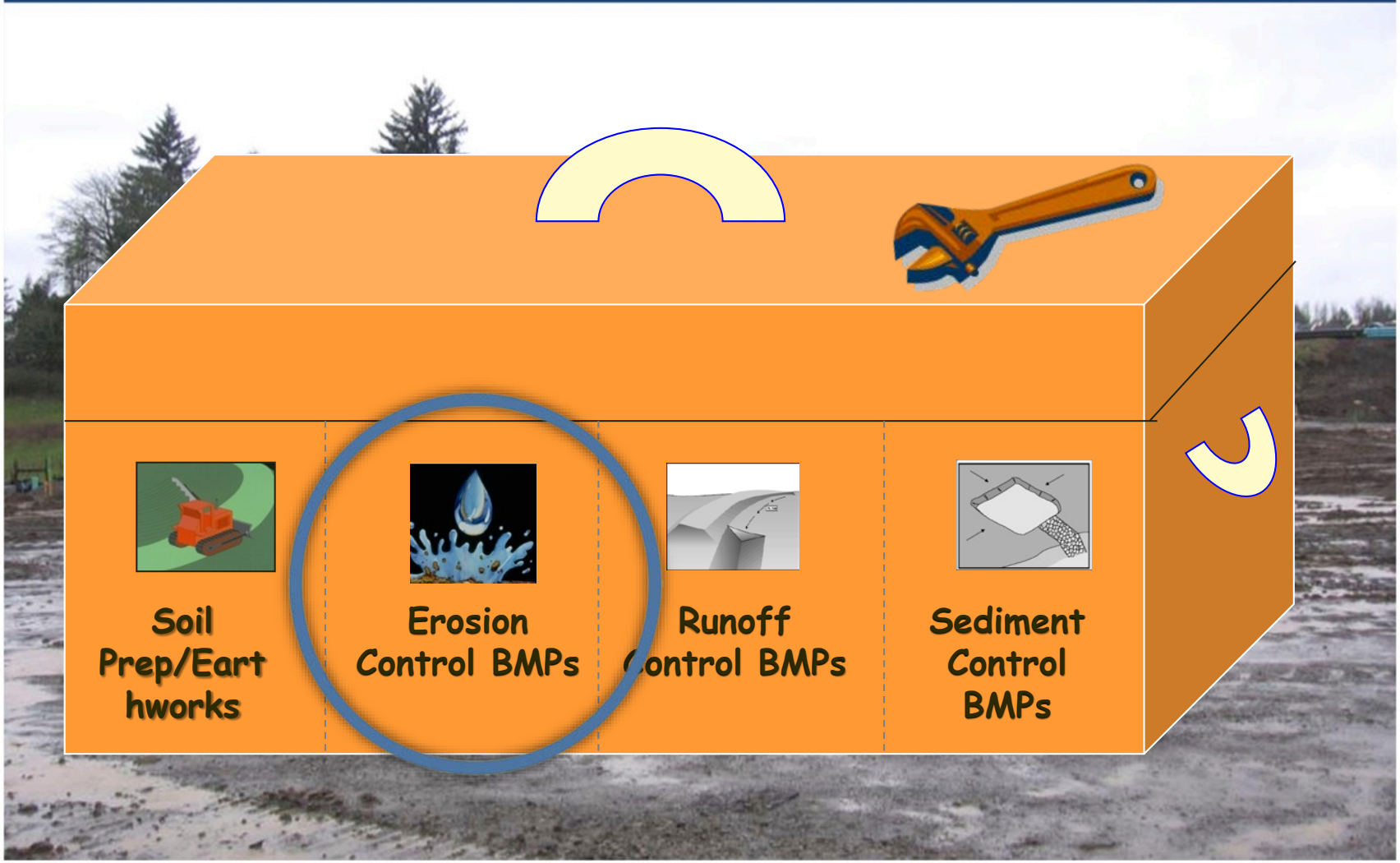


Sediment control was relatively ineffective on this site…..

Temporary straw mulching proved to be most effective.



“Shiny” Dirt is Sheet Flow



Rill Erosion

- Shallow surface flows that converge
- Increased velocity and turbulence.
- Well-defined tiny channels
- The rate of rill erosion can be approximately 100 X greater than sheet erosion

Forest Roads with rills were measured producing 20 tons/ac/yr

Gully Erosion

- Accumulating runoff becomes concentrated and forms small rills throughout the soil
- Several rills may coalesce to form Gullies
- The rate of gully erosion can be approximately 100 X greater than rill erosion (2000 t/ac/yr)

Gully Erosion

Gully Erosion

Hypothesis – All gullies are

Key Point – Gully and Rill erosion are caused by concentrated flows. Always treat the "problem" first – not the symptom.

Channel Erosion

- Results from:
  - Increased volume
  - Velocity
  - Duration of flow
  - Concentration of flow

- Channel erosion occurs in areas where tributaries, storm drains or culverts flow into unprotected channels

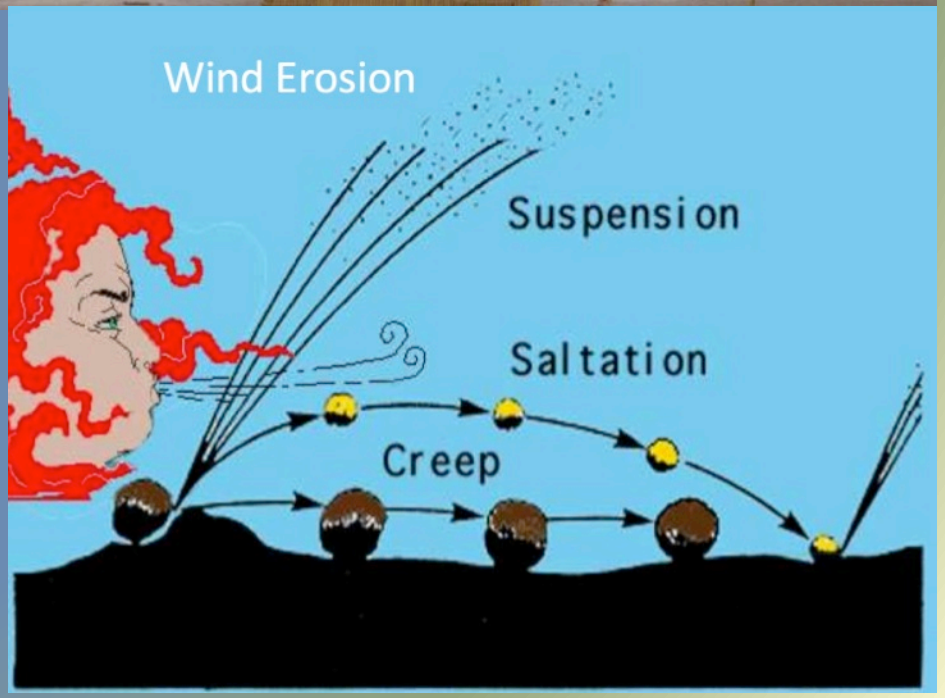
Channel Erosion

- Channel Incision
- Channel Entrenchment

Urbanization results in increases of impervious surfaces, which is reflected in incised and degraded stream channels

Wind Erosion

- Most common in arid and semi-arid regions, but can occur in any region during construction
- Occurs when wind is ≥ 8 mph above dry, bare ground
- Fine particles become suspended, coarser particles bounce and slide



Wind Erosion Control

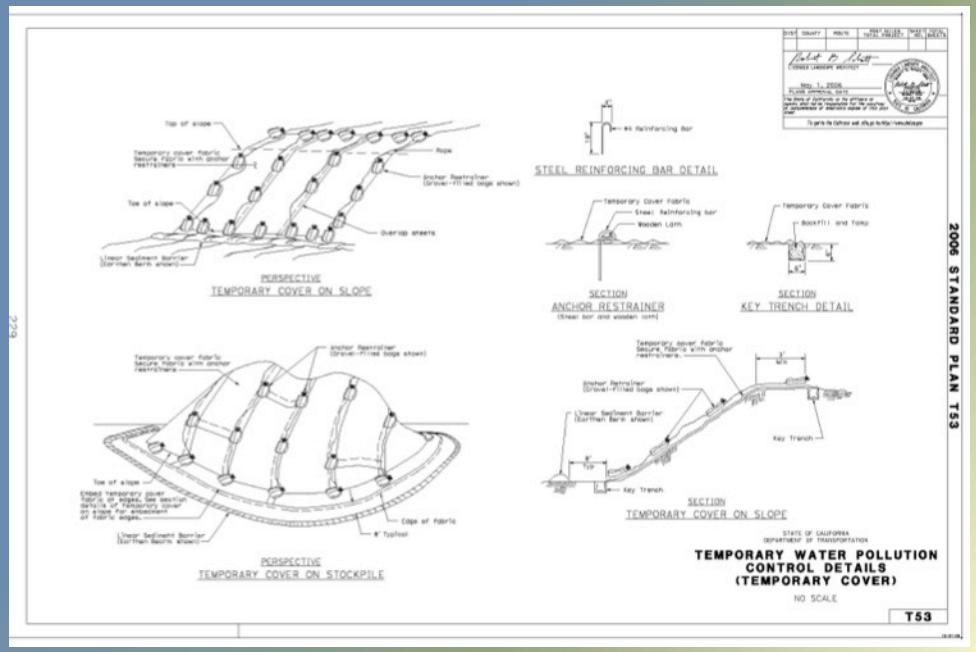
- Control system for wind erosion work in one of two ways:
  - Form a new, less erodible soil surface
  - Reduce wind speed on the soil surface

Wind Erosion Control

- Form a new, less erodible soil surface
  - Apply water to compact and weight the soil surface
  - Apply dust palliatives, binders, tackifiers, and/or hydromulch
  - Establish vegetation

Wind Erosion Control

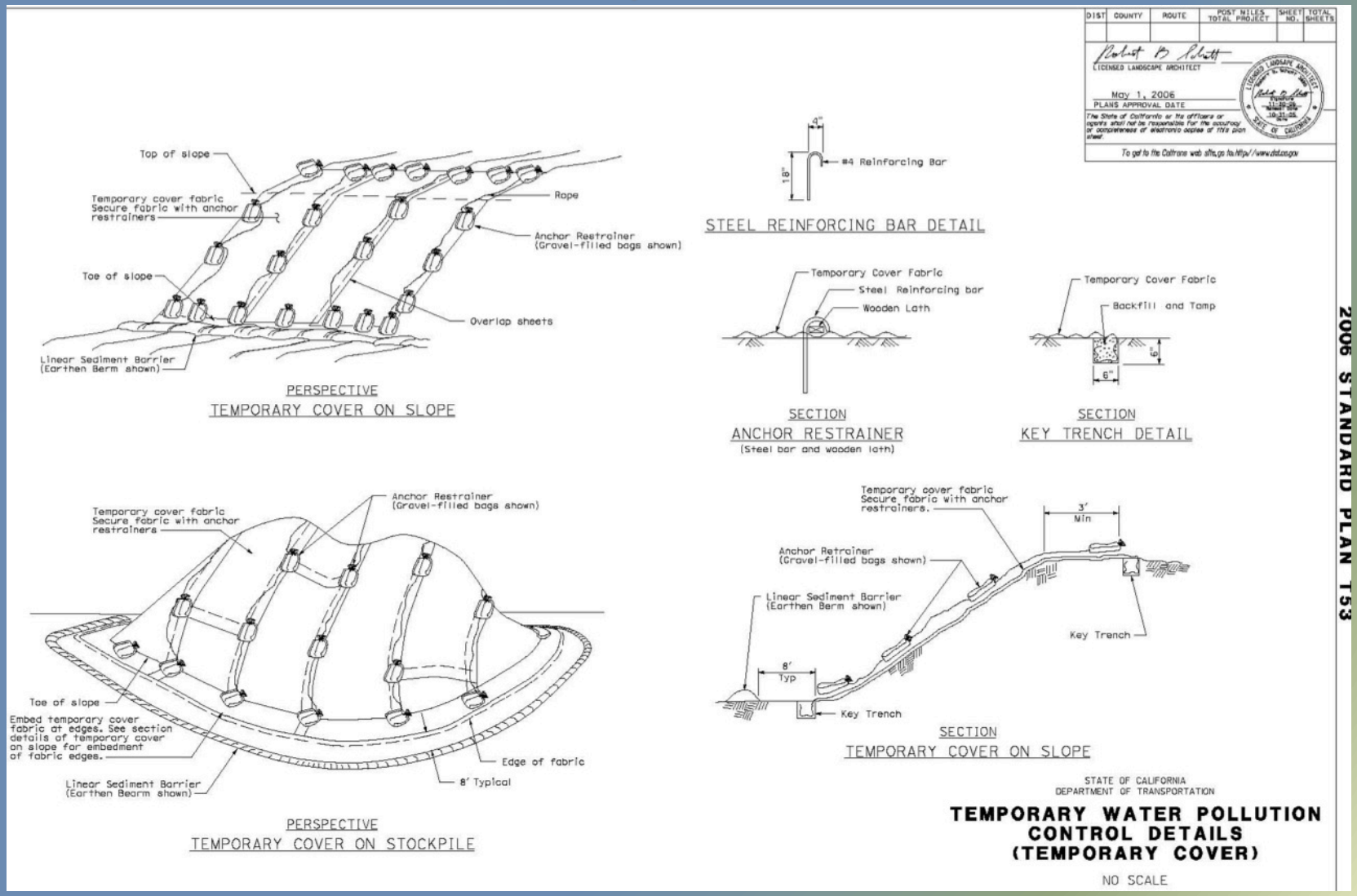
- Reduce wind speed on the soil surface
  - Cover the piles with wind-impervious fabric or geotextile
  - Change the pile orientation and shape



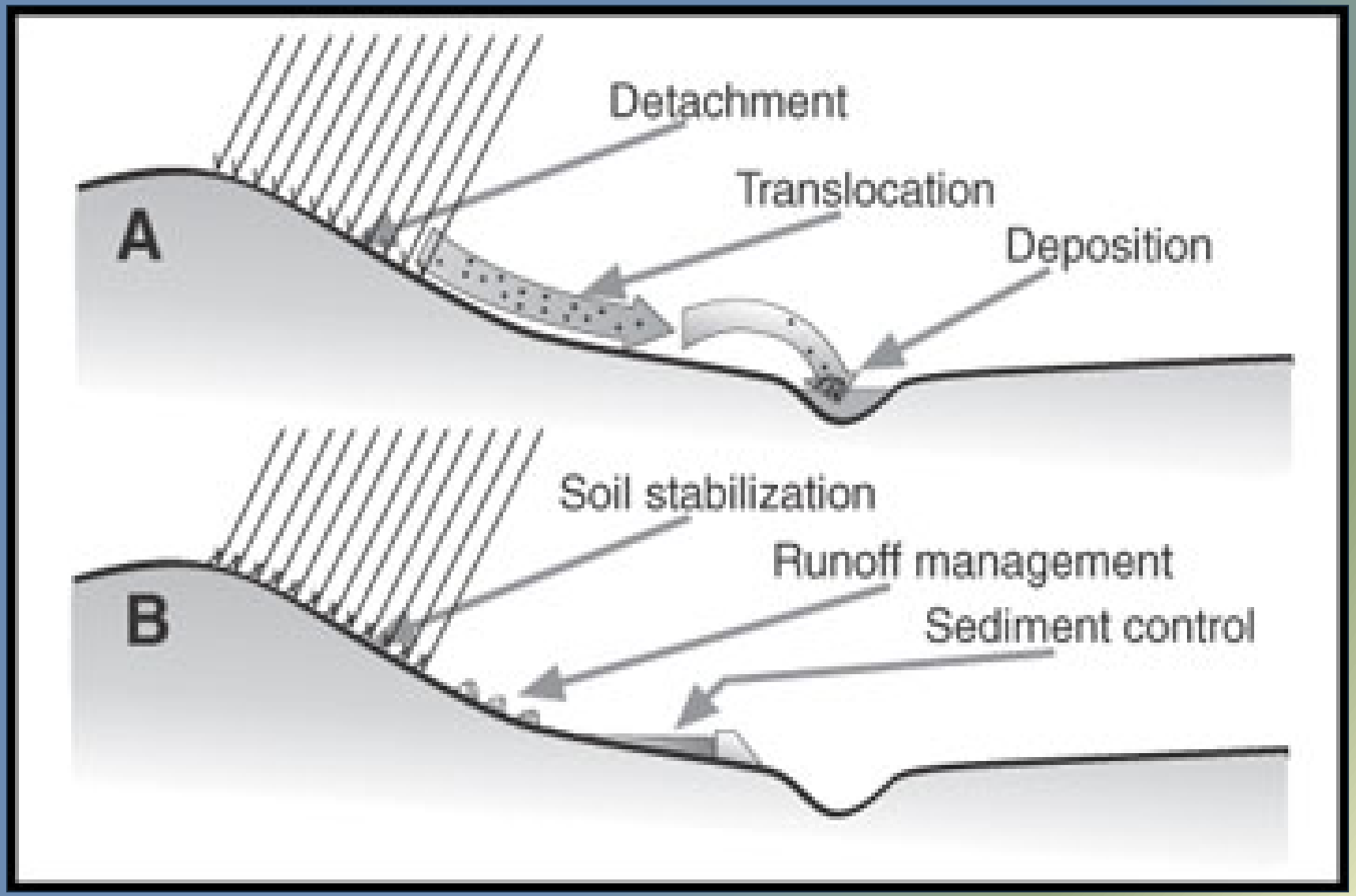
Wind Erosion Control (and Stockpile Management)

- Consider specifying and using woven geotextiles
- They can be used over and over – plastics go to landfill
- They can be anchored with pins / workers can walk on
- Woven geotextiles are semi-permeable – less runoff

SS-7 Temporary Erosion Control Blanket/Temporary Cover (Plastic Covers) (SSPs 07-390 and 07-395)



Erosion Control Principles



Planning for Effective Erosion Control

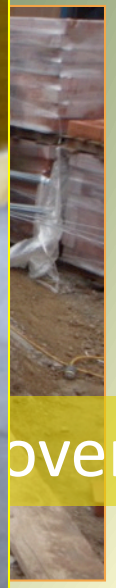
- Planning Strategies – Rules of Thumb
- Why do BMPs fail ?
- How to select appropriate BMPs

Erosion Control Strategies

DSA = Disturbed Soil Area

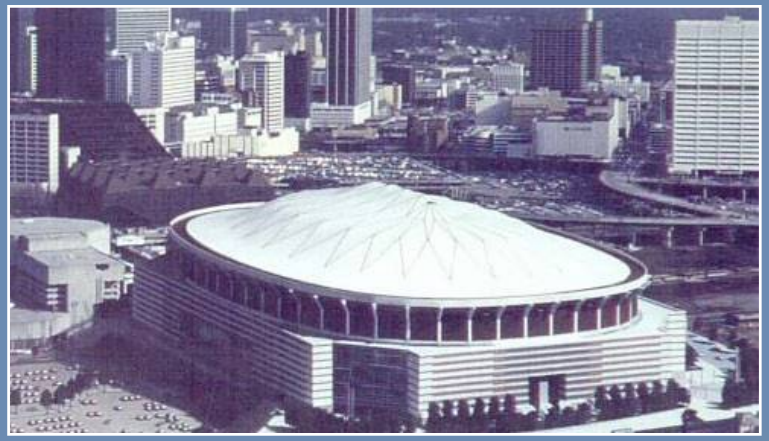
- Prevent storm water contact with the construction site
- Limit amount of disturbed soil areas (DSAs)
- Protect (DSAs) from erosion
- Minimize sediment in storm water before leaving the site
- Prevent storm water contact with other pollutants

Non-Stormwater / Housekeeping BMPs



Prevent Storm Water Contact With The Construction Site

- Storm water from the sky - Rainfall
- Storm Water from adjacent areas - Run-on



Prevent Storm Water Contact With The Construction Site

- Scheduling is a BMP that is practicable to protect DSAs from rainfall

Rainy Season

Scheduling – What is optimum grading period

- Optimum grading period is the non-rainy season, particularly for the critical areas.
- If grading extends into rainy season, minimize the length of time that soils are exposed, and the total area of exposure.
- Materials used for erosion and sediment control should be on site at all times during the rainy season.
- Consider phases of construction
  - Clearing, grading, trenching, vertical

Limit the Amount of DSA (Disturbed Soil Area)

- Limit the amount and duration that DSAs are exposed to rainfall impact, run-on and run-off and wind
- Implement temporary control practices on non-active DSAs prior to the onset of precipitation

- How much area Can be feasibly covered or treated if storms come?
- 100 ac too much!!

for Sec 404 and 401 violations

Limit the Amount of DSA (Disturbed Soil Area)

- What are some tools (BMPs) you might use to Minimize DSA?

1. Do not mass grade – think about phasing

- Think Stabilization!

1. Apply compacted aggregate road base asap ?

Phased Construction

- ✓ And the use of Temporary Surface Stabilization

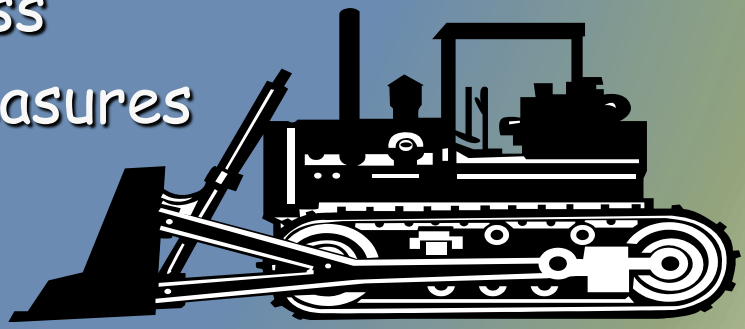
Scheduling / Phasing

- This DOT requires Erosion Control after each 2 m “lift”
- CalTrans permit requires SS for disturbed soil areas after 20 days of inactivity and 17 acres DA
- Alberta DOT requires stabilization after 4 km of highway

- Any examples from your area ?

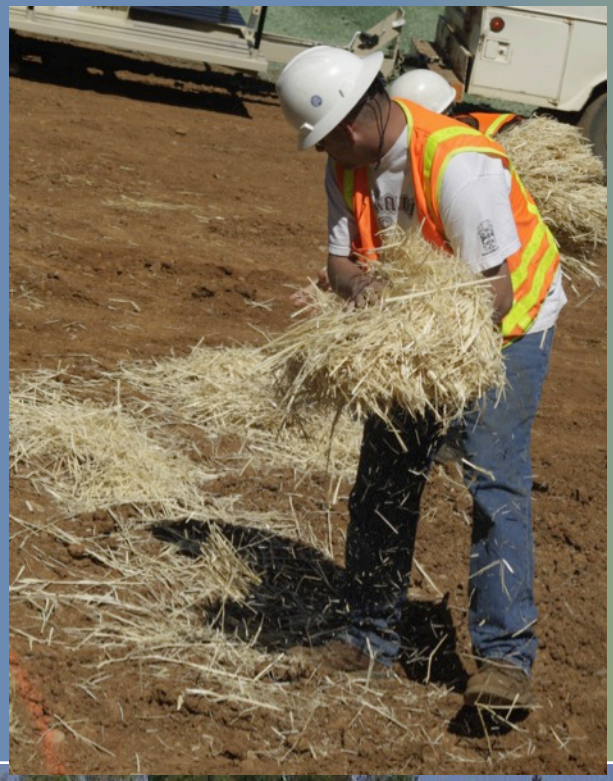
Schedule for Grading and Construction

- Recommended Sequence of Events that assure Effective Erosion and Sediment Control:
  - Stabilize Construction Access
  - Install Sediment Control Measures
  - Install Runoff Control
  - Land Clearing and Grading
  - Soils Stabilization
  - Roadway/Structure Construction
  - Highway Planting and and Final Stabilization



Protect Disturbed Soil Areas From Erosion

- BMPs to protect DSAs from erosion are:
  - Temporary soil stabilization
  - Top of slope dikes or Gravel bag Berms
  - Slope drains
  - Rolls or Corrugated Plastic Pipe



Minimize Sediment In Storm Water Before Leaving Site

- Sediment Barriers
  - Silt Fence
  - Gravelbag barrier
  - Buffer strips
  - Fiber Rolls
- Sediment/Desilting Basins and Sediment Traps
- "Site Containment"

In Summary

- **Minimize** the length of time that soils are left exposed.
- **Reduce** the total area of exposed soil during the winter season.
- **Protect** critical areas such as drainage channels, streams, and natural watercourses.
- **Stabilize** exposed areas quickly.

Special Topics In Erosion Contd.

Today we will also cover

- ~~Jr. Raindrop~~
- ~~The Caltrans Experience~~
- ~~Continuity Equation and Check dams~~
- Myth Busting
- ~~Filter Fabrics – Do they "filter"?~~
- Perimeter Controls

Perimeter Controls –

- Make sure your solution is not the problem
- Incorrectly applied perimeter control can actually increase erosion
- For example: Silt fence should not be installed up and down slope

Perimeter Controls –

- This, ≤1acre site had silt fence installed around the "perimeter"
- The fence effectively collected the sediment-laden water, directed it to lowest point – then failed

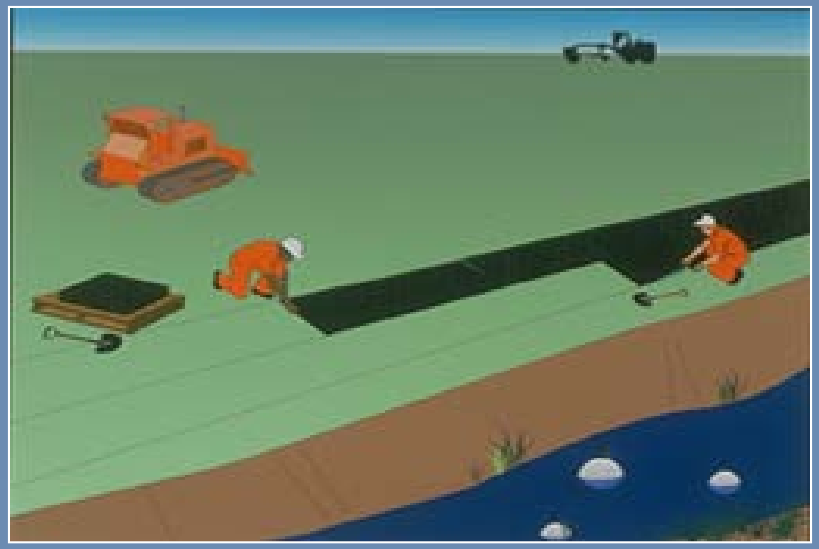
- Then became Office Depot!

Note to Self !!

- Can a sediment pond, with an embankment made from stakes and filter fabric hold and contain the runoff from 1 ac??
- Probably NOT
- What might be a better approach?
- Brainstorm with me!!

Perimeter Control

Perimeter Controls



Vegetated Filter Strip (GOOD)

Silt Fence as a Perimeter Control around the entire site is probably not an effective strategy. And maybe a gross waste of $$. ?

Leave a Buffer Strip

- ADVANTAGES
  - Shields soil surfaces from rainfall impact
  - Root systems reduce erosion by holding soil in place.
  - Reduces runoff velocities and helps drop out sediment.
  - Maintains the soil's capacity to absorb water
  - Maybe avoid installing silt fence

EP-3 Minimize Disturbance and Buffer Strip

- Natural vegetative cover on project sites and vegetative strips along waterways are retained as much as possible
- Soil disturbance is limited to areas immediately needed for construction
- A healthy dense buffer strip can:
  - Greatly reduce the need for alternative sediment control barriers such as silt fence/fiber rolls
  - Filter polluted sheet flow from exposed soil areas

According to a 2002 Caltrans Study of highway shoulders, a 6 foot-wide grass buffer strip removed approximately 85% of pollutants and suspended sediment from contaminated highway runoff.

Perimeter Controls

- 44% to 88% TSS removal rates by 2-3 m of existing vegetative area

EVALUATION OF STORM WATER TREATMENT BY VEGETATED AREAS ADJACENT TO HIGHWAYS, 2003, Misty Scharff, et.al.

Why Do BMPs Fail to be effective ?

1. The wrong practice was chosen for the type of control needed and/or located wrong– incorrect **A**pplication
2. The practice was not installed properly - inadequate **I**nstallation
3. The practice was not inspected nor maintained – not **M**aintained

Take **AIM**

BMP Selection

- It helps to distinguish between or categorize the types of controls needed
  - EARTHWORKS / SOIL PREPARATION – It is important to prepare, de-compact, rip, roughen…
  - EROSION CONTROL – raindrop and sheet erosion processes
  - RUNOFF CONTROL – flowing water, measures which resist the tractive forces of flowing water
  - SEDIMENT CONTROL – always requires the ponding of water to separate sediment from water

BMP Tool Box

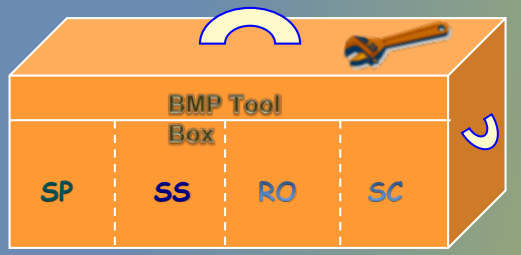
Choose the correct BMP for the type of control needed

- If you choose from the correct category you'll have an effective BMP

Mulch or Cover for Raindrop Impact

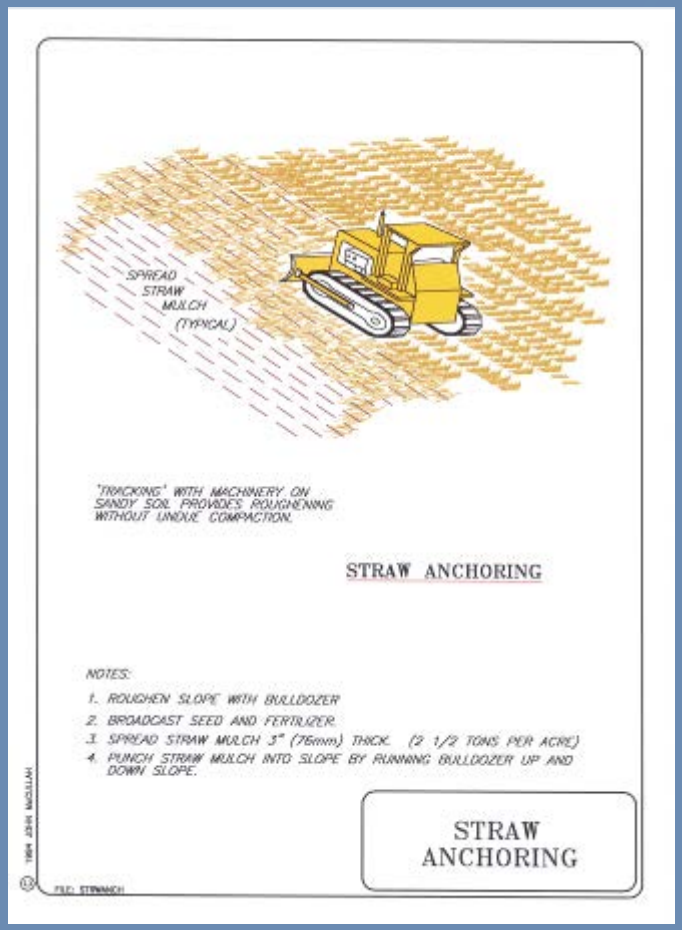
- Name some that you like
  - Straw Mulch
  - ECBs
  - Hydromulch
  - Compost Blankets

Sometimes combining tool from the categories provides the BEST erosion Control



Effective Combination – Free Tip

Track Walking =
52% reduction



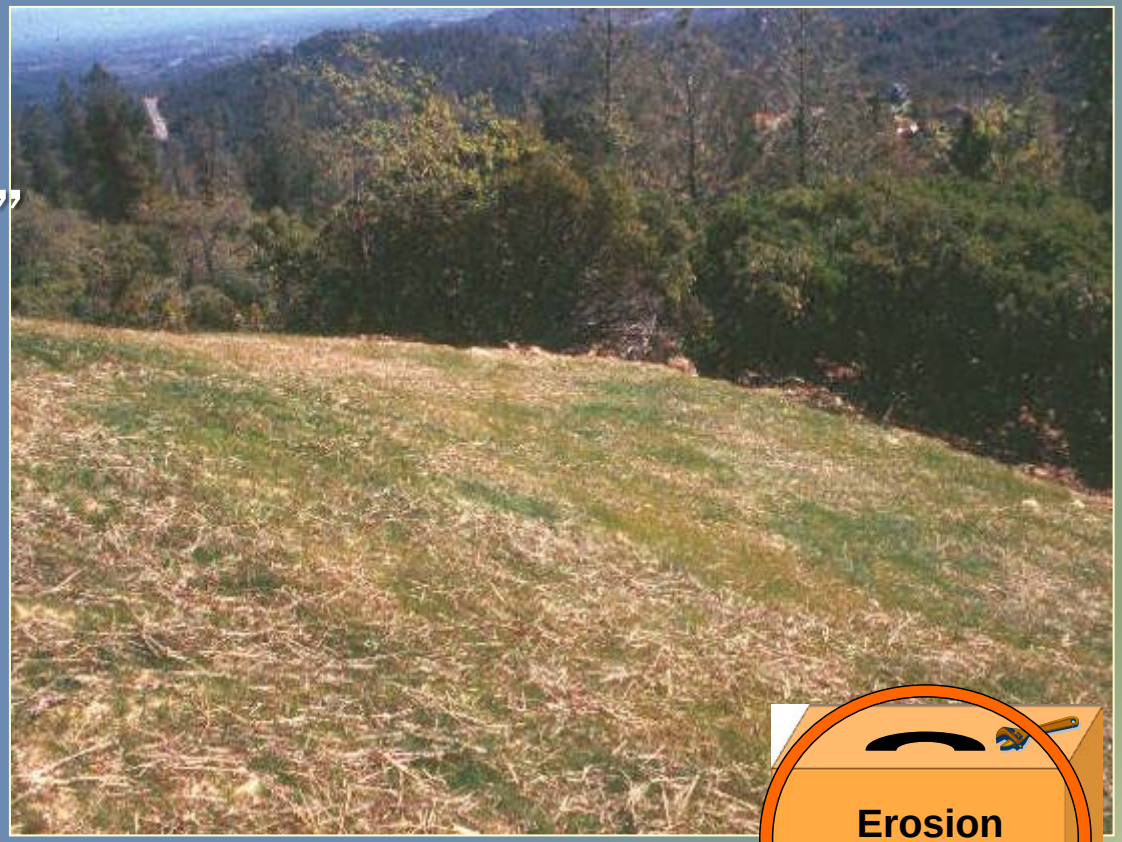
+

Straw Mulching = 90 %
erosion effectiveness

Effective Combination – Free Tip

90% + 52% = 148% reduction in erosion rates!!

The soil "falls" back onto the slope !!



Planning for Effective Erosion Control

- How to select appropriate BMPs

Table 8-2
EROSION AND SEDIMENT CONTROL BMPs
INSTALLED COSTS AND EFFECTIVENESS

BMP	Unit Cost Installed	Estimated Relative Erosion/ Sediment Control Effectiveness
Sediment Control		
Silt Fence:	$1.50 – 2.00 per linear foot	UNK
Fiber Rolls:	$1.50 – 2.00 per linear foot	58%
Erosion Control		
Fertilizer	$450 – 550 per acre	N/A
Seeding	$870 – 2,170 per acre	50%
Stabilizing	$2,200 per acre + cost of solutions	90%
Hydraulic Mulching	$900 – 1,200 per acre	50 – 60%
Compost Application	$900 – 1,200 per acre	40 – 50%
Straw Mulching	$1,800 – 2,100 per acre	90 – 95%
Soil Binders:		
Plant Material-Based (Short-Term)	$700 – 900 per acre	80 – 85%
Plant Material-Based (Long-Term)	$1,200 – 1,500 per acre	60 – 65%
Polymeric Emulsion Blends	$700 – 1,500 per acre	30 – 70%
Petroleum Resin-Based	$1,200 – 1,500 per acre	25 – 20%
Cementitious Binder-Based	$800 – 1,200 per acre	80 – 85%
Bonded Fiber Matrices:	$5,000 – 6,500 per acre	90 – 95%
Rolled Erosion Control Products:		
Biodegradable:		
Jute:	$6,000 – 7,000 per acre	65 – 70%
Curled Wood Fiber	$8,000 – 10,500 per acre	85 – 90%
Straw	$8,000 – 10,500 per acre	85 – 90%
Wood Fiber	$8,000 – 10,500 per acre	85 – 90%
Coconut Fiber	$13,000 – 14,000 per acre	90 – 95%
Coconut Fiber Net	$30,000 – 33,000 per acre	85 – 90%
Straw Coconut	$10,000 – 12,000 per acre	90 – 95%
Non-Biodegradable:		
Plastic Netting	$2,000 – 2,200 per acre	< 50%
Plastic Mesh	$3,000 – 3,500 per acre	75 – 80%
Synthetic Fiber w/Netting	$34,000 – 40,000 per acre	90 – 95%
Bonded Synthetic Fibers	$45,000 – 55,000 per acre	90 – 95%
Combination Synthetic and Biodegradable Fibers	$30,000 – 36,000 per acre	85 – 90%

Source: Erosion Control Pilot Study Report, URS Greiner Woodward Clyde, June 2000, Table 4-1

Erosion Control BMP Selection Criteria

Cost and Effectiveness

TEMPORARY SOIL STABILIZATION CONTROL CRITERIA

CLASS	TYPE	Antecedent Moisture	Availability	Ease of Clean-Up	Installed Cost Per Acre	Degradability	Length of Drying Time (hrs)	Time to Effectiveness (days)	EC Effectiveness (%)	Longevity	Mode of Application	Residual Impact	Native	Runoff Effect	Water Quality Impact
CATEGORY:	STANDARD BIODEGRADABLE MULCHES (SBM)														
Straw Mulch	Wheat Straw	D	S	H	$2,100	B	0	1	90-95	M	L/M	M		+	*
	Rice Straw	D	S	H	$2,100	B	0	1	90-95	M	L/M	M		+	*
Wood Fiber Mulch	Wood Fiber	D	S	H	$900	B	0-4	1	50-60	M	H	L		+	*
Recycled Paper Mulch	Cellulose Fiber	D	S	H	$900	B	0-4	1	50-60	S	H	L		+	*
Bonded Fiber Matrix	Biodegradable	D	S	H	$6,000	B	12-18	1	90-95	M	H	M		+	*
CATEGORY:	ROLLED EROSION CONTROL PRODUCTS (RECP)														
Biodegradable	Jute Mesh	D	S	H	$6,500	B	0	1	85-70	M	L	M		+	*
	Curled Wood Fiber	D	S	H	$10,500	X	0	1	85-90	M	L	M		+	*
	Straw	D	S	H	$8,900	B	0	1	85-90	M	L	M		+	*
	Wood Fiber	D	S	H	$8,900	X	0	1	85-90	M	L	M		+	*
	Coconut Fiber	D	S	H	$13,000	B	0	1	90-95	L	L	M		+	*
	Coconut Fiber Mesh	D	S	H	$31,000	B	0	1	85-90	L	L	M		+	*
	Straw Coconut	D	S	H	$11,000	B	0	1	90-95	L	L	M		+	*
Non-Biodegradable	Plastic Netting	D	M	H	$2,000	P	0	1	<50	L	L	H		+	UNK
	Plastic Mesh	D	M	H	$3,300	P	0	1	75-80	L	L	H		+	UNK
	Synthetic Fiber with Netting	D	M	H	$86,000	P	0	1	90-95	L	L	H		+	UNK
	Bonded Synthetic Fibers	D	M	H	$121,000	P	0	1	90-95	L	L	H		+	UNK
	Combination with Biodegradable	D	M	H	$79,000	P	0	1	85-90	L	L	H		+	UNK
CATEGORY:	TEMPORARY SEEDING (TS)														
High-Density	Ornamental species		S-M	H	$1000 - $4000		0-4	28	50-60	M-L	H	L-M	N/E	+	UNK
	Turf species		S	H	$900		0-4	28	50-60	L	H	M-H	N/E	+	UNK
	Bunch species		S-M	H	$750 - $3200		0-4	28	50-60	L	H	L-M	N	+	UNK
Fast-Growing	Annual		S	H	$900 - $1,600		0-4	28	50-60	L	H	L-H	N/E	+	UNK
	Perennial		S	H	$800 - $2000		0-4	28	50-60	L	H	M	N/E	+	UNK
Non-Competing	Native		S-M	H	$700 - $4000		0-4	28	50-60	L	H	L-M	N	+	UNK
	Non-Native		S-M	H	$1000 - $1200		0-4	28	50-60	L	H	L-H	E	+	UNK
Sterile	Cereal Grain		S	H	$1,200		0-4	28	50-60	L	H	L	E	+	UNK
CATEGORY:	IMPERVIOUS COVERS (IC)														
Plastic	Visqueen		S	H	$17,000	P		1	100	M	L	H		-	UNK
	Woven Geotextile		S	H	$14,800	P		1	90-95	M	L	H		-	UNK
CATEGORY:	HYDRAULIC SOIL STABILIZERS (HSS)														
(PBS) Plant Material Based- Short Lived	Guar	D	S	H	$1,000	B	12-18	Same as Length of Drying Time (hrs	80-85	S	B	L		0	M
	Psyllium	F	S	H	$1,000	B	12-18		30-35	M	B	L		-	L
	Starches	D	S	H	$1,000	B	6-12		IP	S	H	L		IP	IP
(PBL) Plant Material Based- Long Lived	Pitch/ Rosin	D	S	M	$3,000	B	19-24		60-65	M	B	M		-	M
(PEB) Polymeric Emulsion Blends	Acrylic polymers and copolymers	D	S	M	$3,000	P/C	19-24		60-70	L	B	M		-	L
	Methacrylates	D	M	M	$1,000	P/C	12-18		IP	S	W	L		IP	IP
	Na acrylates	D	M	M	$1,000	P/C	12-18		30-70	S	H	L		+/-	M/L
	Polyacrylamide	D	M	M	$1,000	P/C	4-8		IP	M	H	L		IP	IP
	Hydro-colloid polymers	D	M	H	$1,000	P/C	0-4		35-40	M	H	L		+	M
(PRB) Petroleum/ Resin- Based	Petroleum Resin	D	M	L	$3,000	P/C	0-4		15-20	M	B	M		-	H
(CBB) Cementitious Binder- Based	Gypsum	D	S	M	$2,000	P/C	4-8		80-85	M	H	L		-	H

= not applicable for category, class or type

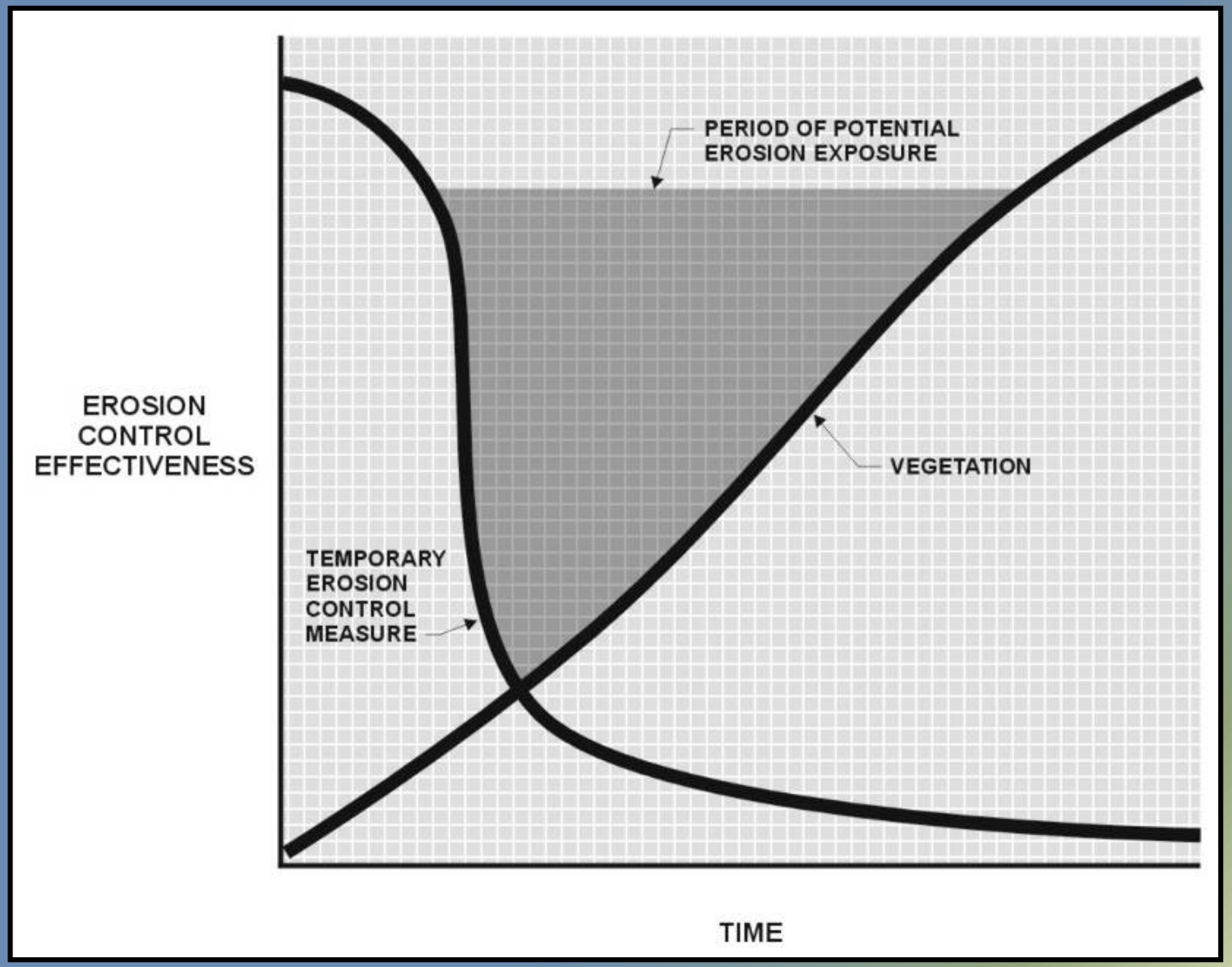
Erosion Control BMP Selection Criteria

CLASS	TYPE	Antecedent Moisture	Availability	Ease of Clean-Up	Installed Cost Per Acre	Degradability	Length of Drying Time (hrs)	Time to Effectiveness (days)	EC (Effectiveness (%)	
CATEGORY:	STANDARD BIODEGRADABLE MULCHES (SBM)									
Straw Mulch	Wheat Straw	D	S	H	$2,100	B	0	1	90-95	M
	Rice Straw	D	S	H	$2,100	B	0	1	90-95	M
Wood Fiber Mulch	Wood Fiber	D	S	H	$900	B	0-4	1	60-90	M
Recycled Paper Mulch	Cellulose Fiber	D	S	H	$900	B	0-4	1	50-90	S
Bonded Fiber Matrix	Biodegradable	D	S	H	$6,000	B	12-18	1	90-95	M
CATEGORY:	ROLLED EROSION CONTROL PRODUCTS (RECP)									
Biodegradable	Jute Mesh	D	S	H	$6,500	B	0	1	65-70	M
	Curled Wood Fiber	D	S	H	$10,500	X	0	1	85-90	M
	Straw	D	S	H	$8,900	B	0	1	85-90	M
	Wood Fiber	D	S	H	$8,900	X	0	1	85-90	M
	Coconut Fiber	D	S	H	$13,000	B	0	1	90-95	L
	Coconut Fiber Mesh	D	S	H	$31,000	B	0	1	85-90	L
	Straw Coconut	D	S	H	$11,000	B	0	1	90-95	L
Non-Biodegradable	Plastic Netting	D	M	H	$2,000	P	0	1	~50	L
	Plastic Mesh	D	M	H	$3,300	P	0	1	75-90	L
	Synthetic Fiber with Netting	D	M	H	$6,000	P	0	1	90-95	L
	Bonded Synthetic Fibers	D	M	H	$121,000	P	0	1	90-95	L
	Combination with Biodegradable	D	M	H	$70,000	P	0	1	85-90	L
CATEGORY:	TEMPORARY SEEDING (TS)									

- Hydromulch (BFM+) = 90-95%
- Straw Mulch = 90-95%
- Erosion Control Blankets = 85-95% *

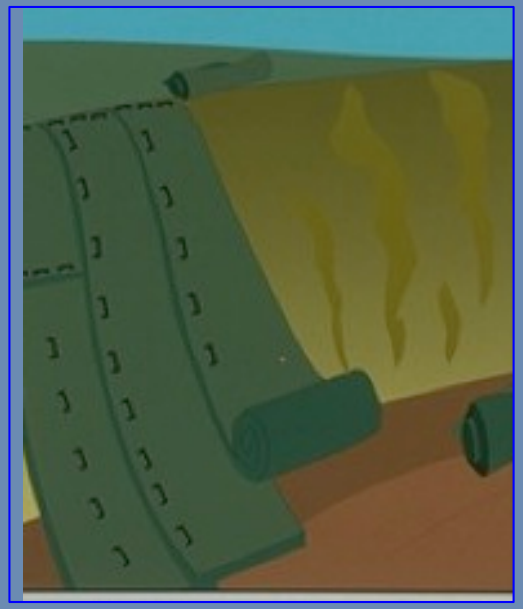
* Note that Jute Mesh is 65-70% **WHY ?**

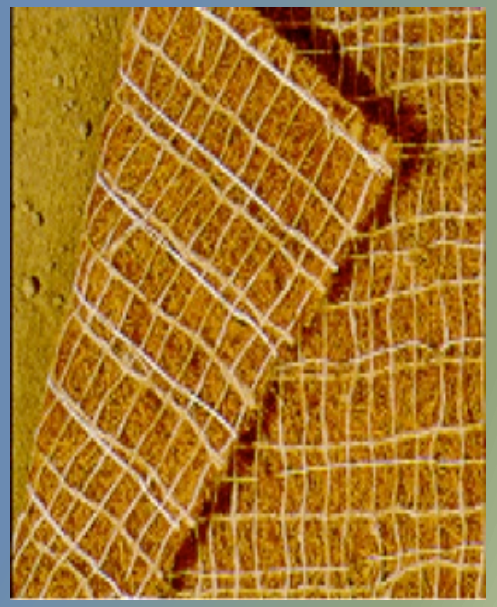
Longevity and Duration of Need



Erosion Control BMP Selection Criteria

- Environmental Considerations – only biodegradable materials allowed
- Soil Surface – rocky, well-groomed, caliche
- How will material be anchor





Erosion Control BMP Selection Criteria

- What if can't trench for silt fence?

Hwy 101 Windsor CA

- DFW Warden arrested CalTrans RE and Contractor

- Finally agreed to Compost Berms in lieu of silt fence

- Berm doesn't need removal

Review of This Module

- The Selection of effective BMPs is dependent on many variables.
- It is very complicated, like brain surgery
- Planning for EC - Minimizing the exposure of DSA is the "name of the game"
- Perimeter Controls refer to the areas where pollutants can leave construction site, NOT the physical boundary.

After 24 days seeded w/ Annual Rye (BAD)

The remainder of this Course will focus on Erosion and Sediment Control BMPs

Compost

- Berms, Compost Socks and Compost Blankets

Compost Berm and Blanket – 8" in 4 hr storm

Compost and 8" storm