Dirt Cheap: The Cost Of Erosion (Why Be Compliant?)

Erosion costs you money with every rain event

Eddie Snell
Applied Polymer Systems, Inc.

What If There Were No Rules Requiring Erosion And Sediment Mitigation?

What If There Were No Rules Requiring Erosion And Sediment Mitigation?

Like: Back In The Day

Operating Costs:

- Equipment costs (rental/depreciation)
- Fuel
- Operators
- Site Delivery (soil)
- Labor
- Insurance
- Inspection/Survey

Road Construction Design Cost Estimates

USDA
United States Department of Agriculture

Forest Service
Intermountain
Southwestern
Rocky Mountain
Regions
Engineering

Cost Estimating Guide for Road Construction

March 2012

Cost Estimating Guide for Road Construction

OCTOBER 2017

USDA FOREST SERVICE NORTHERN REGION ENGINEERING

2017

FDOT

Florida Department of Transportation

RICK SCOTT
GOVERNOR

605 Suwannee Street
Tallahassee, FL 32399-0450

ANANTH PRASAD
SECRETARY

ROADWAY DESIGN BULLETIN 14-17

(FHWA Approved: November 18, 2014)

DATE: November 18, 2014

TO: District Directors of Transportation Development, District Directors of Operations, District Design Engineers, District Consultant Project Management Engineers, District Construction Engineers, District Structures Design Engineers, District Traffic Operations Engineers, District Planning and Environmental Managers, Program Management Engineers

FROM: Michael Shepard, P. E., State Roadway Design Engineer
Marjorie Kirby, Manager, Environmental Management Office

COPIES: Brian Blanchard, Tom Byron, Duane Brautigam, David Sadler, Tim Lattner, Mark Wilson, Bruce Dana, John Krause, Greg Schiess, Nicholas Finch (FHWA), Chad Thompson (FHWA) and Phillip Bello (FHWA)

SUBJECT: Urban Arterial Lane Width and Bicycle Lane Options

This bulletin modifies the criteria for Urban Arterial Travel Lane Width, Bicycle Lane Facilities and related Bicycle Lane Markings. Specifically, this bulletin establishes eleven foot travel lanes for roadways with a divided typical section in or within one mile of an urban area and with a Design Speed of 45 mph or less. This bulletin also establishes seven foot Buffered Bicycle Lanes as the standard for marked bike lanes.

REQUIREMENTS

Plans Preparation Manual (PPM) Revisions:

1. **Replace PPM, Volume 1, Sections 2.1.1 and 2.1.2** with the following:

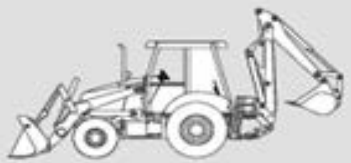
2.1.1 Travel Lanes and Auxiliary Lanes

Standard practice is to provide lane widths that are consistent with AASHTO Guidelines. See ***Table 2.1.1***. Auxiliary lanes for speed change, turning and storage, and other purposes supplementary to through-traffic movement should be of the same width as the through lanes.

www.dot.state.fl.us

Deere 410C (discontinued 1992)
Tractor-Loader-Backhoes

Size Class:
Max. Backhoe Digging Depth: 14' to Under 15'
Weight:
14,400 lbs.



See more data for this model:
Custom Cost Evaluator
Green Guide
Last Bid
Serial Number Guide

Blue Book Rates

Rate Effective Dates: Always Use Current Rate

printable report

	Ownership Costs				Estimated Operating Costs	FHWA Rate
	Monthly	Weekly	Daily	Hourly	Hourly	Hourly
Published Rates	$1,955.00	$545.00	$135.00	$20.00	$19.85	$30.96
Adjustments						
Region (Missouri: 97.8%)	-$43.01	-$11.99	-$2.97	-$0.44		
Model Year (1989: 98.3%)	-$32.50	-$9.06	-$2.24	-$0.33		
Ownership (100%)	-	-	-	-		
Operating (100%)					-	
Total:	**$1,879.49**	**$523.95**	**$129.79**	**$19.23**	**$19.85**	**$30.53**

For details, see Rate Element Allocation

Adjustments

Model Year: 1989

Region: Missouri
Canadian Regions Alaskan Regions

User Defined

Ownership: %

Table 33. Variable Haul Cost ($/Cubic Yard-Mile and $/Ton-Mile) by Truck Type for Idaho And Montana

mph	Idaho 10-12 CY End Dump $/CY-Mile	Idaho 10-12 CY End Dump $/Ton-Mile	Idaho 18 CY Bottom Dump $/CY-Mile	Idaho 18 CY Bottom Dump $/Ton-Mile	Montana 10-12 CY End Dump $/CY-Mile	Montana 10-12 CY End Dump $/Ton-Mile	Montana 18 CY Bottom Dump $/CY-Mile	Montana 18 CY Bottom Dump $/Ton-Mile
10	$2.74	$2.03	$1.60	$1.19	$2.92	$2.16	$1.70	$1.26
15	$1.82	$1.35	$1.07	$0.79	$1.94	$1.44	$1.14	$0.84
20	$1.37	$1.01	$0.80	$0.59	$1.46	$1.08	$0.85	$0.63
25	$1.09	$0.81	$0.64	$0.47	$1.17	$0.86	$0.68	$0.51
30	$0.91	$0.68	$0.53	$0.40	$0.97	$0.72	$0.57	$0.42
40	$0.68	$0.51	$0.40	$0.30	$0.73	$0.54	$0.43	$0.32
50	$0.55	$0.41	$0.32	$0.24	$0.58	$0.43	$0.34	$0.25

The *total haul cost* is the sum of the variable costs plus fixed costs.

$$Total\ Haul\ Cost = Total\ Variable\ Cost + Total\ Fixed\ Costs$$

Haul Calculation Example

Given: Montana Zone 1
10-12 End Dump, 30 mph, 5 mile haul
500 LOOSE CY

Road Segment	Average Speed Roundtrip (mph)	Length (Miles)	$/Cubic Yard-Mile ($/Ton-Mile)	Loose CY (Tons)	Variable Cost
MP 5.0	30	5	$0.97	500	$2425

$$Fixed\ Cost = 500\ CY\ x\ \$2.43 = \$1215$$

$$Total\ Haul\ Cost = \$2425 + 1215 = \$3640$$

$$Unit\ Haul\ Cost = \frac{\$3640}{500\ CY} = \$7.28/CY$$

$$Engineers\ Estimated\ Unit\ Cost = \frac{\$}{CY}\ x\ ADJUSTMENT\ FACTOR\ FOR\ PUBLIC\ WORKS\ DAVIS - BACON\ ZONES$$

$$Engineers\ Estimated\ Unit\ Cost = \$7.28\ x\ 0.97 = \$7.06$$

$$Specified\ Road\ Unit\ Cost = \frac{\$/CY}{ADJUSTMENT\ FACTOR\ FOR\ CONSTRUCTION\ WAGE\ RATE\ DIFFERENTIALS}$$

$$Specified\ Road\ Unit\ Cost = \frac{\$7.06}{1.12} = \$6.30$$

Table 12 - Graders, Motor: (Basic machine plus EROPS and rear scarifiers):

Model	Engine	Moldboard size	Hourly Rate ($)		
	HP	Feet	AZ, NM, UT	CO, ID, KS, NE, NV	CA, SD, WY
Caterpillar 120H 12' 125hp	125	12	39.93	68.22	39.93
Caterpillar 12H 12' 145hp	145	12	45.54	78.77	45.54
Deere 770C II 12' 155hp	155	12	52.25	92.09	52.25
Caterpillar 14H 14' 220hp	220	14	69.36	133.27	69.36
Caterpillar 16H 16' 285hp	285	16	88.50	173.60	88.50

Table 13 – Hydraulic Excavators: Crawler mounted tractor, with thumb, diesel powered:

Model	Capacity	Weight	Hourly Rate ($)		
	Cubic Yards	Tons	AZ, ID, NM, UT	CO, KS, NE, NV	CA, SD, WY
Caterpillar 312C L 0.68cy 90 hp	0.68	14	73.69	75.76	79.16
Caterpillar 315C L 0.77cy 110 hp	0.77	18	87.30	89.70	93.65
Caterpillar 320C L 1.25 cy 138 hp	1.25	23	114.66	117.80	122.99
Caterpillar 325C L 1.5 cy 186 hp	1.25	30	134.18	137.62	143.31
Caterpillar 330C L 2.25 cy 244 hp	2.25	38	161.56	165.58	172.23
Caterpillar 345B L Series II 2.5 cy 321 hp	2.50	49	234.97	241.08	251.14
Caterpillar 365B L Series II 3.61 cy 404 hp	3.60	75	298.04	305.62	318.13
Caterpillar 385B L 6.0 cy 513 hp	6.00	94	390.60	400.95	418.03

Table 14 - MINI – Hydraulic Excavators: Crawler mounted tractor, diesel powered:

Model	Capacity	Hourly Rate ($)		
	Cubic Yards	AZ, ID, NM, UT	CO, KS, NE, NV	CA, SD, WY
Deere 17ZTS(ROPS) 0.05cy bucket 12.3hp	0.05	11.60	11.88	12.36
CAT 303.5C CR Cab 0.27cy bucket 22.9hp	0.07	23.17	23.74	24.69

Table 29 - Pickups and flatbeds:

Axle Configuration	Capacity		Hourly Rate ($)	
	Cubic Yards	AZ,ID,NM,UT	CO,KS,NE,NV	CA,SD,WY
4x2	5-6	44.80	45.43	46.35
6x4	8-10	69.91	70.80	72.10
6x4	10-12	87.73	88.86	90.52
6x4	12-18	94.66	96.03	98.04

Table 30 - Rear dump, highway type, diesel powered:

Axle Configuration	Capacity		Hourly Rate ($)	
	Cubic Yards	AZ,ID,NM,UT	CO,KS,NE,NV	CA,SD,WY
4x2	5-6	44.80	45.43	46.35
6x4	8-10	69.91	70.80	72.10
6x4	10-12	87.73	88.86	90.52
6x4	12-18	94.66	96.03	98.04

Table 31 - Water tankers, highway:

Fuel	Capacity		Hourly Rate ($)	
	Gallons	AZ,ID,NM,UT	CO,KS,NE,NV	CA,SD,WY
Gasoline	1500	47.36	47.90	48.69
Gasoline	2500	48.47	49.06	49.91
Diesel	2500	36.49	37.11	38.02
Diesel	3000	44.16	44.90	45.98
Diesel	3500	57.84	58.74	60.06
Diesel	4000	65.67	66.91	68.71

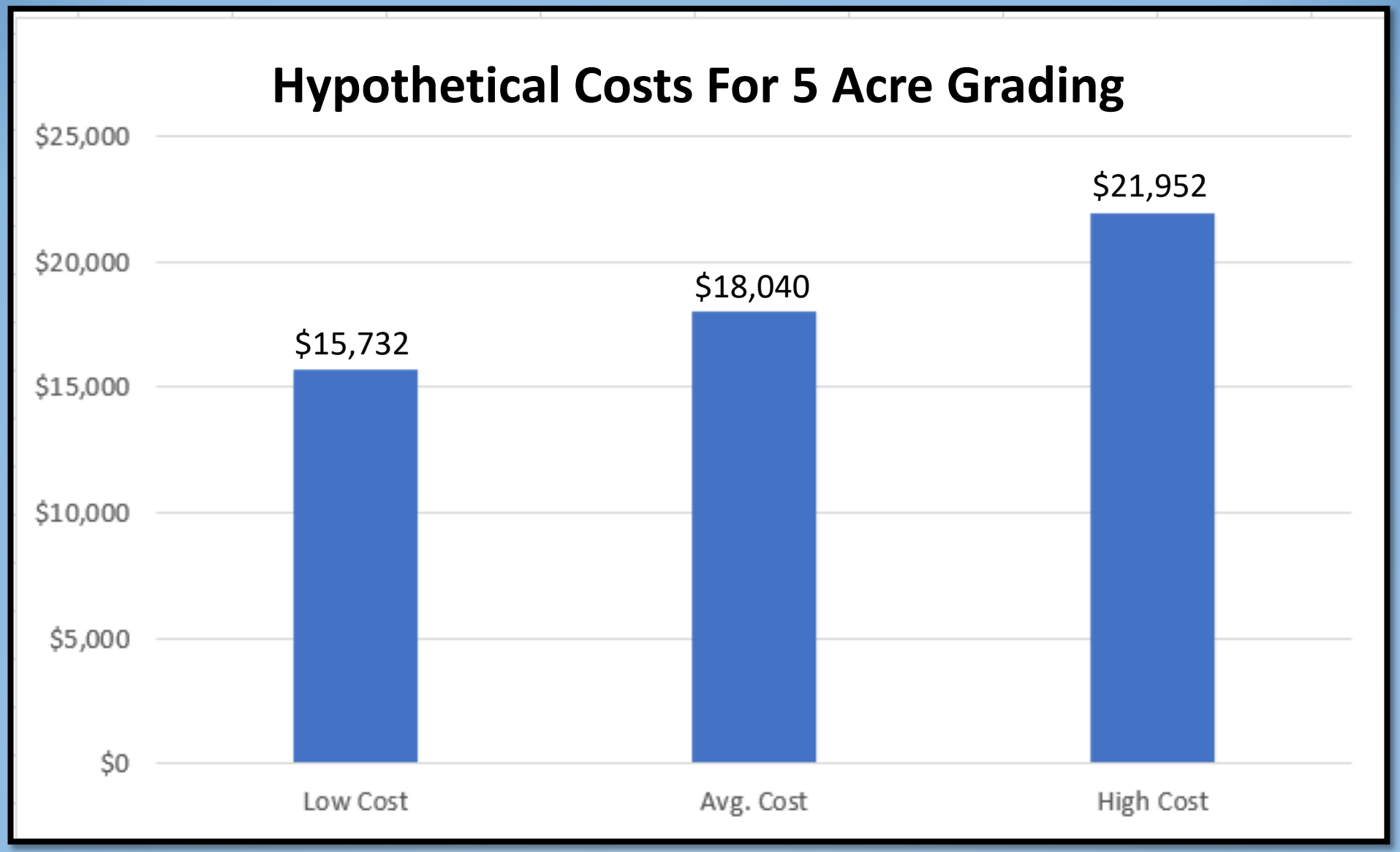
Hypothetical Costs: 5 acre area/2 days

- 2 Dozers
- 2 Compactors
- 1 Grader
- 2 Dump Trucks
- 7 Operators
- 6 Laborers
- 5 Loads of Fill Soil

Equipment	Number	Unit Cost/Hr.	Subtotal/Hr.	x 8 Hrs.	2 Day Cost
Dozer	2	65	130	1040	2080
Compactor	2	50	100	800	1600
Grader	1	50	50	400	800
Dump Truck	2	55	110	880	1760
Equipment Operators	7	46	322	2576	5152
Laborers	6	40	240	1920	3840
Fill Dirt	5	100	500	500	500
LOW TOTAL			$1,452	$8,116	$15,732

Equipment	Number	Unit Cost/Hr.	Subtotal/Hr.	x 8 Hrs.	2 Day Cost
Dozer	2	70	140	1120	2240
Compactor	2	62	124	992	1984
Grader	1	75	75	600	1200
Dump Truck	2	65	130	1040	2080
Equipment Operators	7	50	350	2800	5600
Laborers	6	41	246	1968	3936
Fill Dirt	5	200	1000	1000	1000
AVG. TOTAL			$2,065	$9,520	$18,040

Equipment	Number	Unit Cost/Hr.	Subtotal/Hr.	x 8 Hrs.	2 Day Cost
Dozer	2	75	150	1200	2400
Compactor	2	80	160	1280	2560
Grader	1	90	90	720	1440
Dump Truck	2	70	140	1120	2240
Equipment Operators	7	65	455	3640	7280
Laborers	6	42	252	2016	4032
Fill Dirt	5	400	2000	2000	2000
HIGH TOTAL			$3,247	$11,976	$21,952


Hypothetical Costs For 5 Acre Grading
$25,000
$20,000
$15,000
$10,000
$5,000
$0
$15,732
$18,040
$21,952
Low Cost
Avg. Cost
High Cost

PREDICTING SOIL LOSS

THE REVISED UNIVERSAL SOIL LOSS EQUATION (RUSLE)

$$A = R \times K \times L \times S \times C \times P$$

<u>There are 6 major factors affecting soil loss according to the RUSLE:</u>

A = Average annual soil loss (tons/acre)
R = Rainfall erosion index (100 ft. tons/acre-in/hour)
K= Soil erodibility factor (soil survey data)
L = Slope length factor (dimensionless)
S = Slope gradient factor (dimensionless)
C = Vegetative cover factor (dimensionless)
P = Erosion control practices factor (contractor)

PREDICTING SOIL LOSS

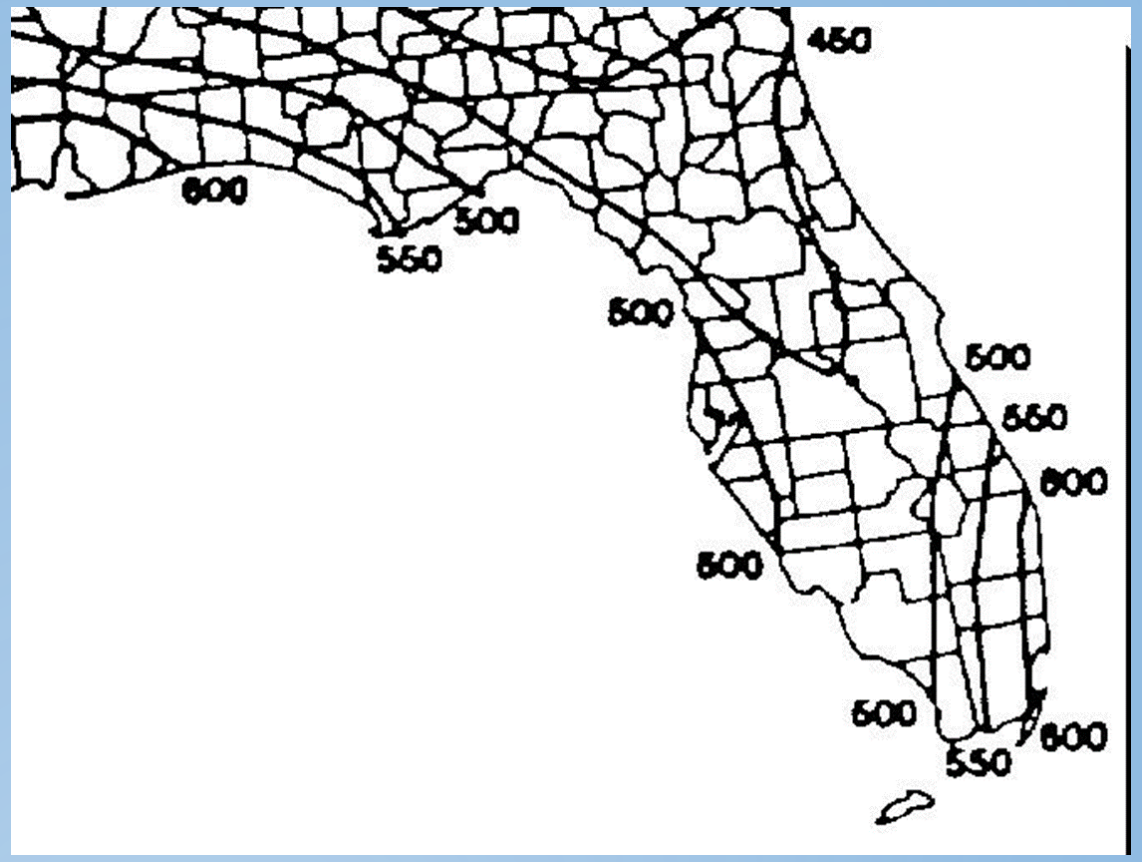
A - The Soil Loss Factor

This is an estimated annual average of the soil eroded from the site in an average year.

PREDICTING SOIL LOSS

- R - The Rainfall Erosion Index
- This is a measure of erosive force/intensity of rain in a normal year.

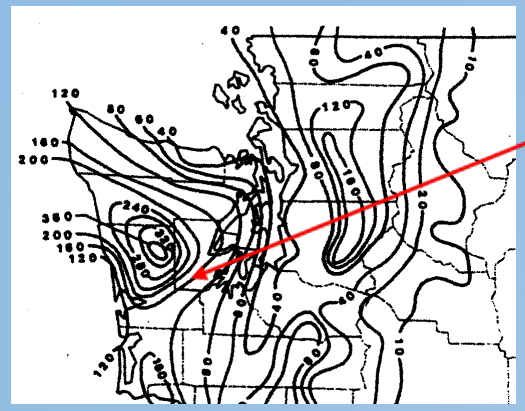
*Current Isoerodent Map (EPA2001)



PREDICTING SOIL LOSS

Comparing Rainfall Factors Universal Soil Loss Equation

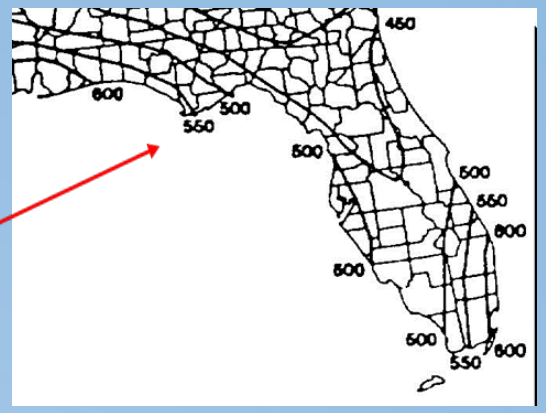
PACIFIC NORTHWEST



R = 340

R= 500-600

FLORIDA



- Although the Olympian Rain Forest receives twice the annual rainfall of Florida, the R Factors in Florida are much greater.
- Due to rain drop geometry and rainfall intensity Florida has a climate with very erosive conditions (high R Factors).

HAWAII

R= 150-450

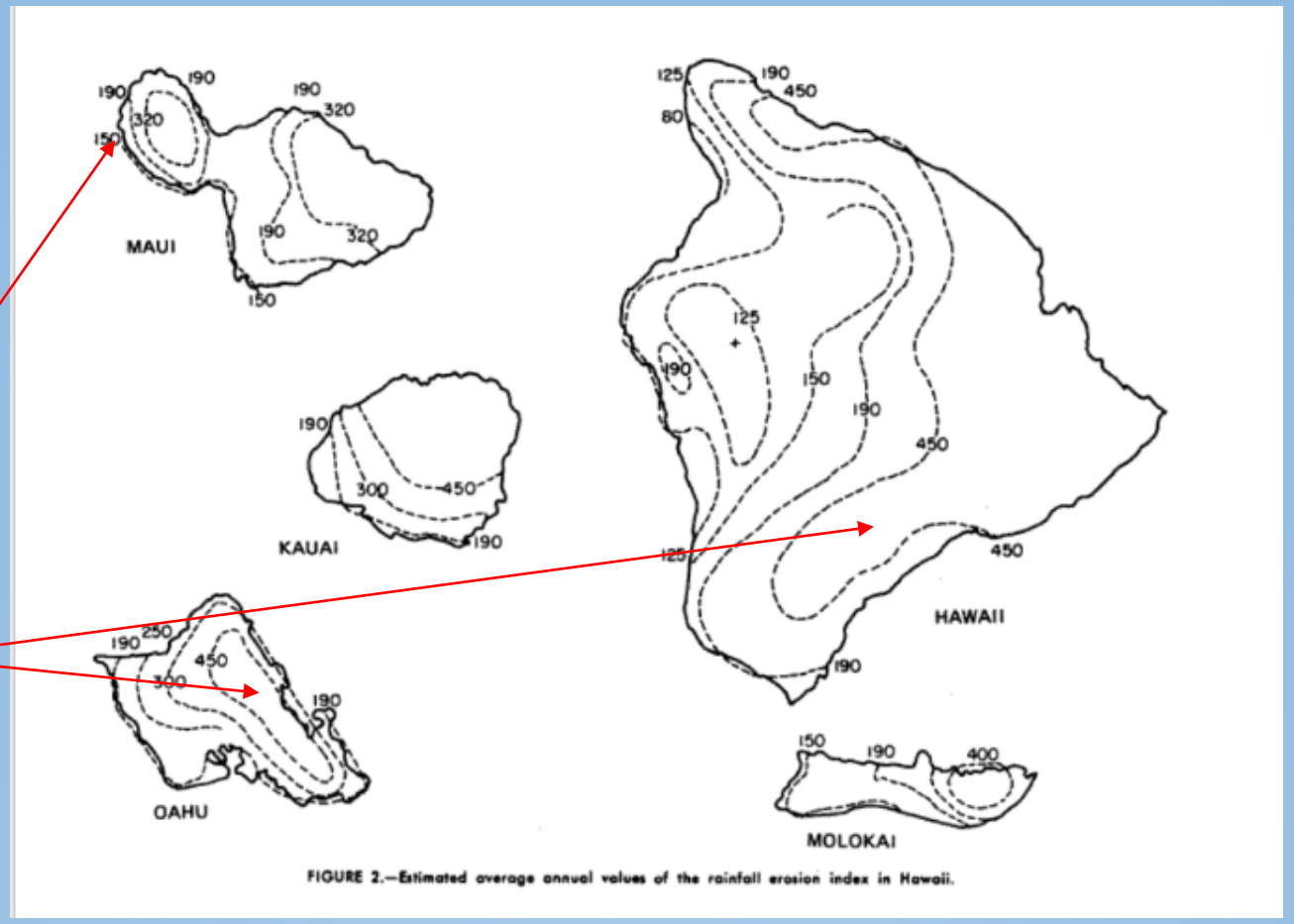
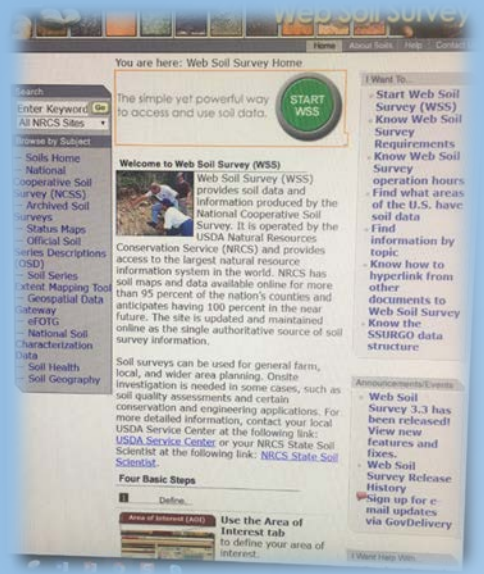


FIGURE 2.—Estimated average annual values of the rainfall erosion index in Hawaii.

PREDICTING SOIL LOSS

- K - The Soil Erodibility Factor
- A measure of the soil's susceptibility to detachment and transport by rainfall and runoff.

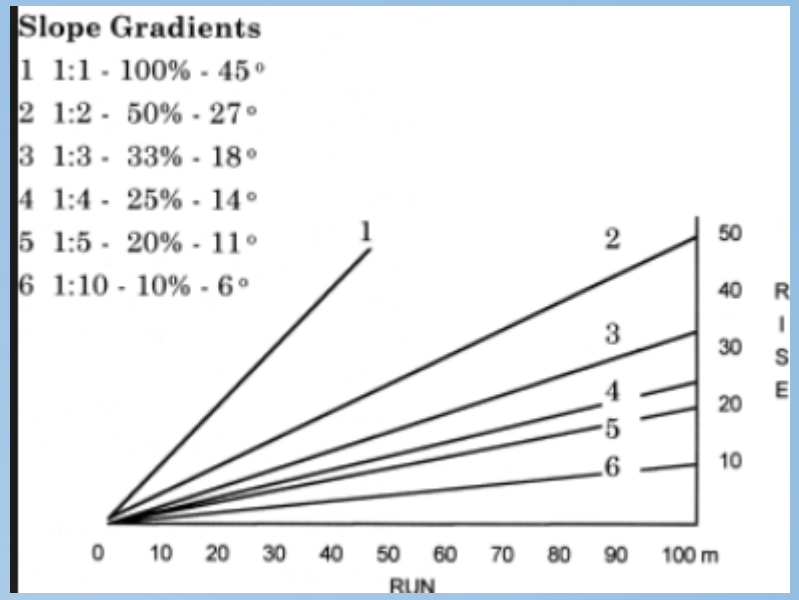


Soil reaction	Shrink-swell potential	Erosion factors		Wind erodibility group	Organic matter
pH		K	T		Pct
3.6-5.5	Low	0.17	5	2	2-5
4.5-5.5	Low	0.20			
4.5-5.5	Low	0.24			
3.6-5.5	Low	0.17	5	2	2-5
4.5-5.5	Low	0.20			
4.5-5.5	Low	0.24			
4.5-6.0	Very low	0.10	5	2	>.5
4.5-6.0	Very low	0.10			
4.5-6.0	Very low	0.10			

http://websoilsurvey.nrcs.usda.gov

PREDICTING SOIL LOSS

- L and S - The Slope Length and the Gradient Factors
- This is described by the combined effect of slope length and slope gradient.



PREDICTING SOIL LOSS

- C – The Vegetative Cover Factor
- This is the ratio of soil loss from land under specified types of cover to the corresponding loss from tilled or disturbed bare soil.

PREDICTING SOIL LOSS

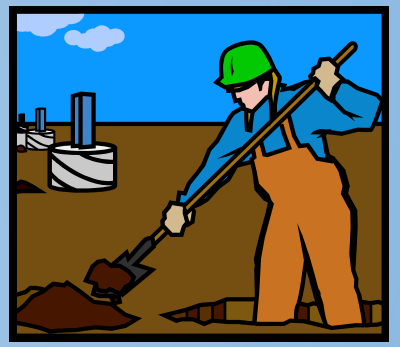
- P – The Erosion Control Practices Factor
- This accounts for the selected erosion control practices of the contractor that reduce and control the erosion potential of the runoff by reducing the runoff velocity and the tendency of runoff to flow directly down slope.

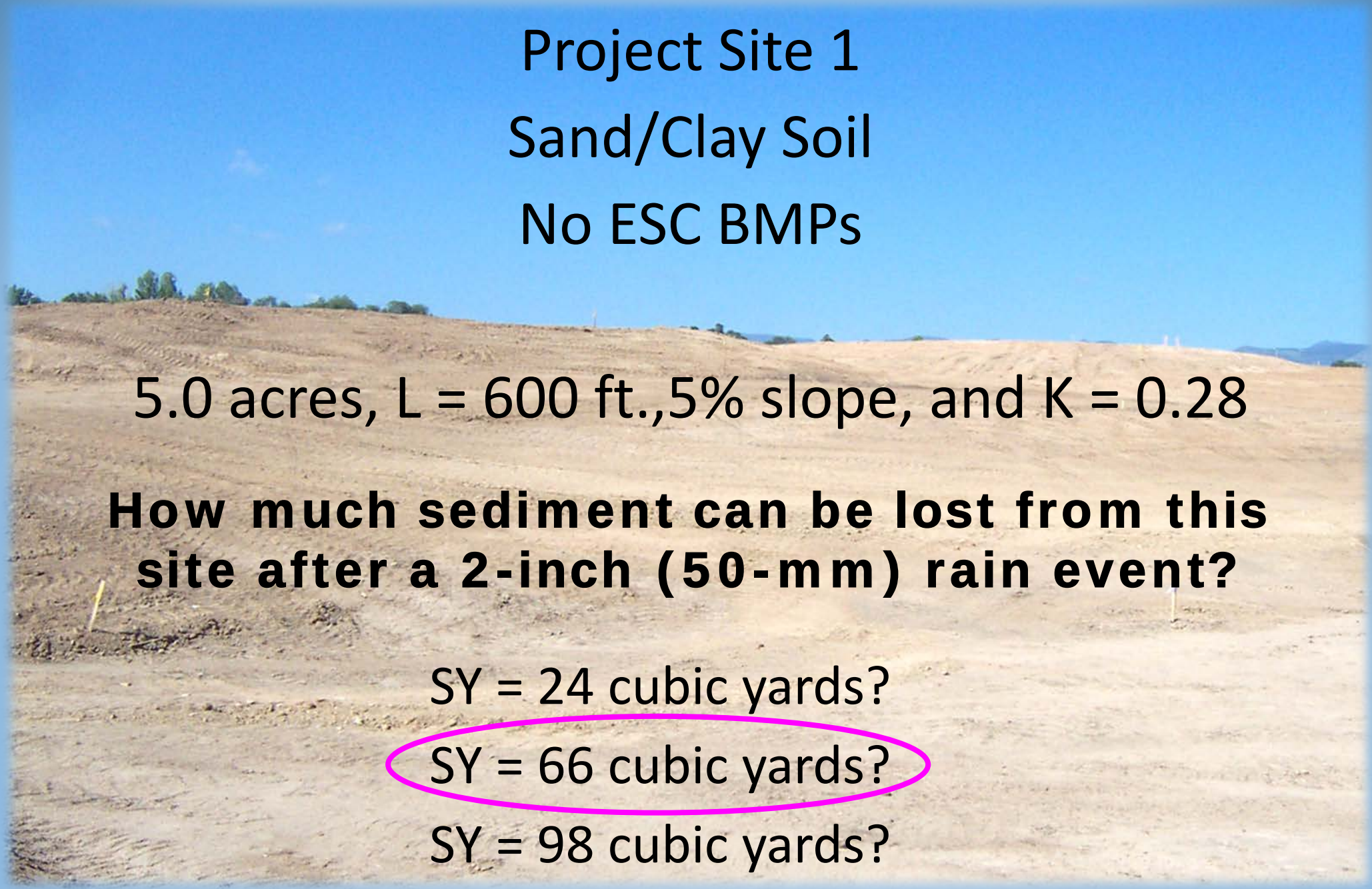
PREDICTING SOIL LOSS

Rainfall is the only factor not under your control!

What can you do to minimize soil loss?

1. Protect soil from raindrop impact
2. Minimize compaction when appropriate
3. Minimize slope length
4. Minimize slope gradient (steepness)
5. Minimize peak flow





Project Site 1
Sand/Clay Soil
No ESC BMPs

5.0 acres, L = 600 ft.,5% slope, and K = 0.28

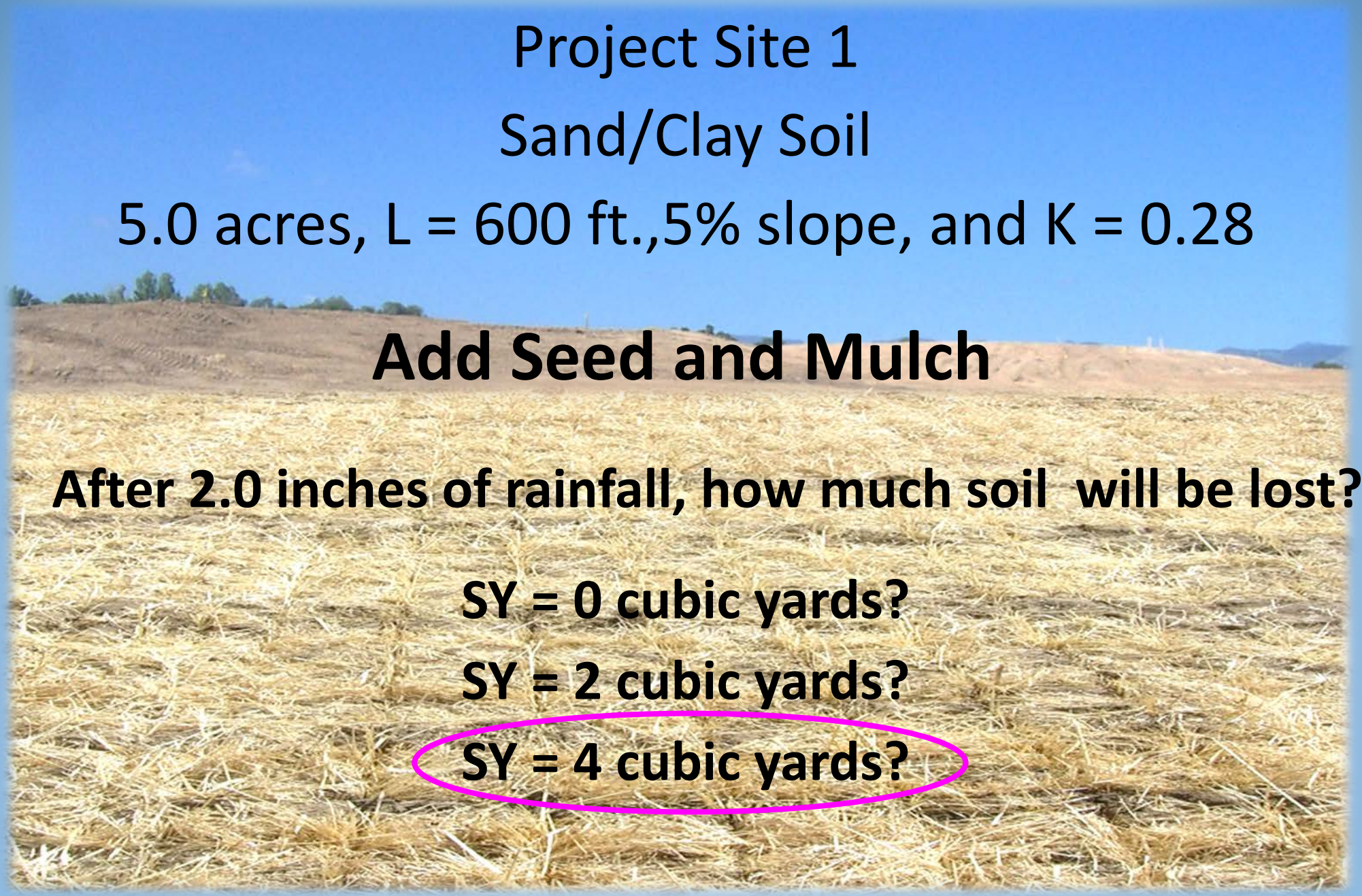
How much sediment can be lost from this site after a 2-inch (50-mm) rain event?

SY = 24 cubic yards?

SY = 66 cubic yards?

SY = 98 cubic yards?

5 Dump Truck Loads Of Soil Lost



Project Site 1

Sand/Clay Soil

5.0 acres, L = 600 ft.,5% slope, and K = 0.28

Add Seed and Mulch

After 2.0 inches of rainfall, how much soil will be lost?

SY = 0 cubic yards?

SY = 2 cubic yards?

SY = 4 cubic yards?

Project Site 2

Sand/Clay Soil

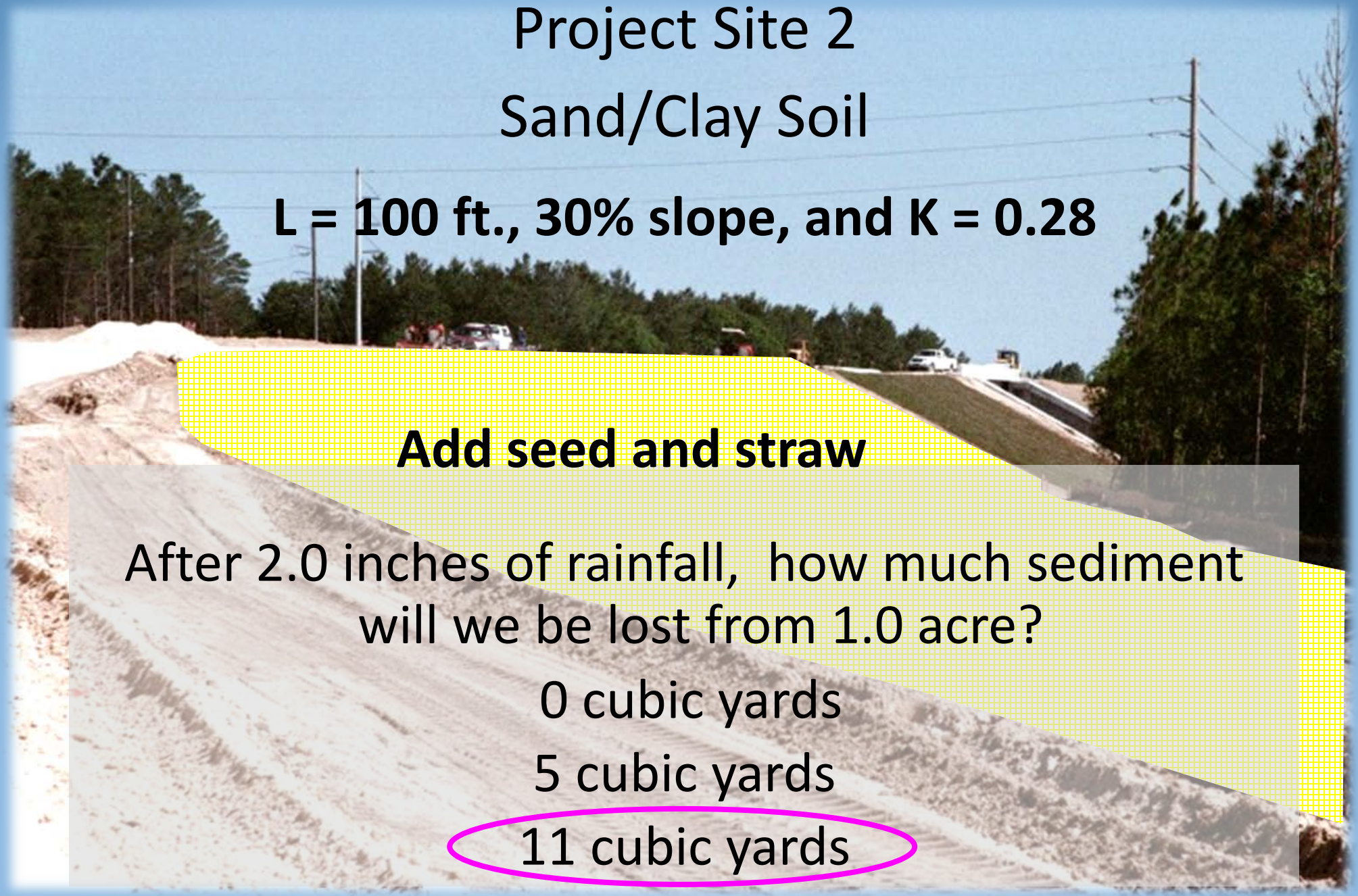
L = 100 ft., 30% slope, and K = 0.28

After 2.0 inches of rainfall, how many acres of exposed slope lost 66 cubic yards of sediment?

1.0 acres

2.5 acres

4.0 acres



Project Site 2

Sand/Clay Soil

L = 100 ft., 30% slope, and K = 0.28

Add seed and straw

After 2.0 inches of rainfall, how much sediment will we be lost from 1.0 acre?

0 cubic yards

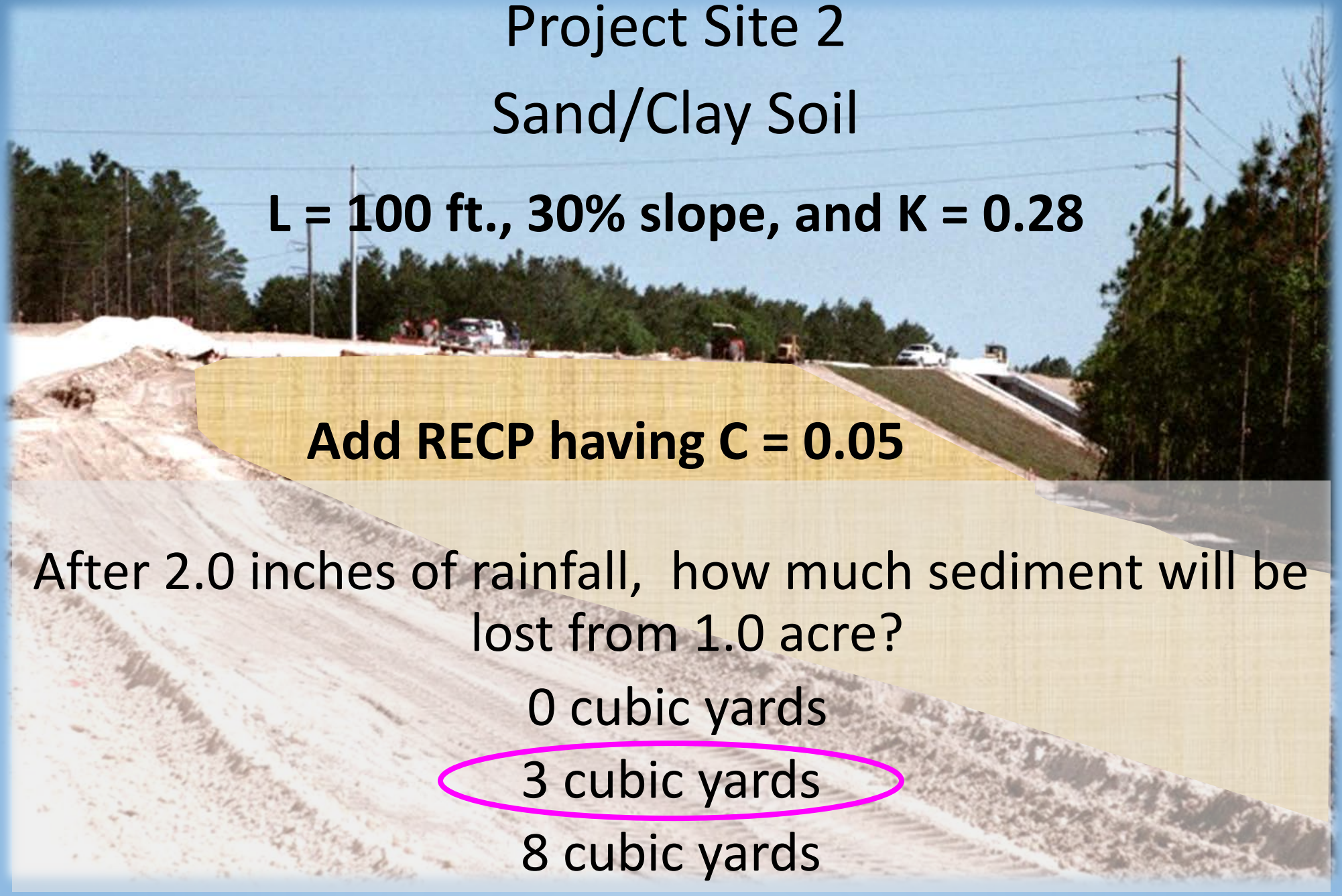
5 cubic yards

11 cubic yards

Project Site 2

Sand/Clay Soil

L = 100 ft., 30% slope, and K = 0.28



Add RECP having C = 0.05

After 2.0 inches of rainfall, how much sediment will be lost from 1.0 acre?

0 cubic yards

3 cubic yards

8 cubic yards

In Summary:

- Be concerned about sediment yields
- Don’t leave bare ground conditions for extended times
- Large amounts of sediment can leave the site
- Stabilize disturbed lands ASAP to save money

You Have To Spend Money To Save Money

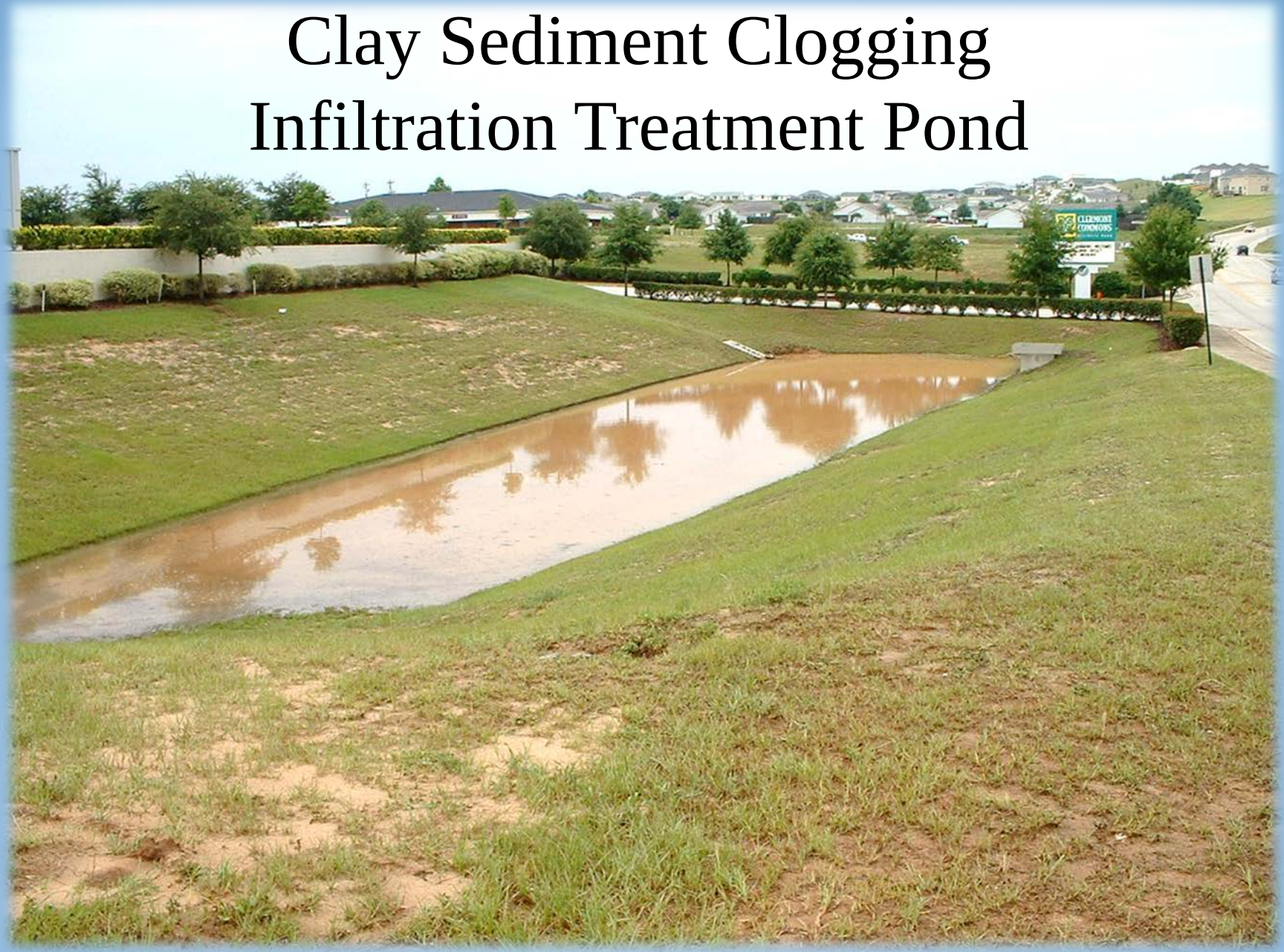
Costs of Erosion:

- It costs between $35,000-$50,000 to use a vac-truck to clean out the storm drains on an average multi-family neighborhood.
- It costs between $8,000-$15,000 to chemically treat a turbid stormwater pond (3-8 acres).
- There are usually multiple stormwater treatment BMPs (ponds, pipes, vaults, swales, etc.) on an average multi-family neighborhood.
- Worst case scenario where the entire stormwater system must be cleaned and restored to functionality may cost $100,000 or more.
- Failure to control erosion costs time, material, and money.

Vac Truck Clean-out

Poorly Maintained Inlet Protection BMPs

Clay Sediment Clogging Infiltration Treatment Pond



Chemical Treatment of Stormwater Pond

Severe Erosion Creating Dangerous Driving Hazard

Severe Erosion Creating Dangerous Driving Hazard

Stormwater Pollution Traveling Off-site & Causing More Erosion

Erosion Exposing 15KV Powerline

Maintain and Correct This

Before It Leads To This

Or Becomes Catastrophic

Failure to Control Erosion Costs:

- Time
- Material
- Money

Contact information:

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