Bio-Stabilization Case Studies

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Biologically Mediated Influences on Soil

1. Bio-control - use of one organism to suppress another
2. Bio-remediation - use of micro-organisms w/ capacities for environmental clean-up of contaminated soil
3. Bio-induration - sealing or plugging of pores in a soil with micro-organisms to prevent the movement of groundwater
4. Bio-stabilization - the reinforcement of soil w/ plant roots to increase shear strength and resistance to soil erosion & shallow slope failures

Bio-Stabilization

- Biotechnical
- Bioengineering

Biotechnical Stabilization (Definition)

- The integrated or combined use of living vegetation and inert structural components to protect slopes and stream banks against erosion and shallow failures

Biotechnical Stabilization
(Examples)

- Veg. Mechanically Stab. Earth *(VMSE)*
- Vegetated Gabion Walls
- Vegetated Riprap *(Joint Planting)*
- Turf Reinforcement Mats *(TRMs)*

Bioengineering Stabilization (Definition)

- The imbedment and arrangement of live plants and cuttings in the ground in various arrays ...where they serve as reinforcements, hydraulic drains, wicks, and barriers to earth movement.

Bioengineering Stabilization
(Examples)

- Live staking
- Live fascines
- Brushlayering
- Live pole planting
- Brush mattresses

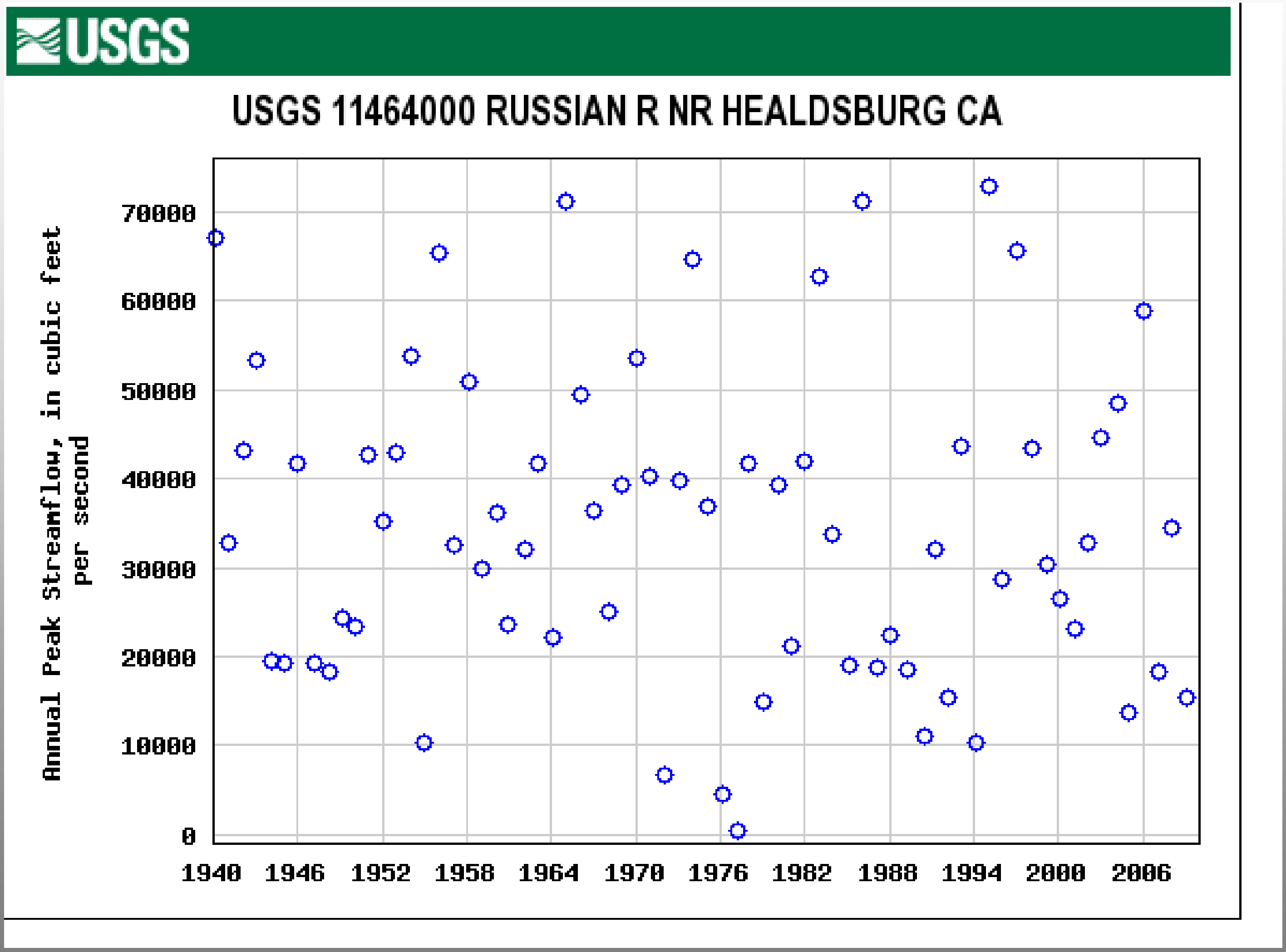
Bio-stabilization Case Studies

Case Study No. 1 - Stream Bank Stabilization

- Bridge Site, Russian River
- Geyserville, California
- Caltrans Project

Initial Site Conditions

Peak Annual Stream Flow



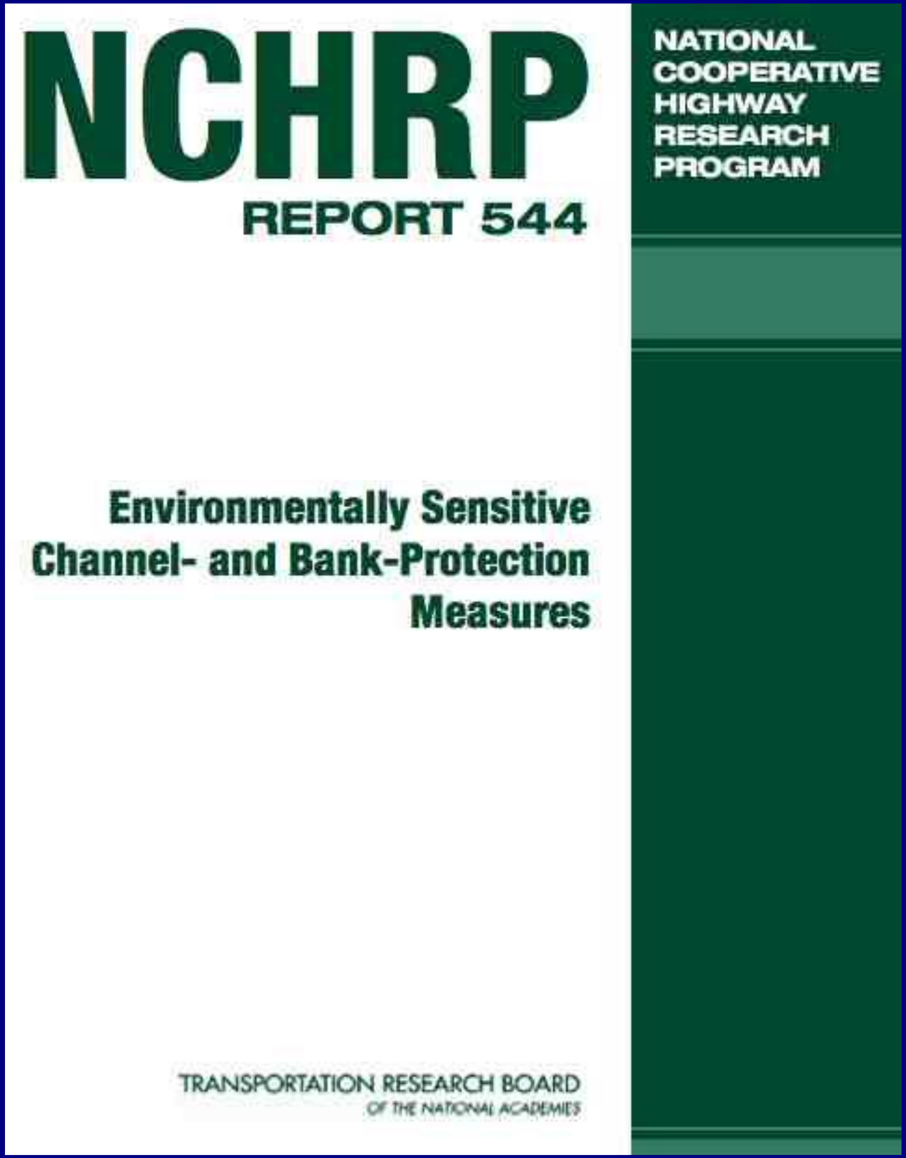
Principal Remedies Implemented

- Access Ramp and Pad
- Rock Vanes
- Live Siltation
- Low-Flood Terrace
- Willow Pole Planting

Environmentally Sensitive Channel and Stream Bank Protection Measures

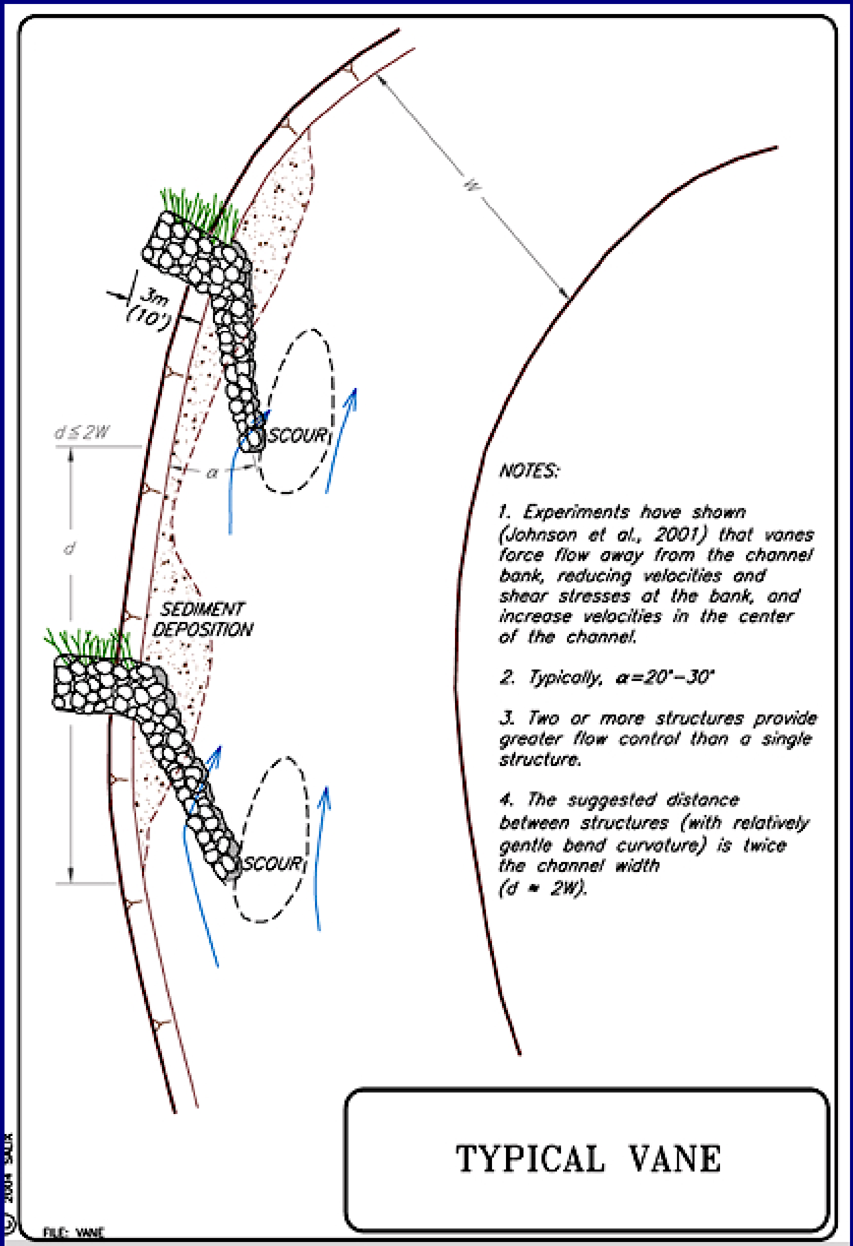
NCHRP Project 24-19

1. *River Training Measures*
2. *Bank Armor & Protection*
3. *Riparian Buffer and Stream Corridor Treatments*
4. *Slope Stabilization*



Access Ramp and Rock Pad

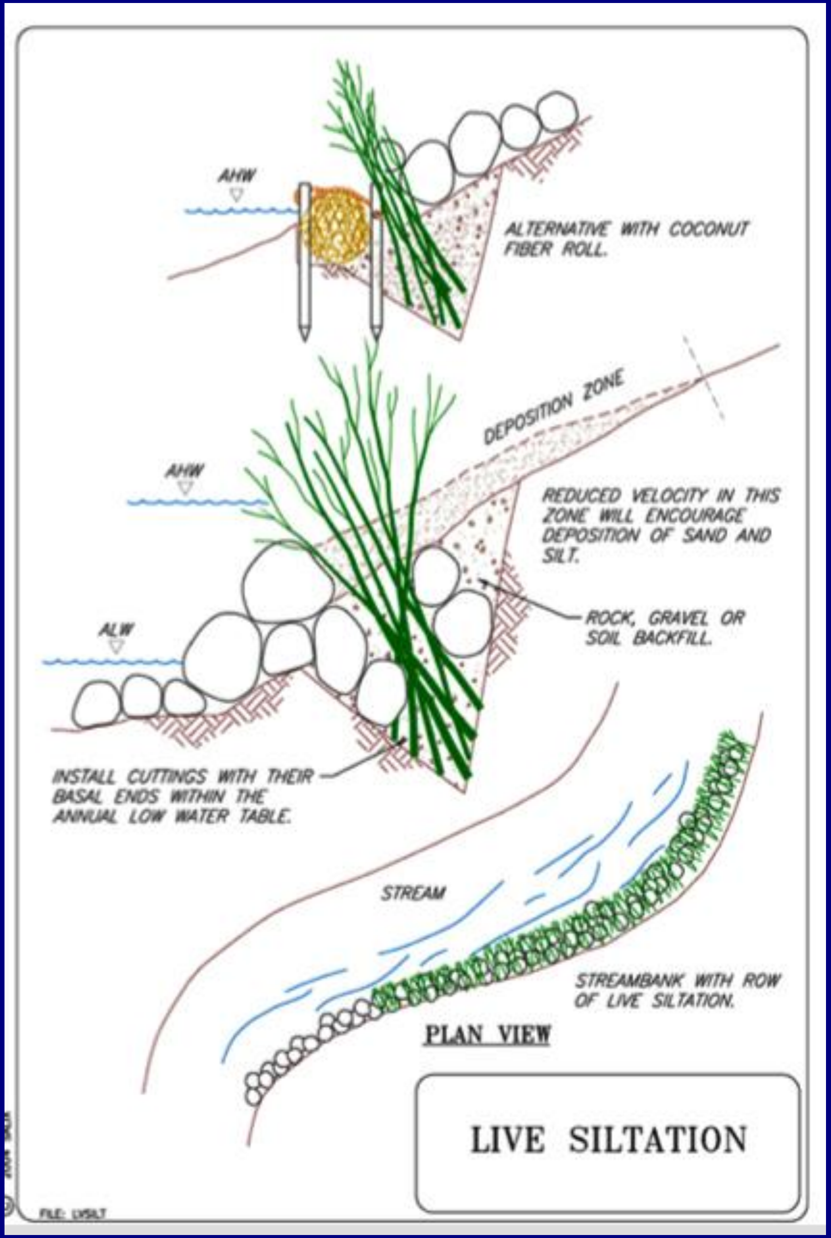
Rock Vanes

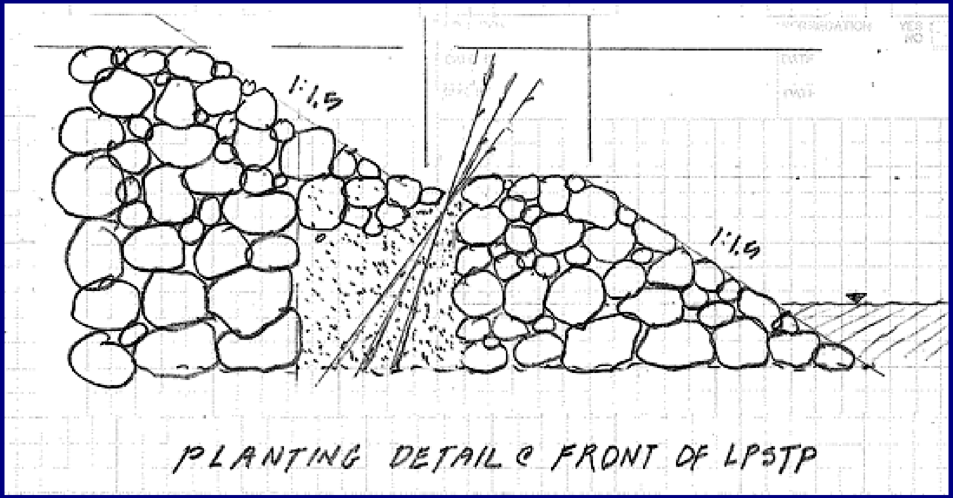


3m
(10')
W
d ≤ 2W
d
α
SCOUR
SEDIMENT
DEPOSITION
SCOUR
NOTES:
1. Experiments have shown (Johnson et al., 2001) that vanes force flow away from the channel bank, reducing velocities and shear stresses at the bank, and increase velocities in the center of the channel.
2. Typically, α=20°–30°
3. Two or more structures provide greater flow control than a single structure.
4. The suggested distance between structures (with relatively gentle bend curvature) is twice the channel width (d ≈ 2W).
TYPICAL VANE
FILE: VANE

CAT

Live Siltation



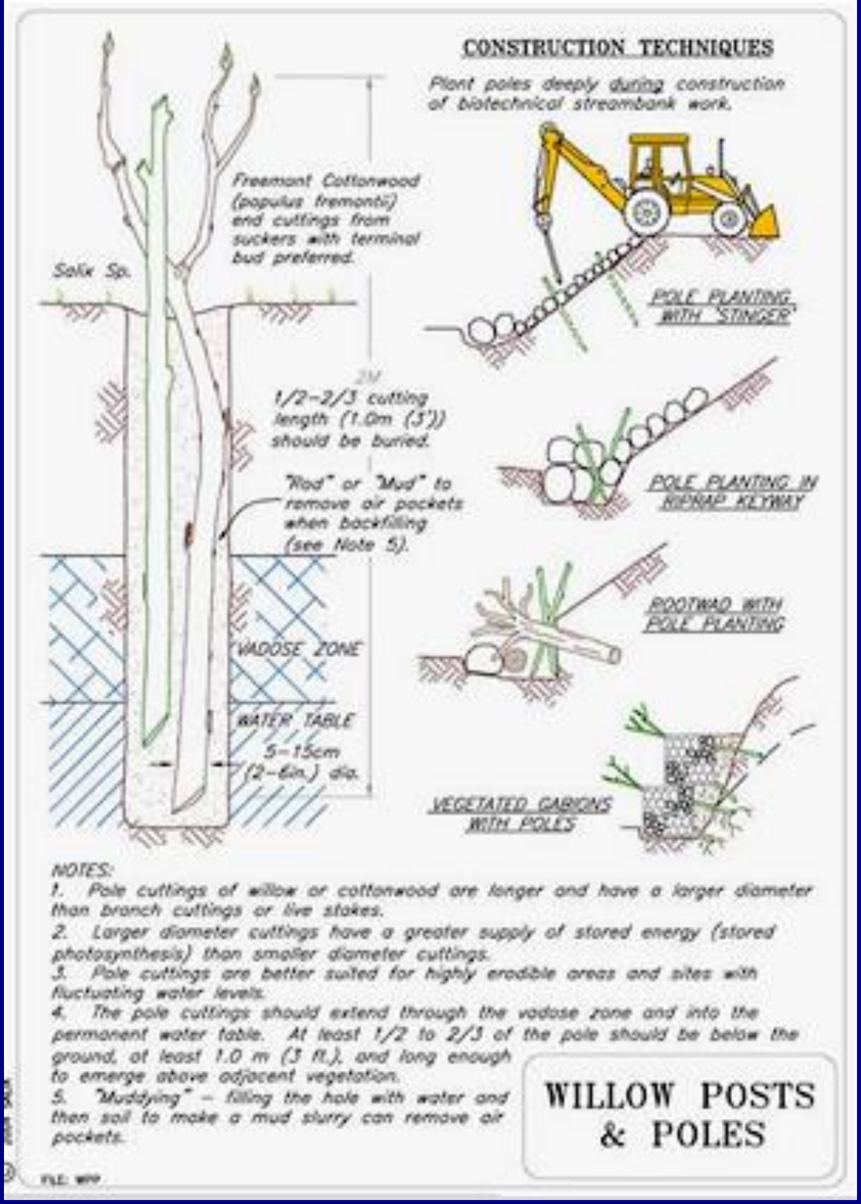


Live Siltation Construction

Live cuttings were placed behind and leaning against a LSTP on edge of rock ramp

Low-Flood Terrace

Willow Pole Planting



Overview of All Measures after Construction

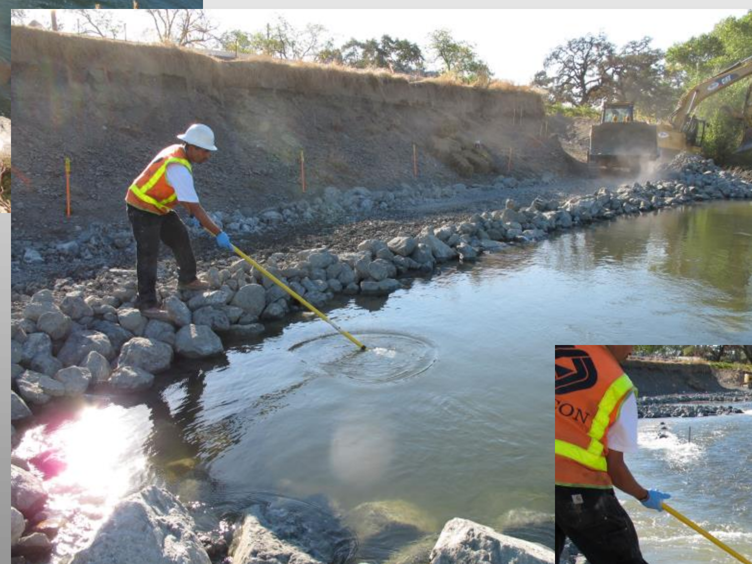
Performance Evaluation

- Visual Observation
- Turbidity Monitoring
- Thalweg Displacement
- Vegetation Establishment
- Storm (Flood) Response

Visual Observations

CalTrans Webcam: www.dot.ca.gov/dist4/128russianriver

Turbidity Monitoring



Thalweg Displacement

Vegetation Establishment

One Year
Later------->

Storm (Flood) Response

<---During Dec 2010 flood

After Winter------->
2010/2011 Floods

Conclusions

- The rock vanes were redirected the high flow currents away from the actively eroding bank
- The project demonstrates that rock vanes can be effective in large, high energy rivers, where large rock armor has traditionally been used
- Willow cuttings used for live siltation and willow poles planted on the low flood terrace helped to slow stream velocities and promote sedimentation.
- After a relatively short learning curve, the techniques employed were very “buildable” and cost-effective.

Case Study No. 2 - Slope Stabilization

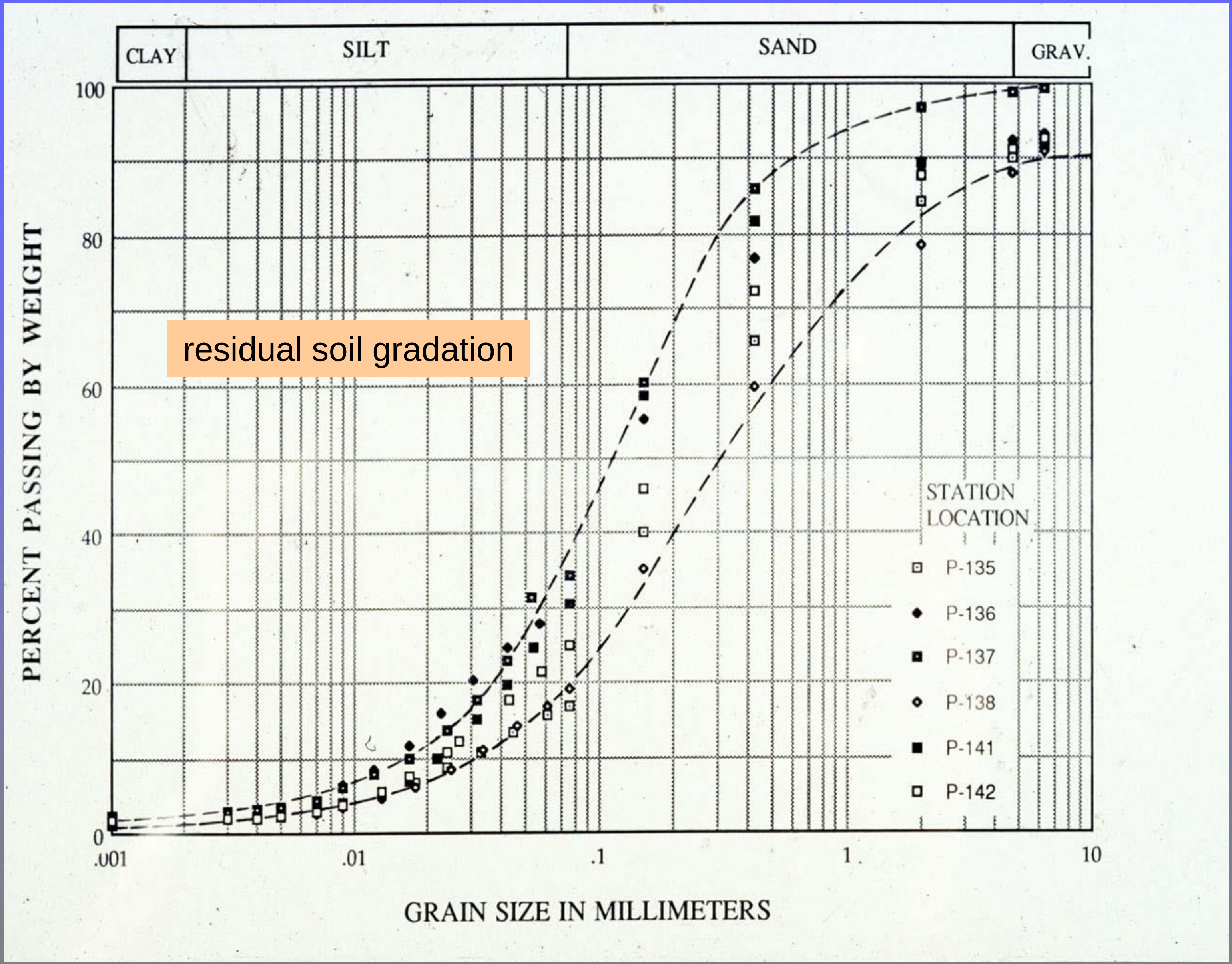
- Highway Cut
.
- Greenfield Road
.
- Colrain, Massachusetts

Soil and Site Conditions

- Geology
- Soils
- Hydrology
- Slope failures


<------------------cut slope failure area---------------->
major slump


<-------------residual soil---------------------------->
<---exposed bed rock--->



residual soil gradation
CLAY
SILT
SAND
GRAV.
PERCENT PASSING BY WEIGHT
GRAIN SIZE IN MILLIMETERS
100
80
60
40
20
0
.001
.01
.1
1
10
STATION
LOCATION
P-135
P-136
P-137
P-138
P-141
P-142

TABLE 3. MEASURED ANGLE OF INTERNAL FRICTION AND COHESION BASED ON DRAINED, TRIAXIAL COMPRESSION TESTS ON SAMPLES COMPACTED TO 75 % RELATIVE DENSITY

SAMPLE LOCATION	DRAINED SHEAR STRENGTH PARAMETERS	
	FRICTION (degrees)	COHESION (psi)
135+00 RT	36.3	3.2
136+00 RT	35.4	3.9
137+00 RT	35.9	4.2
138+00 RT	36.3	3.4
141+75 RT	35.9	3.0
142+75 RT	35.5	3.6
AVERAGE	35.9	3.5

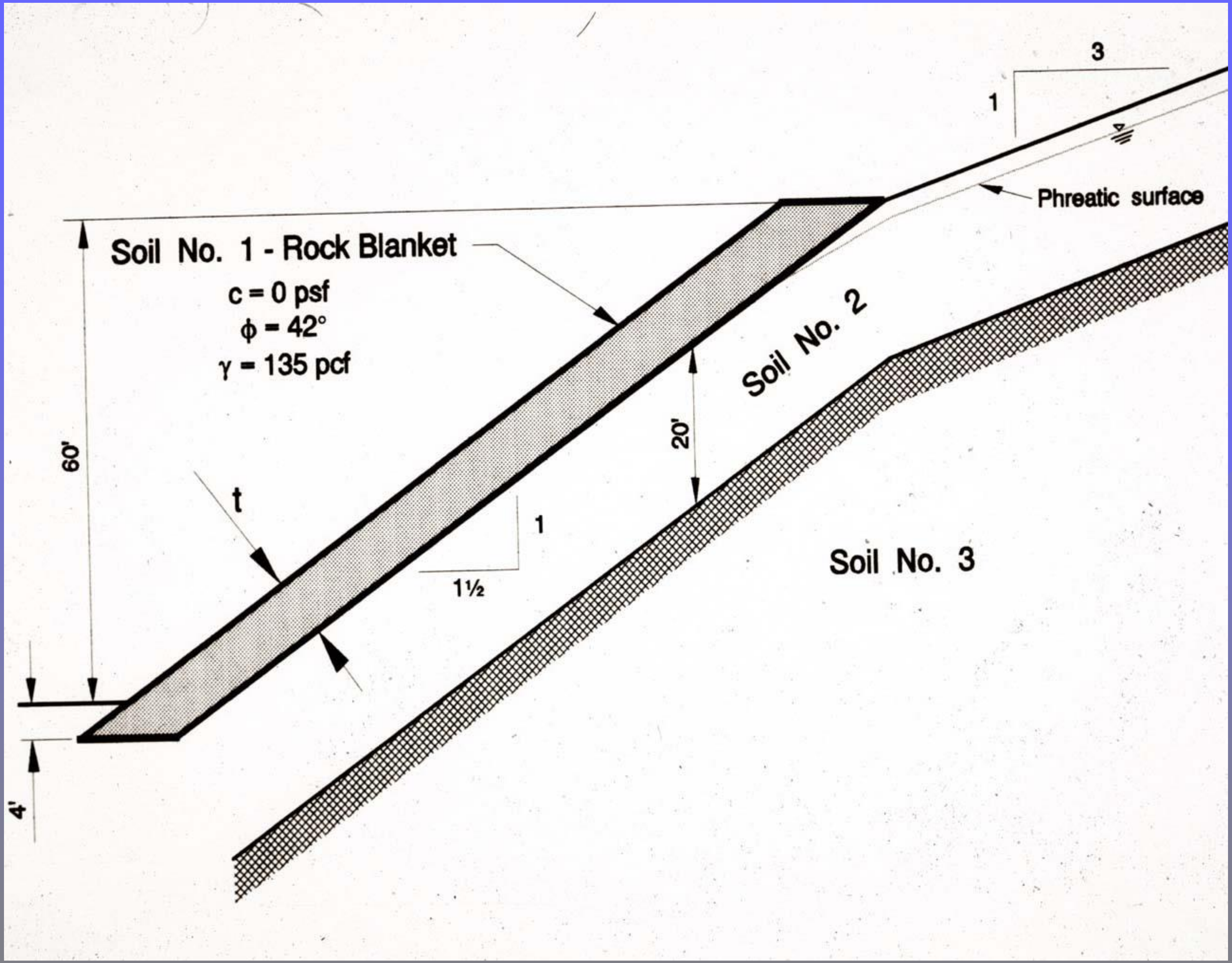
Stabilization Alternatives

- Uniform rock blanket
- Rock toe-buttress
- Uniform earthen brush layer fill
- Rock toe-buttress w/ brushlayer fill

Stability Analyses

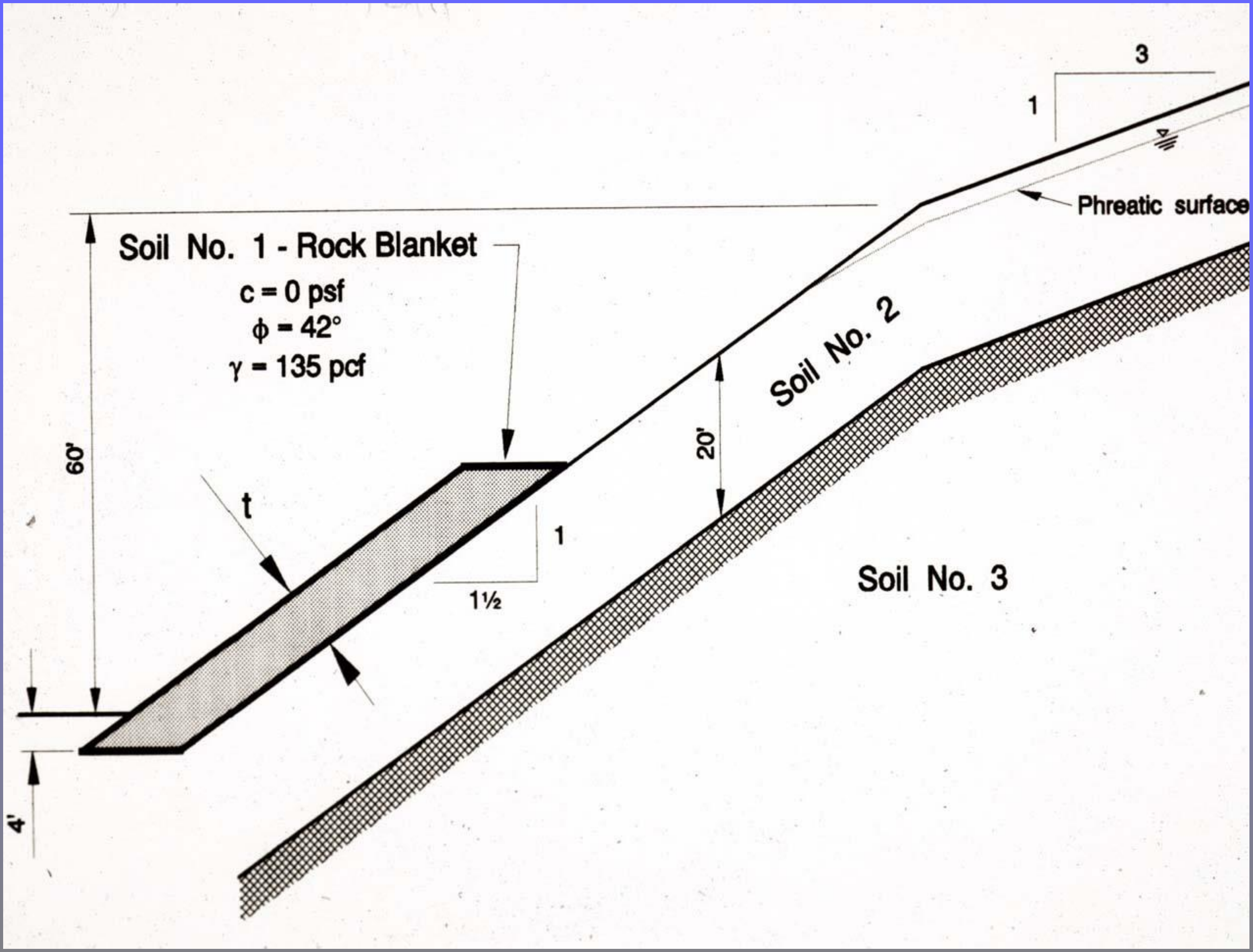
- Uniform rock blanket


Uniform rock blanket

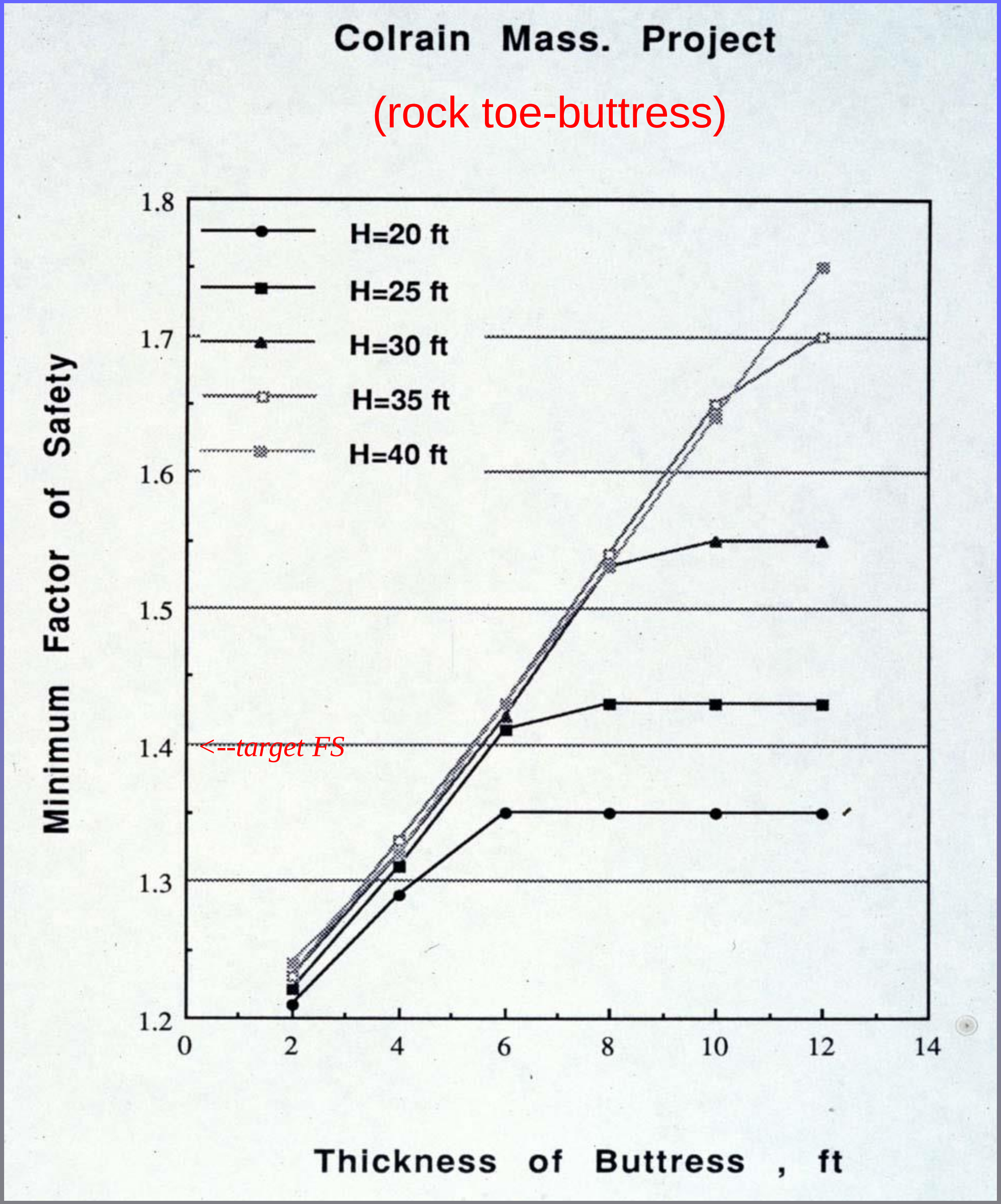

3
1
Phreatic surface
Soil No. 1 - Rock Blanket
c = 0 psf
ϕ = 42°
γ = 135 pcf
Soil No. 2
20'
60'
t
1
1½
Soil No. 3
4'

Stability Analyses

- Rock toe-buttress alone



Soil No. 1 - Rock Blanket
c = 0 psf
ϕ = 42°
γ = 135 pcf
Soil No. 2
Soil No. 3
Phreatic surface
60'
20'
4'
t
1
1½
3
1



Colrain Mass. Project
(rock toe-buttress)
Minimum Factor of Safety
Thickness of Buttress , ft
H=20 ft
H=25 ft
H=30 ft
H=35 ft
H=40 ft
<--target FS
1.8
1.7
1.6
1.5
1.4
1.3
1.2
0
2
4
6
8
10
12
14

Stability Analyses

- Rock toe-buttress with brushlayer reinforced fill

Simplified Bishop Slope Stability Analysis

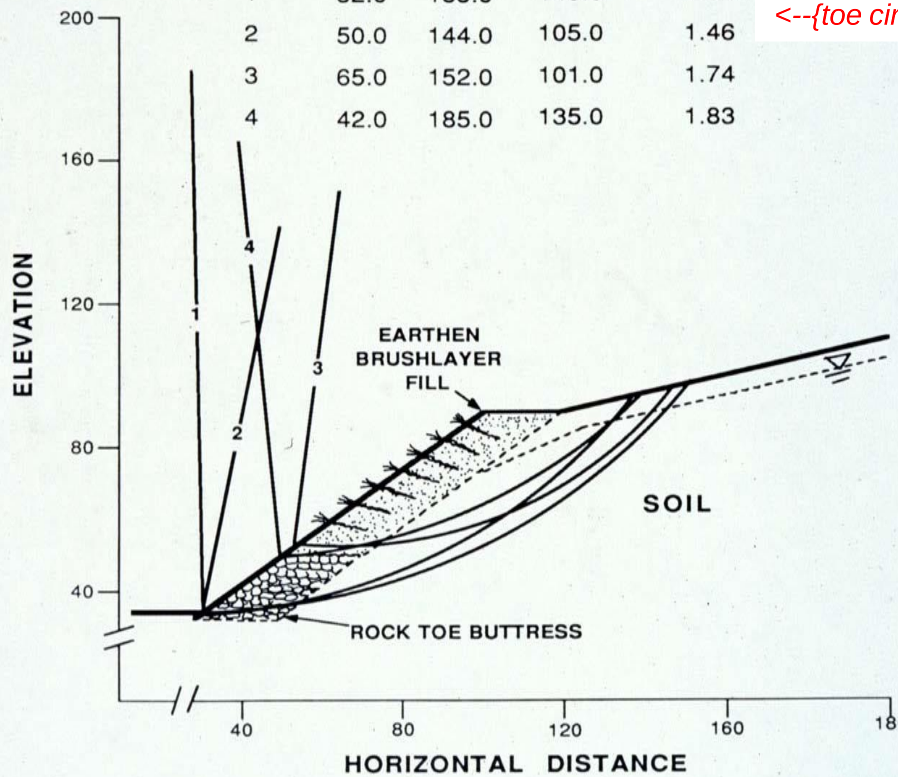
PROJECT: SLOPE REPAIR WITH COMPOSITE ROCK TOE BUTTRESS AND EARTHEN BRUSHLAYER FILL

LOCATION: COLRAIN, MASSACHUSETTS

COMPLETE SLOPE CROSS SECTION

CIRCLE	X	Y	RADIUS	FS
1	32.0	185.0	145.0	1.50
2	50.0	144.0	105.0	1.46
3	65.0	152.0	101.0	1.74
4	42.0	185.0	135.0	1.83

<--{toe circle failures



Adopted Treatments

- Rock toe w/ brushlayer buttress fill
- Live Fascines (along crest)
- Live Staking and netting


First year


Winter (after const)


Summer


Second year


Third year

Fascines - first year


Fascines - second year


Live staking & netting
Brushlayer fill
Transition area

Benefits and Lessons Learned

1. Willows performed better than alder; pre-construction trials may be necessary to identify best performing plant material

2. Conventional geotechnical slope stability analyses can be adapted to evaluate the stability of biotechnical slope stability installations.

3. Conventional slope stabilization techniques, e.g., a rock-toe buttress, can be combined successfully with soil biostabilization techniques, e.g., live brushlayering.

That’s it for now…thanks for your attention!