Maintenance and Management of Gravel Roads

2024

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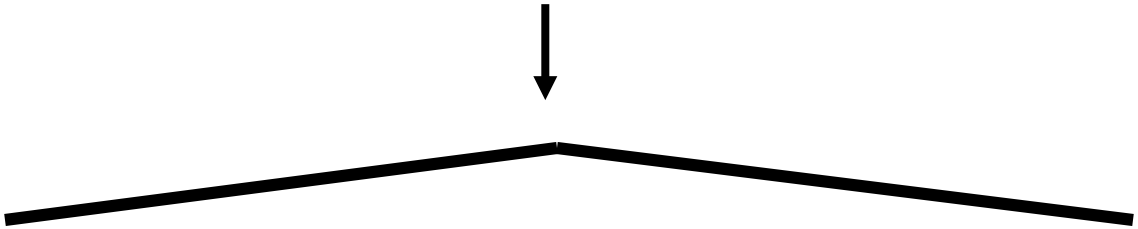
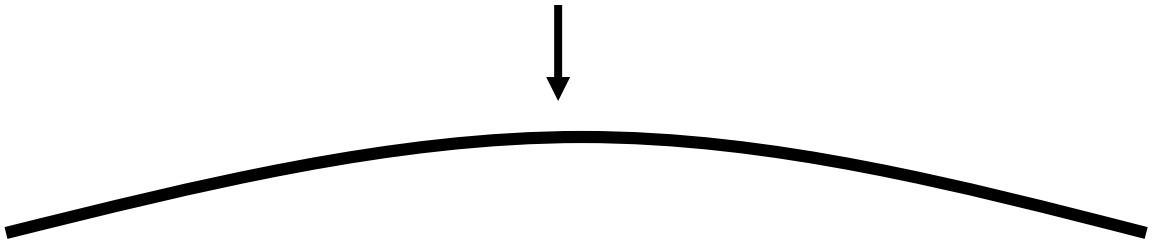
Crown shape is critical….

You want crown shaped like this



Not like this



Roadway Drainage

- Crowning
- Aggregate Surfacing
- Granular Road Base
- Ditches
- Culverts

Maintenance problems, and therefore expenditures are primarily a result of drainage problems in the road structure.

Ditches….

Why, what type, how deep, how often do we cross drain, etc?

Good ditch construction and drainage

Flat Bottom Ditch Construction: Video
V- Ditch Maintenance Video

Good ditch construction and drainage

Sometimes this is reality in confined ROW

Examples of Poor Drainage

Examples of Proper Drainage

From: Southern Soil Saver

From: Knoxnews.com

Barnes and Connor, 2017

No real cross section here.
You have to do better than this!

Preventing Ditch Erosion

Drainage run-out to carry water away from road with erosion control – good practice.

Culverts

- Capacity
- Excavation Safety
- Installation

Culvert Terminology

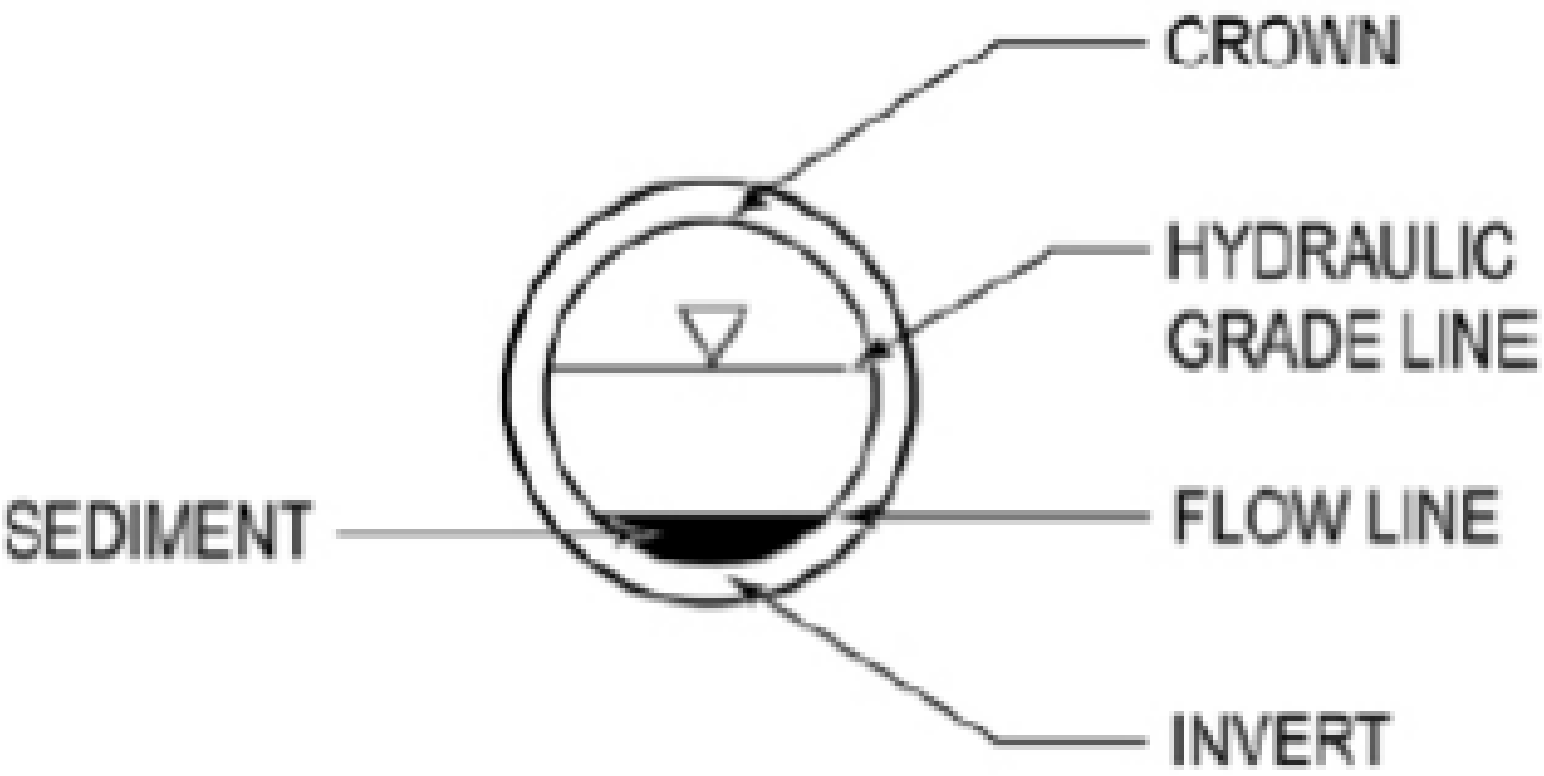


Figure 5-1 Culvert Terms

Capacity of Culverts/ Drainage Pipes

If the volume in cubic feet per second (CFS) is known, a culvert may be sized using the Hydraulic Design methodology

Q = C*i*A

Q = Flow in Cubic Feet per Second

C = Runoff Coefficient

i = Intensity of Rainfall Inches per Hour

A = Drainage Area in Acres

Culvert Capacities

Arch Pipe	Round	Cap. 0.5% Slope In Miners Inches	Cubic Feet per Second (CFS)
	12”	68	1.7
18”x 11”	15”	120	3
22”x 13”	18”	196	4.9
25”x 16”	21”	300	7.5
29”x 18”	24”	400	10
36”x 22”	30”	760	19
43”x 27”	36”	1240	31
50”x 31”	42”	1840	46
58”x 36”	48”	2720	68
65”x 40”	54”	3600	90
72”x 44”	60”	4800	120

1 CFS = 40 MINERS INCHES = 449 gpm

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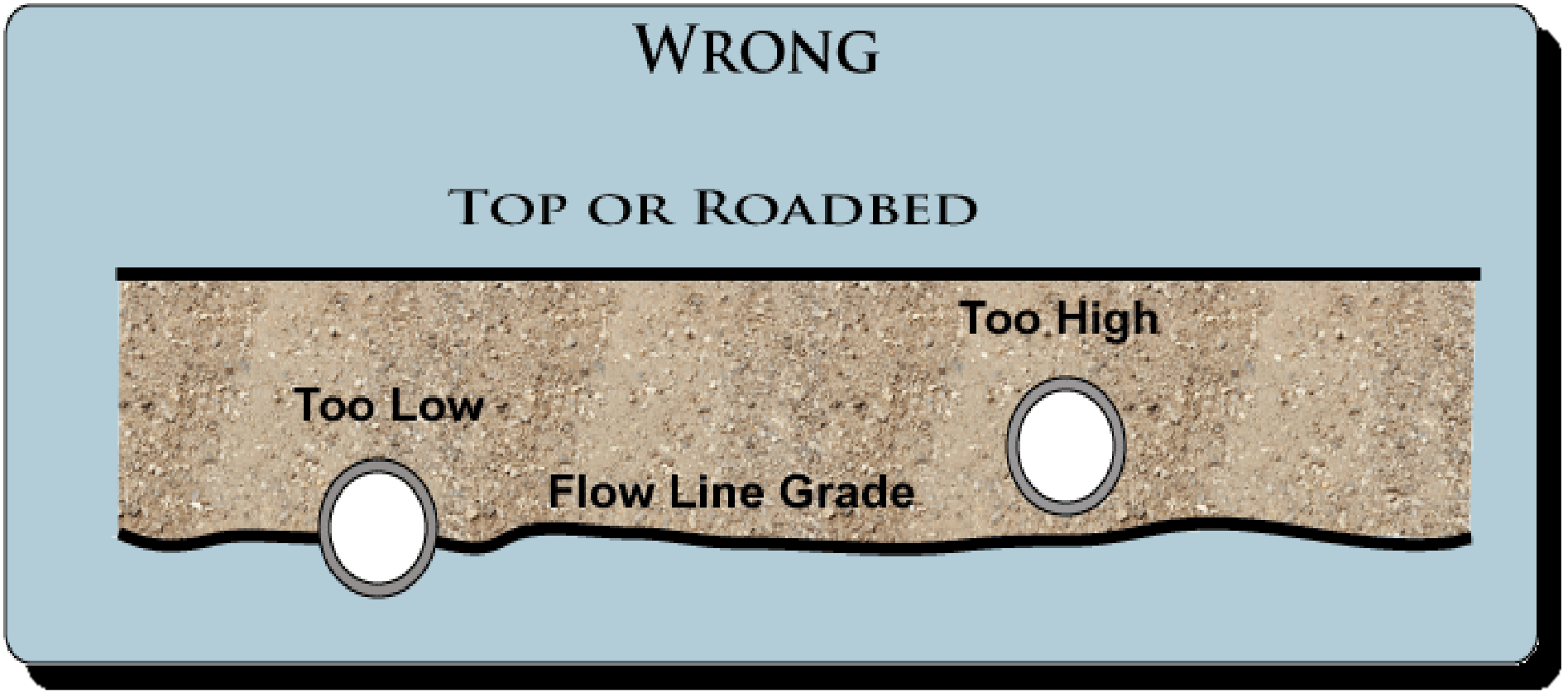
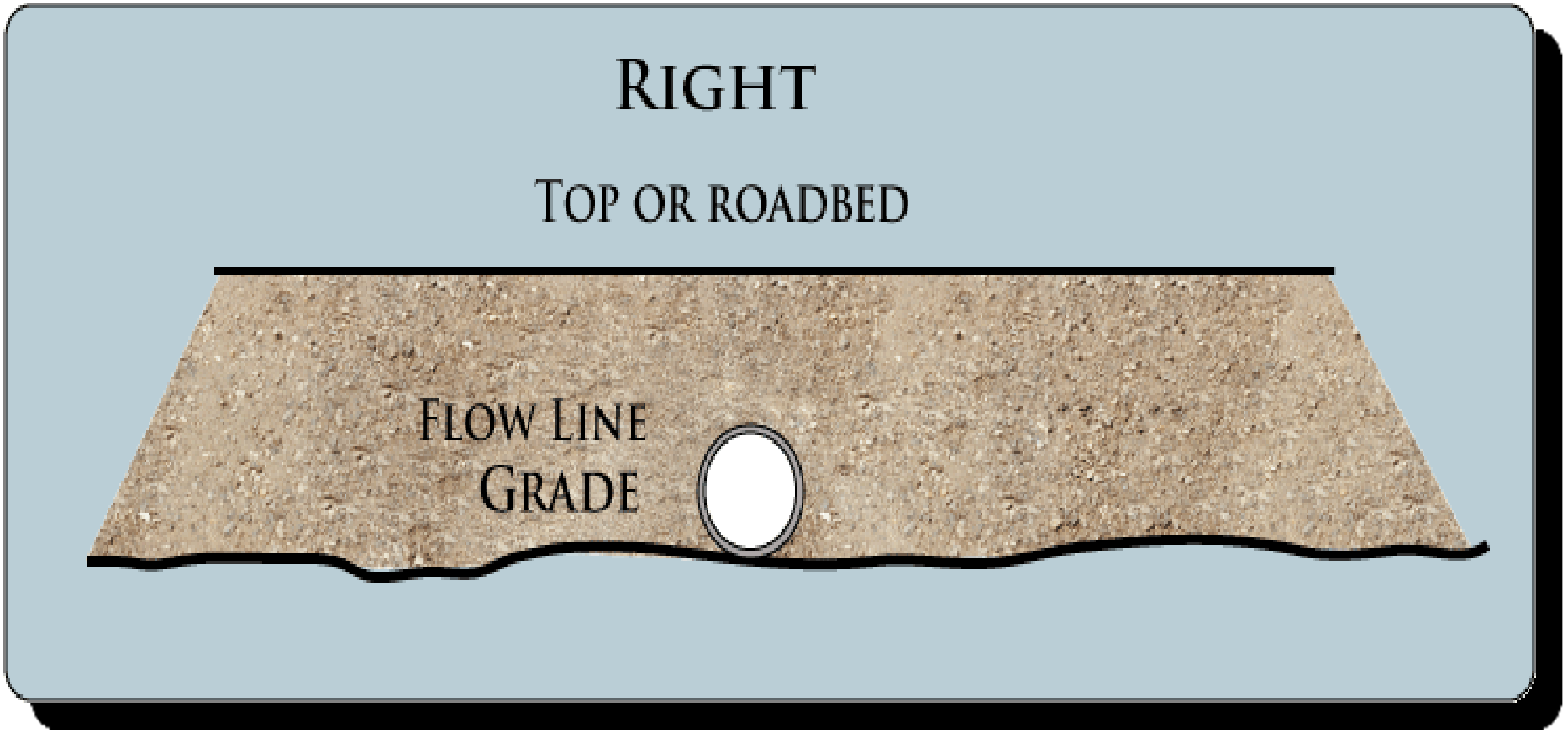
Improper Installation of a Culvert or Cross-drain



Proper Installation of a Culvert or Cross-drain



Good culvert installation at junction

Remember where water is going to go….
DOWNHILL!

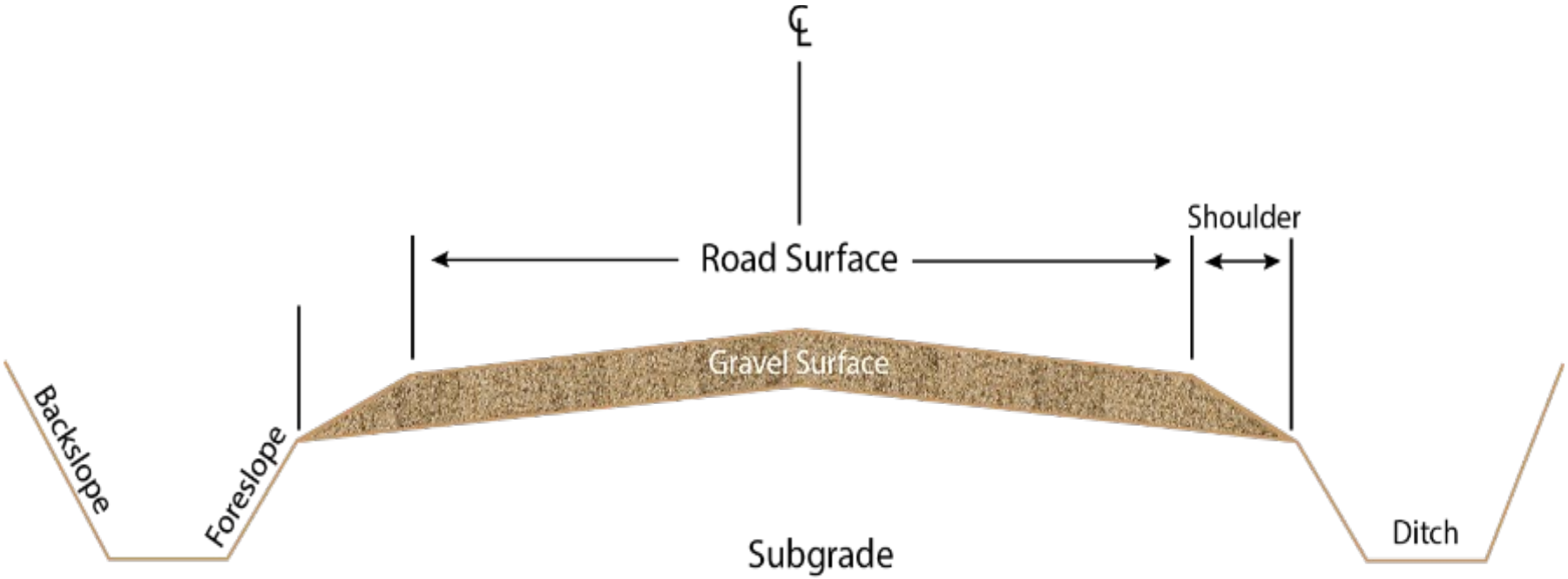
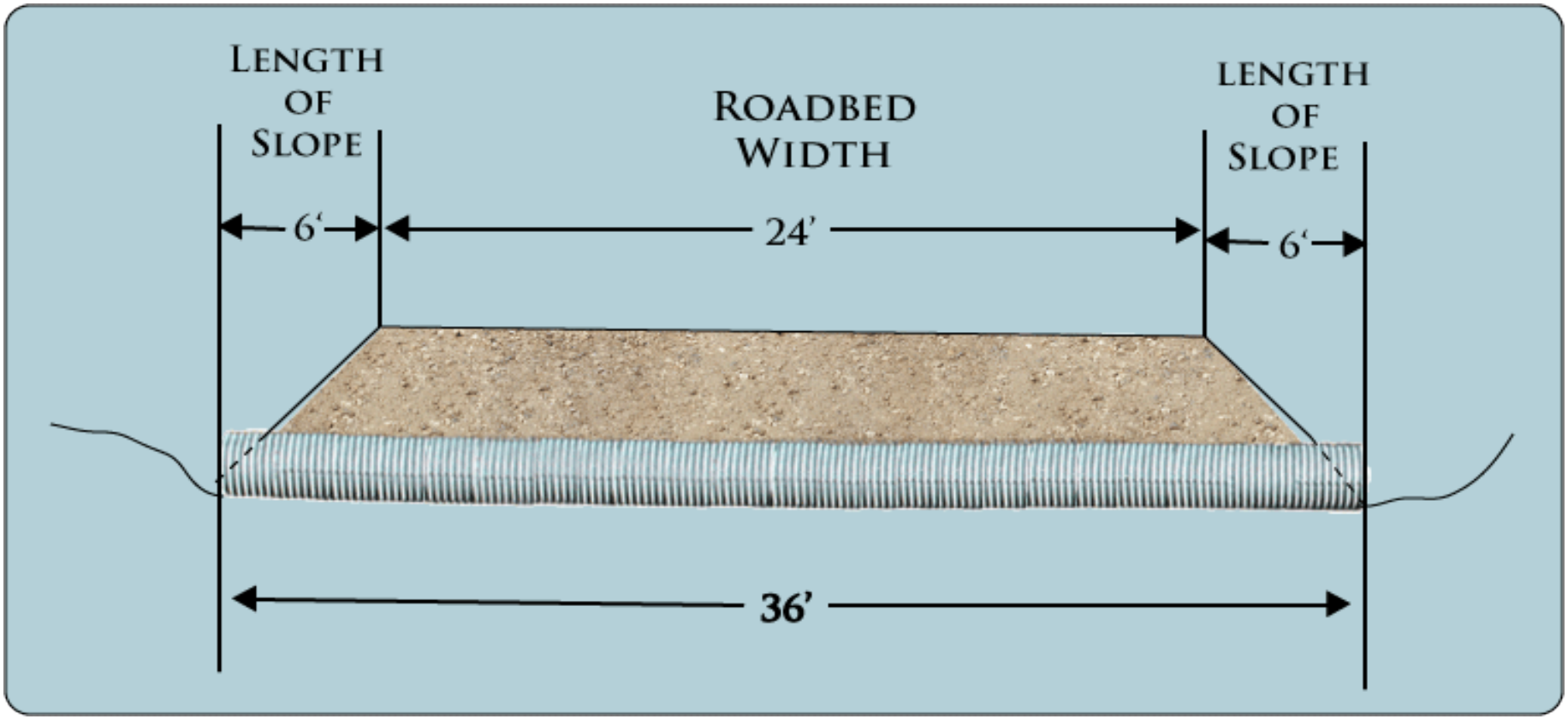


Figure 1: The components of the roadway cross section.

Consider calculations necessary for length of need



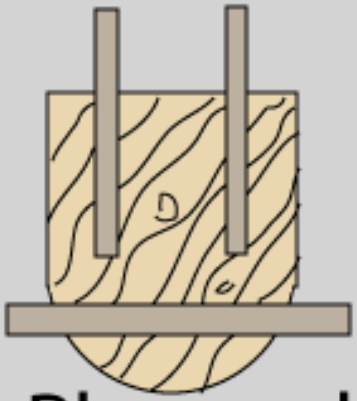
Culvert Length Needed

Length of culvert equals the length of slope on the left, plus the roadbed width, plus the length of slope of the right.

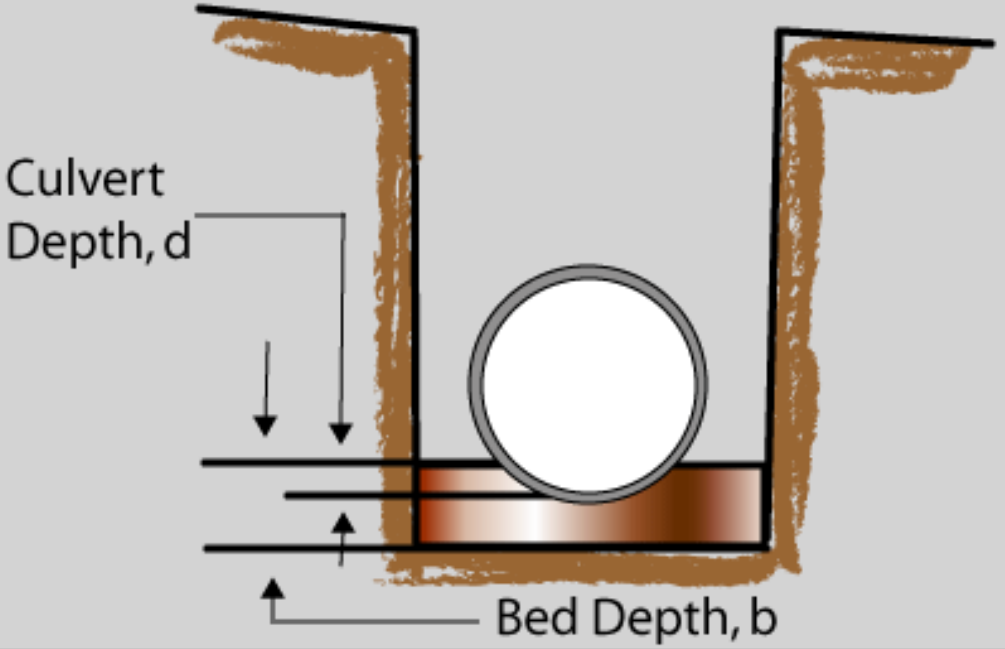
Example: If the length of slope is 6 feet on each side and the Roadbed width is 24 feet, the length equals 36 feet.

Culvert Bedding

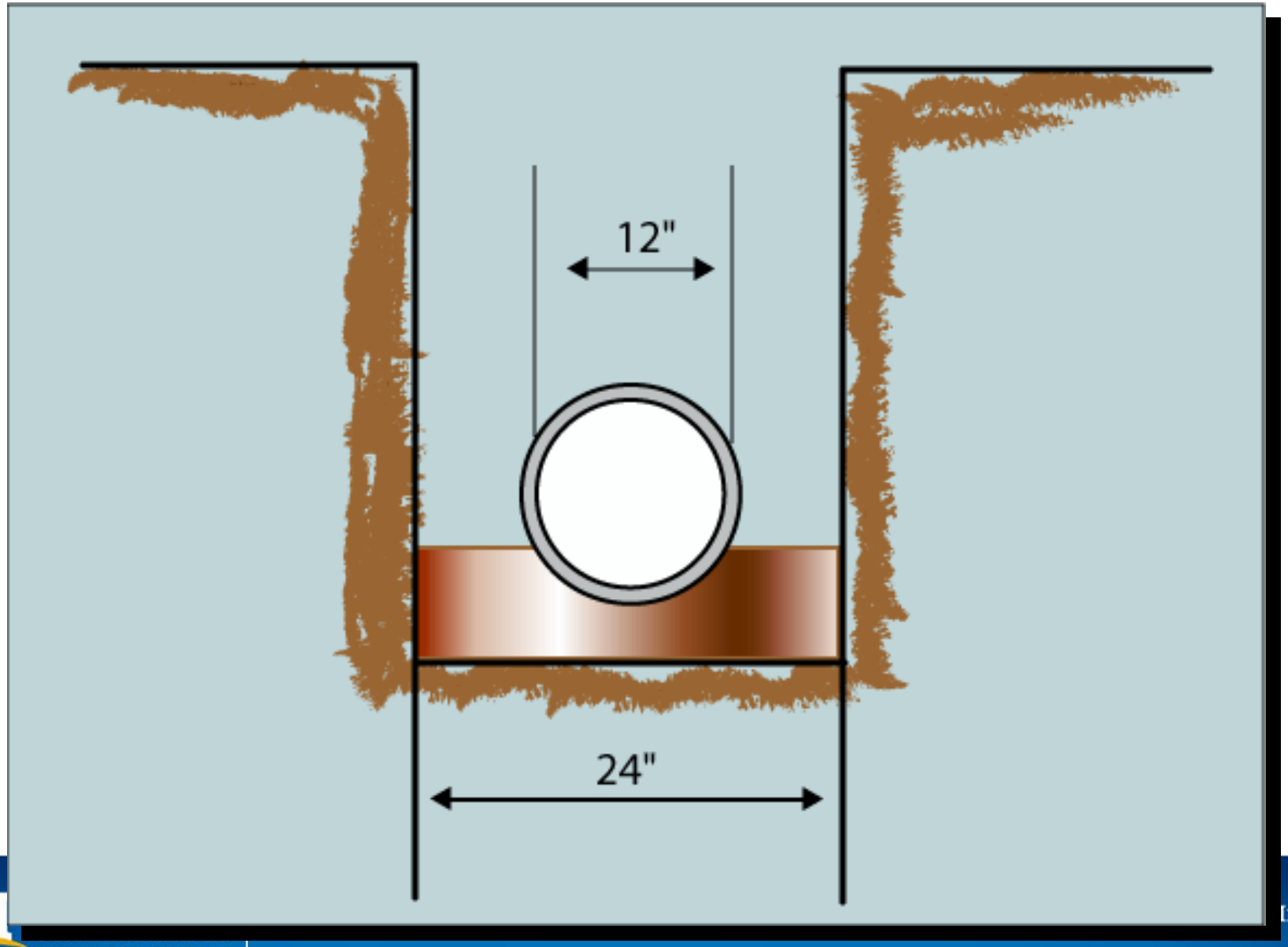
Culvert Diameter (in)	Culvert Depth, d, (in)	Total Bed Depth, b, (in)
12	1.5	4
18	2	5
24	2.5	6
30	3	7
36	3.5	8
48	5	9



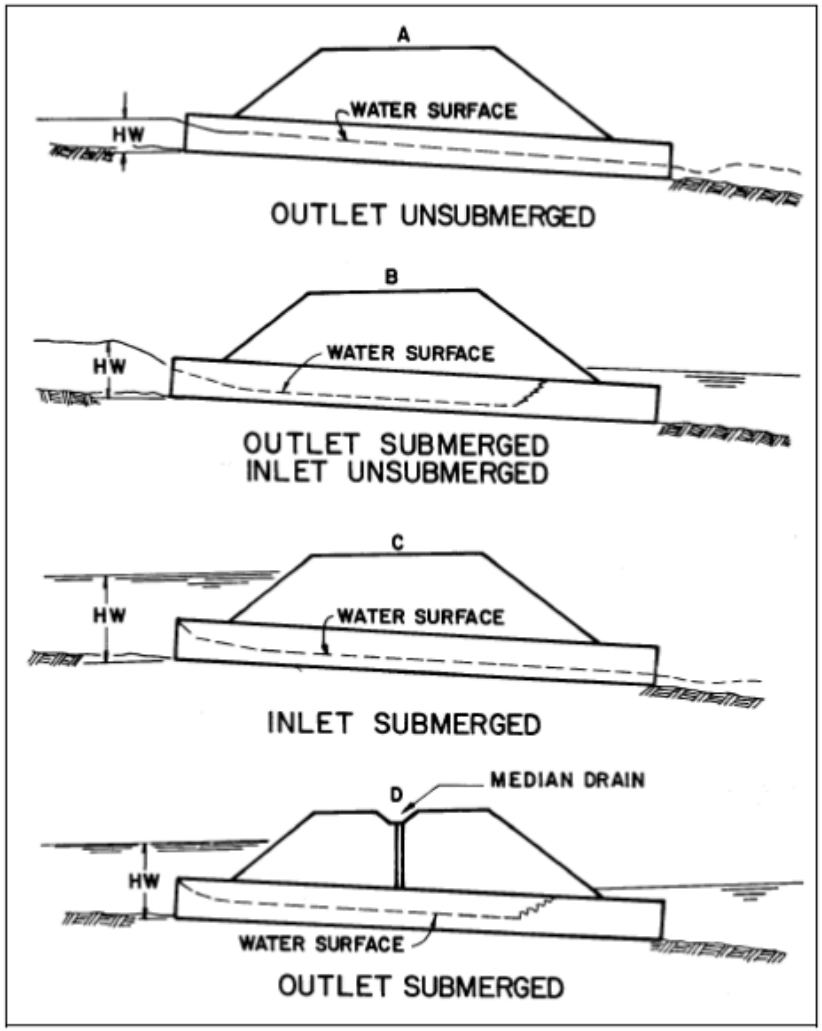
Plywood Template



Trench Width

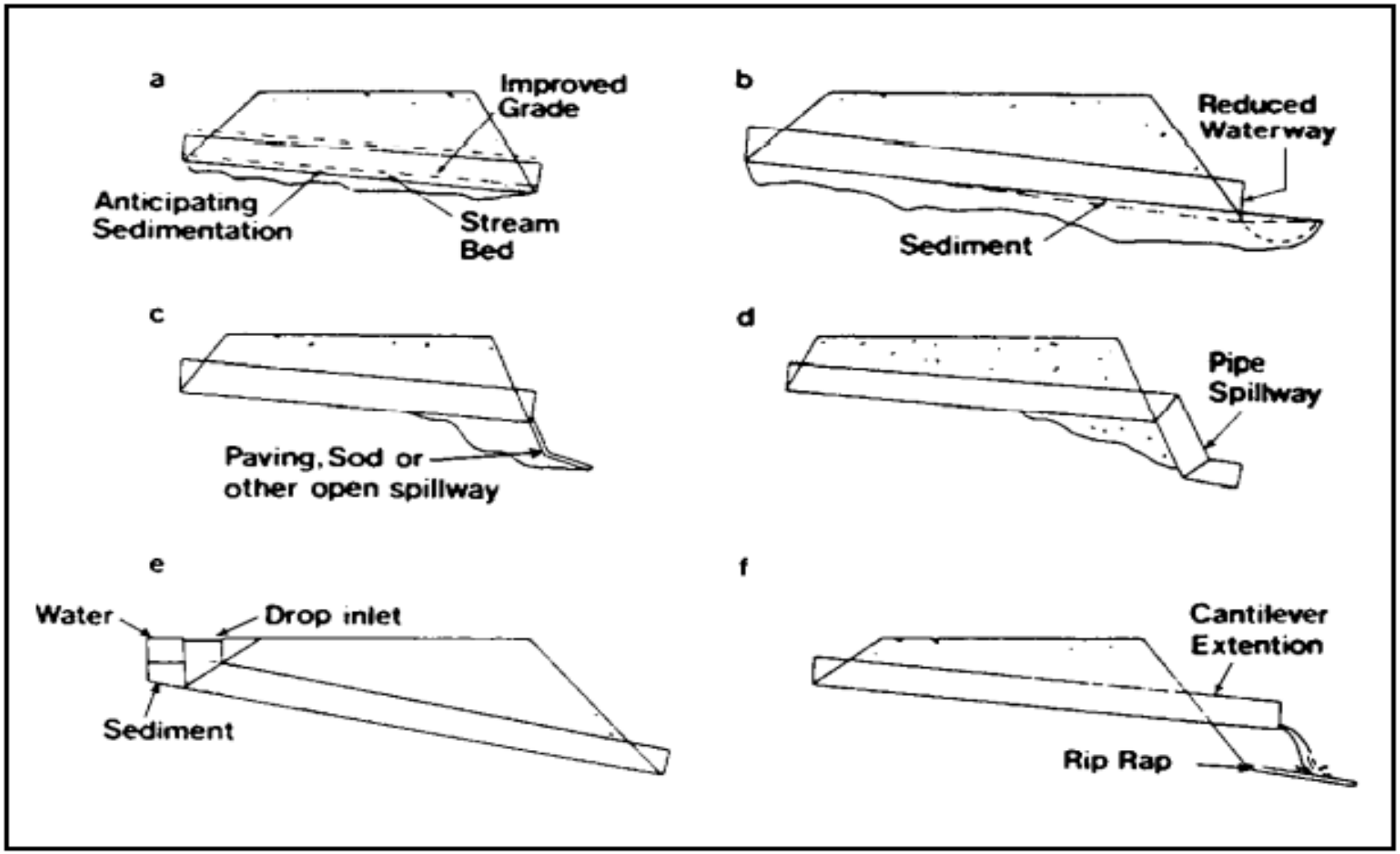


Culverts and their function

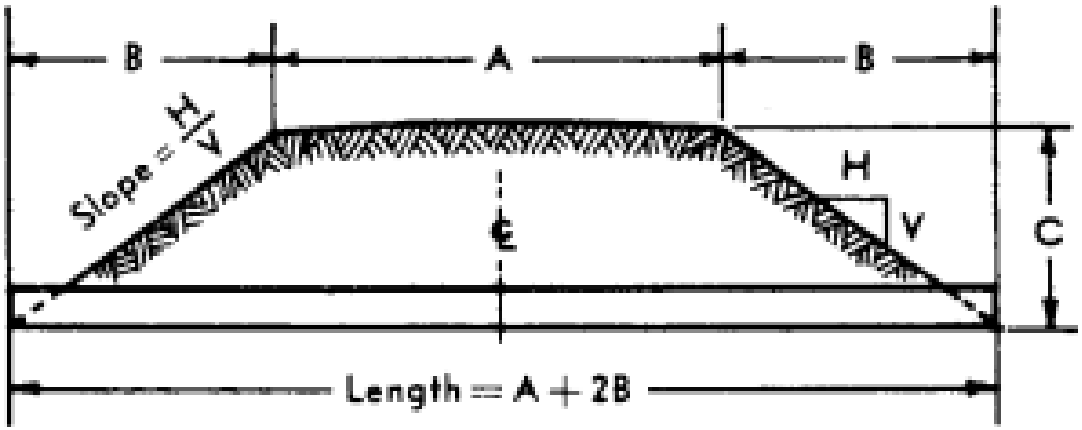


- Inlet/outlet control
- Design principles
- Installation practices
- Maintenance practices

Culvert Grades and Outfall Treatments



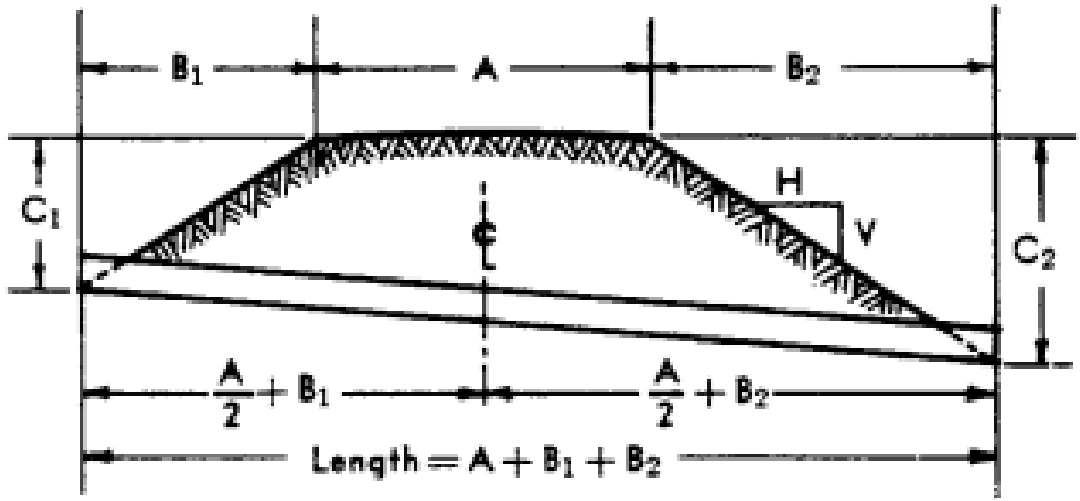
Basic culvert length



Example: Roadway = [1]24 ft., Slope = 1½:1, Depth of Fill = [2]10ft.
Then B = Side Slope × C = 1½ C
and Length = [1]24 + (3 × [2]10) = [3]54 ft.

Figure 24. Computation of culvert length-flow line on flat grade.

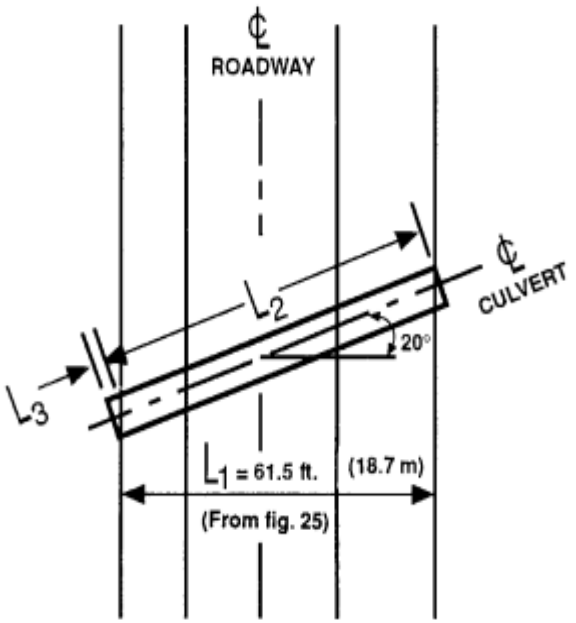
Culvert length on a grade



Example: Roadway = [1]24 ft., Slope = 1½:1,
Depth of Fill — Upstream = [3]10ft. Downstream = [4]15 ft.
Then $B_1 = 1½ \times C_1$ and $B_2 = 1½ \times C_2$
and Length = [1]24 + (1½ × [2]10 + 1½ × [4]15) = [5]61.5 ft., Use [6]62 ft.

Figure 25. Computation of culvert length-flow line on steep grade.

Skewed pipe length



PLAN VIEW

Use example in Figure 25, but the pipe is skewed 20° to the roadway (i.e., cross 20° off the perpendicular). The pipe is 4 ft. (1220 mm) in dia.

L1 = actual culvert length for no skew
= 61.5 ft. (18.7m) (from Figure 25)

$$L2 = \frac{L1}{\cos \text{skew}\angle} = \frac{61.5}{\cos 20°} = 65.4 \text{ ft. } (19.9\text{m})$$

L3 = pipe span x tan skew∠
= 4 x Tan 20° = 4 x 0.364 = 1.46 ft. (.45m)

Length = L2 + L3 = 65.4 + 1.46 = 66.86 ft. (20.3m)
use 68 ft. (20.5m)

Figure 26. Computation of culvert length skewed to the roadway embankment.

Problems seen in the field:

- Scour
- Sedimentation
- Perched pipes

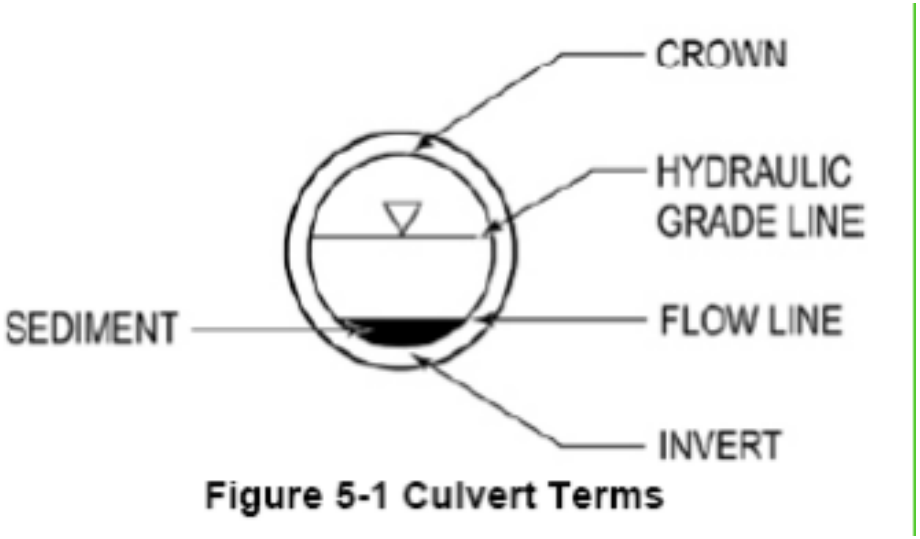


Figure 5-1 Culvert Terms

Problems….

More resources..

NCSPA

Installation Manual *for*

- **Corrugated Steel Pipe**
- **Pipe Arches**
- **Structural Plate**

All this discussion of culverts…. That begs the question!

Where are these located? Many are located near our streams, lakes and wetlands.

Maintenance of Unpaved Roads Near Wetlands

- Road Shoulders
- Vegetation considerations
- Silt Fences or Straw Bales or ????
- Excess Material disposal
- Slope Roads Away from Lakes Streams and Marshes
- Live Stream Crossings
  - Avoid Heavy Use of Salt
  - Proper Dust Control Practices
- Rip Rap and Water Steps

Maintenance of Unpaved Roads Near Wetlands

Over 50% of our nations Wetlands have been drained or otherwise lost since early colonization.

Wetlands provide many hunting, recreation, and fishing opportunities.

Why are wetlands important?

Wetlands serve many functions

- Mitigate flood impacts
- Enhance water quality
- Improve biological productivity
- Increase recharge of ground water
- Provide direct human benefits

Flood Impact Mitigation

- Storm Water Management
  1. Detain – Reduce Flood Peak
  2. Retain – Groundwater recharge
  3. Release – Slow release of surge

→Flood Peak Reduction←

Water Quality Enhancement

- Shoreline Stabilization
- Pollution Control
- Nutrient Removal and Transformation

Biological Productivity

- Freshwater Fish
- Habitat for Threatened and Endangered Species
- Rare Plant Habitat
- Nutrient Cycling

National Goal: No Net Loss of Wetlands

- US Government (bipartisan support) supports a policy of “No Net Loss.”
- …the nation establish a national wetlands protection policy to achieve no overall net loss of the nation’s remaining wetland base, as defined by acreage and function, and to restore and create wetlands where feasible the quality and quantity of the nation’s wetlands resource base.

Regulations Governing Wetlands

- Federal Government – Wetlands are considered “waters of the U.S.”
- State Government – Activities that modify the bed of a stream or bank are governed by the State of Montana.

Sedimentation

- Sedimentation fills drainage channels, and plugs culverts and storm drainage systems
- A stream constantly changes thalweg to adjusts to hydraulic needs of the water flows

Sedimentation

- Our activities can limit a stream's ability to maintain a balance. These include:
  - modifying streams,
  - diverting or adding water,
  - building in floodplains, or
  - removing vegetation

Sedimentation

- Avoid disrupting vegetation on road shoulders near lakes, streams, and wetlands.
- Minimize road maintenance 100 feet before and after live stream crossings (fords) to reduce sedimentation.


SOUP CR

Sedimentation

- Avoid grading excess material off road shoulders whenever possible.
- Establishing and maintaining adequate turf on roadway shoulder is often a difficult task.
- Remember the function of the shoulder is primary, vegetation growth must be favorable to the function

Factors Influencing Erosion

Vegetation Cover

- Shields the soils surface from the impact of falling rain
- Holds soil particles in place
- Maintains the soil's capacity to absorb water
- Slows the velocity of runoff; and
- Removes subsurface water between rainfalls through the process of evapotranspiration
- Topography
- Climate

Stabilization

- When feasible, use of vegetation in swales and ditches is the best method and most permanent method of erosion control
- Gravel Filter Berms
  - Construct gravel filter berms on road shoulders closest to lakes, streams, or wetlands.

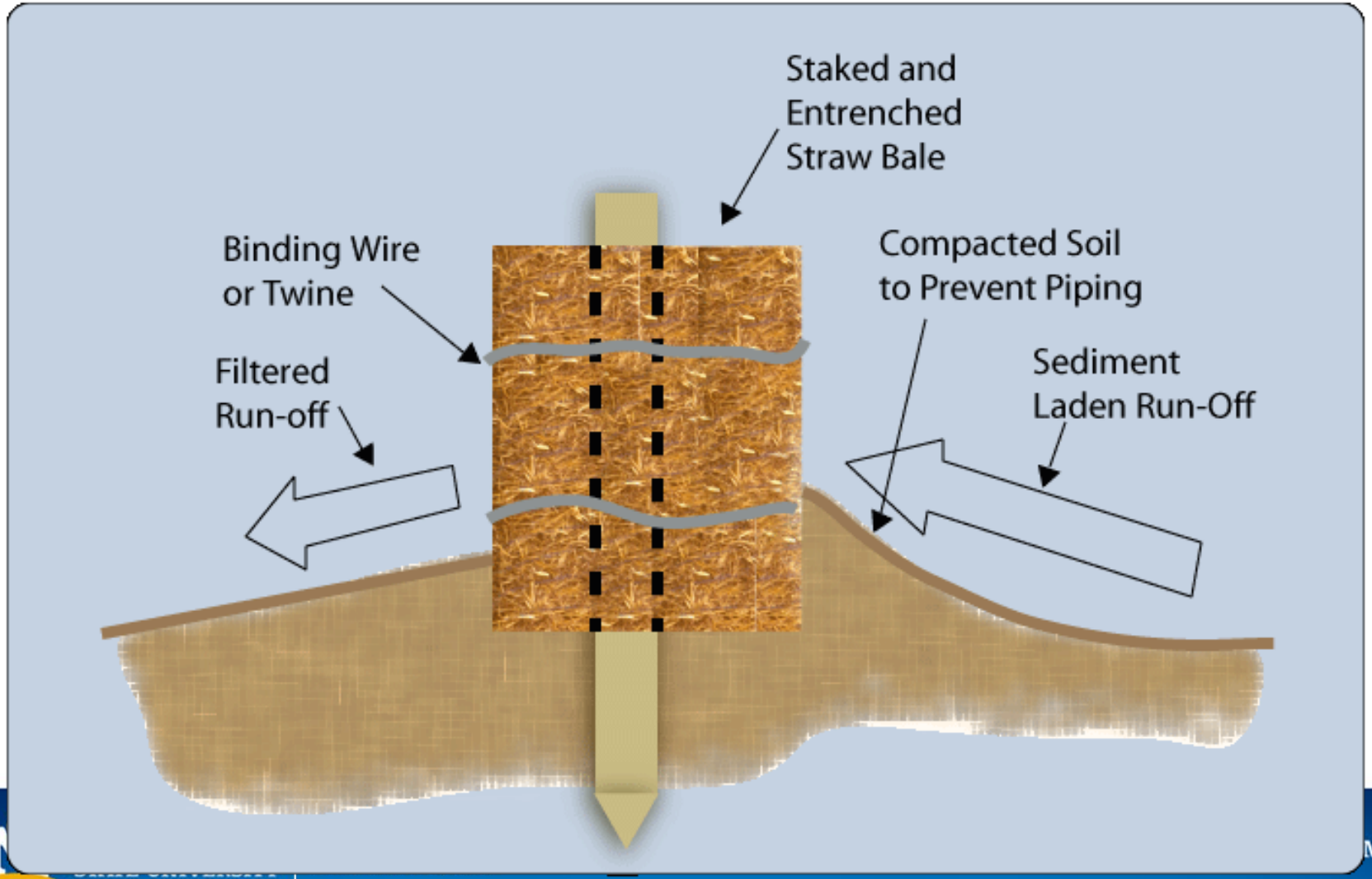
Sediment Control

- When feasible, use of vegetation in swales and ditches is the best method and most effective
- Slope roads away from lakes, streams, and wetlands

Sediment Control

- Avoid undercutting established slopes when removing material

Sediment Control
Function of Straw Bales



Riprap

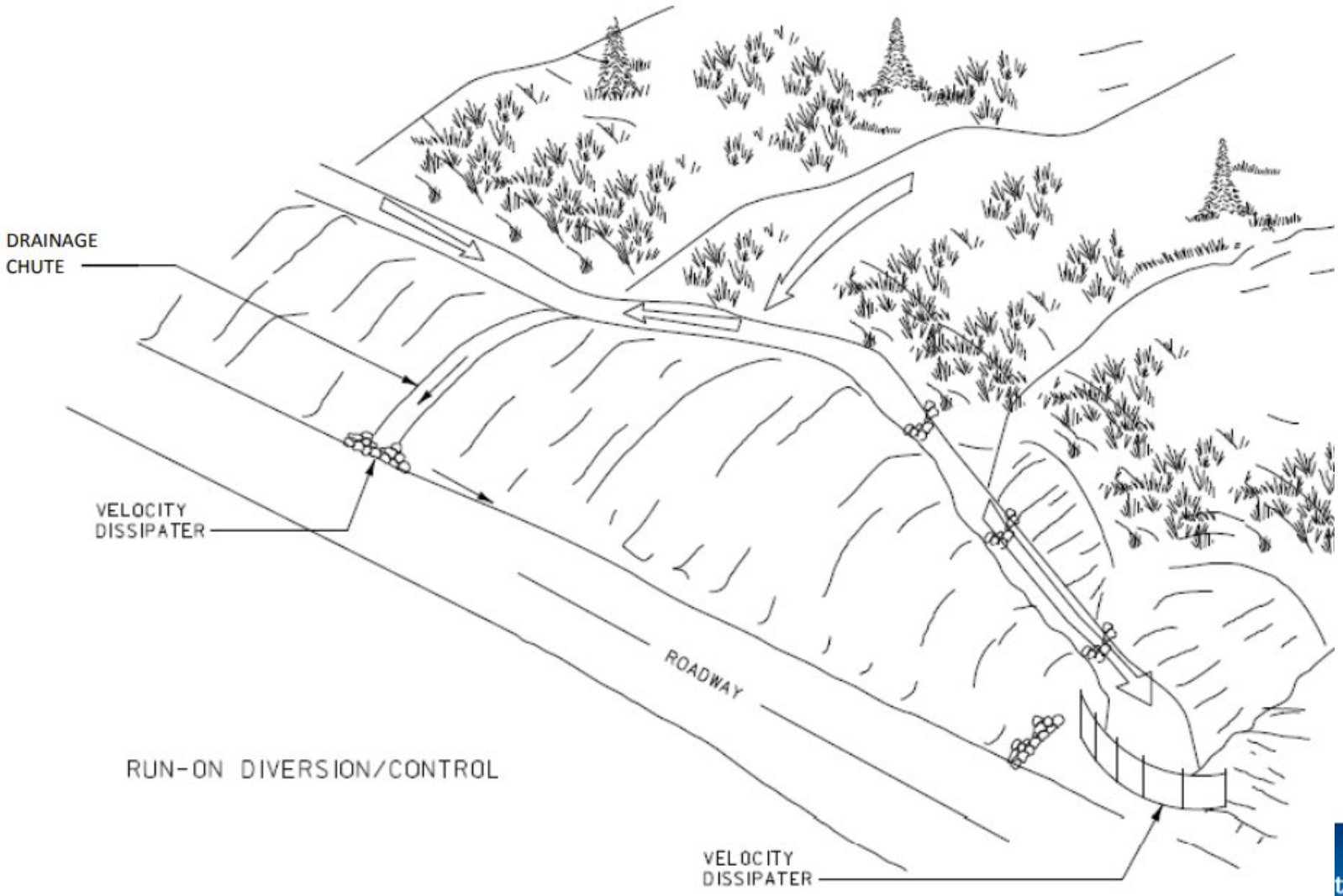
- Riprap can cause permanent changes to natural flow.
- For this reason, riprap should be used on outfalls from drainage ways only, not in live streams (without US Army CORPS of Engineers involvement)
-

Salt & the Environment

- Excessive amounts of sodium and chloride ions may have deleterious effects on water, soil, and vegetation
- Runoff from highway deicing operations can affect roadside wells, small ponds and other water supplies near the roadway.
- Avoid use of salt (including blocks) near lakes, streams, and marshes

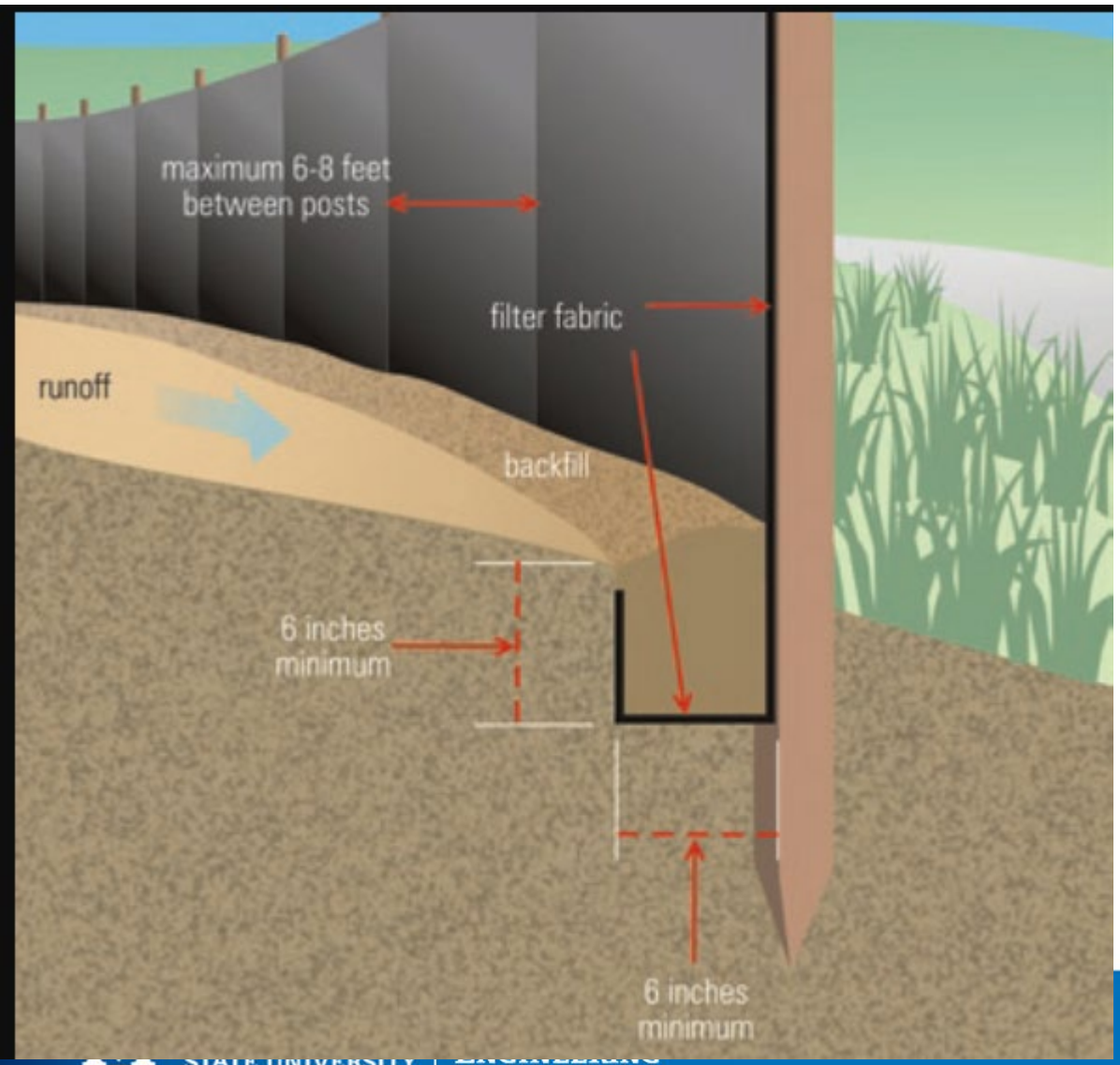
In the field…

- Construction-related Erosion Control can use available materials or engineered solutions
- Silt fence, wattles, straw bales all have pros and cons
- Use the concepts for long-term siltation control for all roads and bridges, not just during construction



RUN-ON DIVERSION/CONTROL

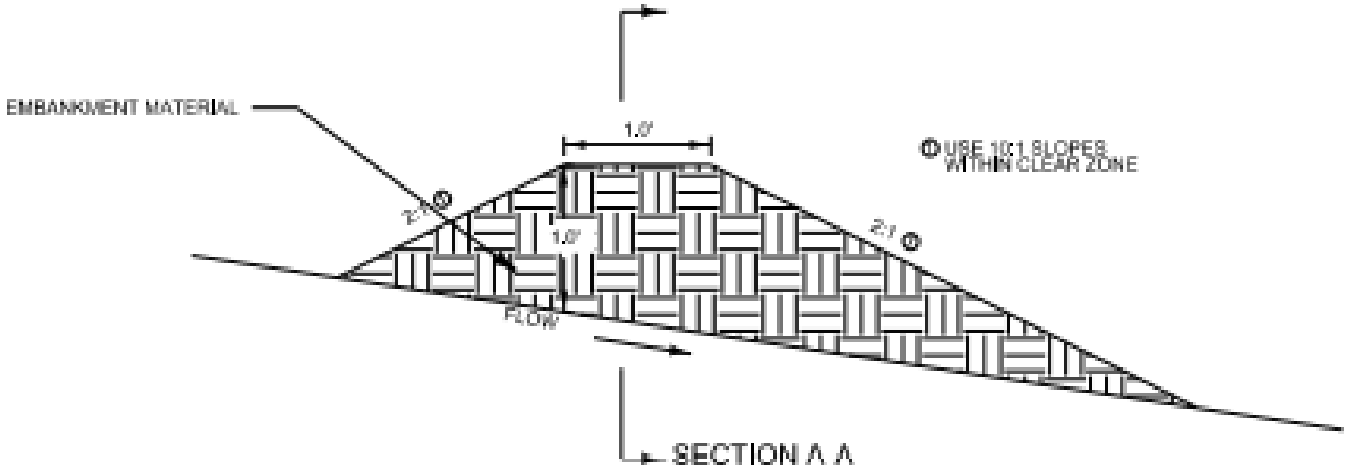
SILT Fence: Love or hate?

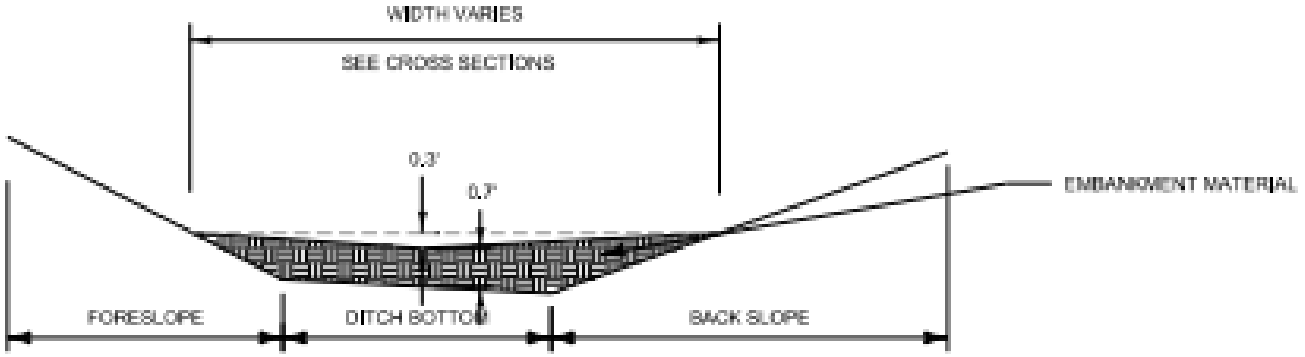


- Effective
- Relatively durable
- Labor intensive
- Must be removed
- Multiple ways to fail

VEGETATED EARTH CHECK DAM

DRAWING NOT TO SCALE

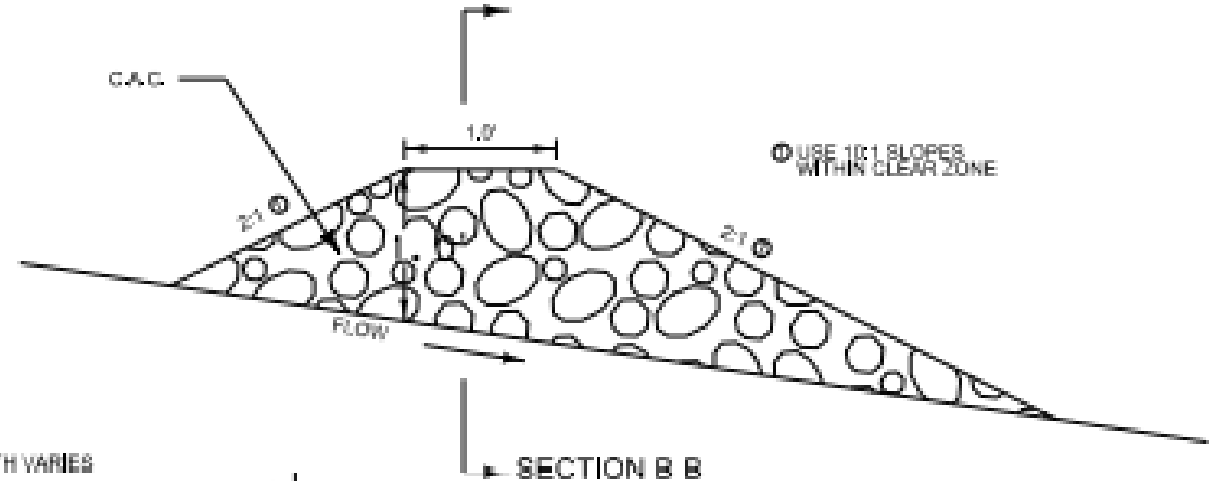


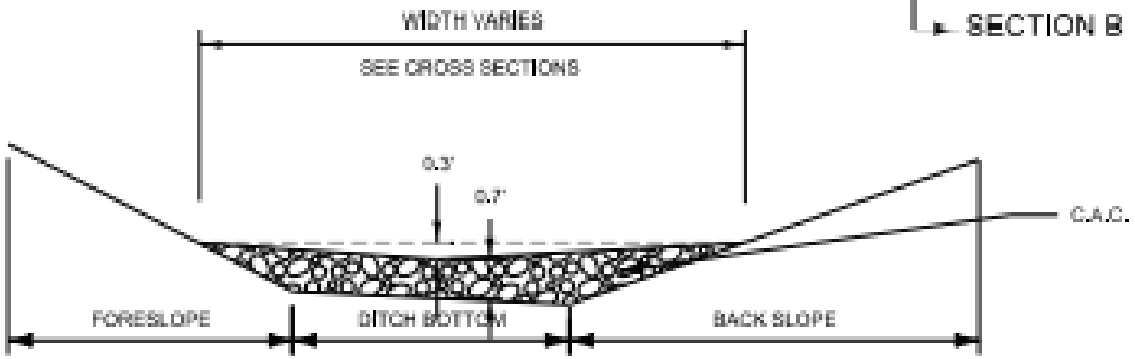


SECTION A-A

GRAVEL CHECK DAM

DRAWING NOT TO SCALE

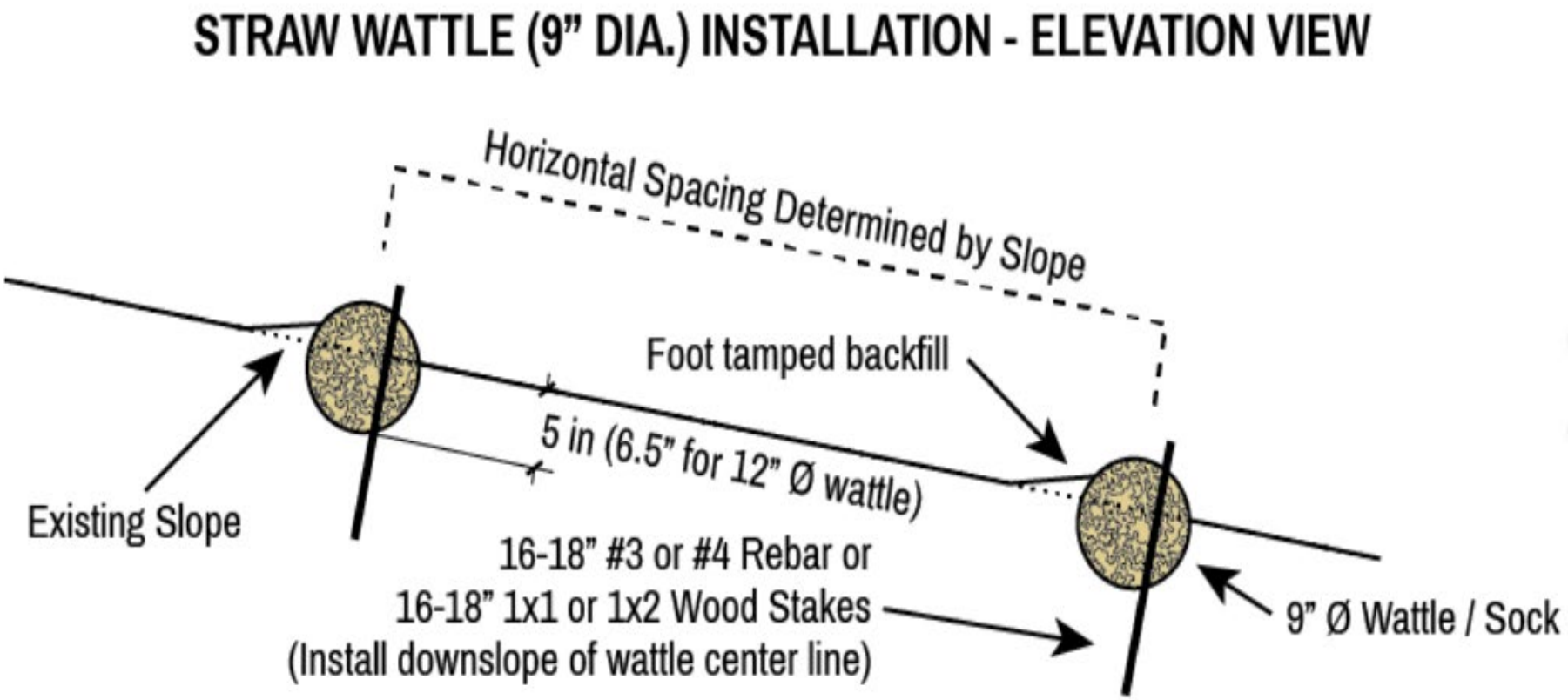


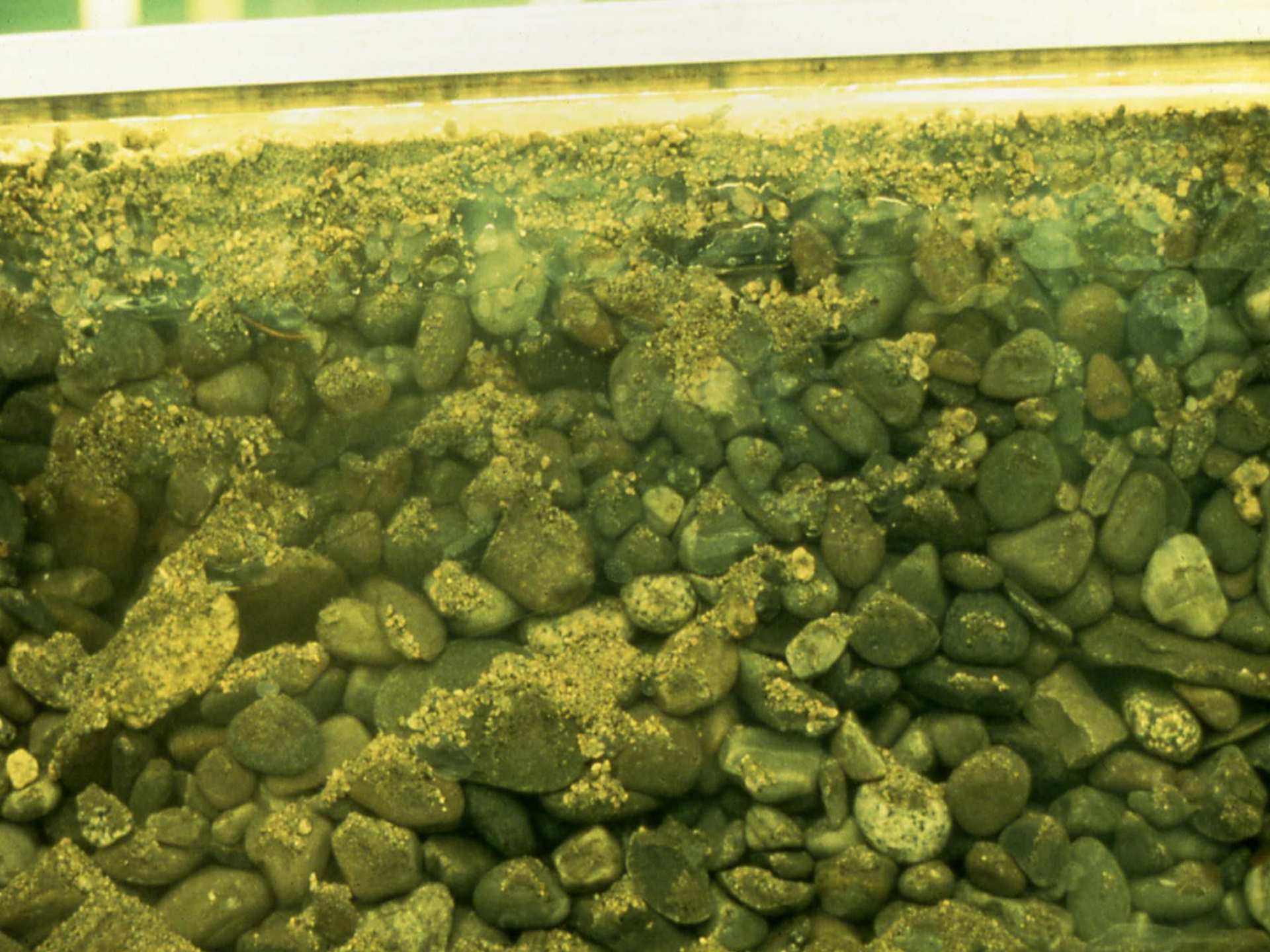


SECTION B-B

Straw Wattles

Straw Wattles





Drainage

- The three most important things to understand in building and maintaining roads are **drainage**, **drainage**, and **drainage**.

Three basic drainage topics:

1. Ditches
2. Culverts
3. Underdrains

Underdrains

- It may be cost effective to consider installing either a “fabric,” technically known as a geotextile, to help stabilize the road, and the addition of a perforated pipe can be used to carry water out of the roadbed.
- Many commercial products are pre-assembled for this purpose.

Underdrains

- The product most commonly used is a flexible polyethylene pipe. The pipe is installed longitudinally, generally parallel with the center line of the gravel road. Most commonly in the shoulder line.
- This method generally works best when the pipe has a fabric wrap or “sock” to keep very fine soils from infiltrating the pipe and plugging it.

Drainage is key

Roadway Drainage

- Crowning
- Ditches
- Culverts
- Road Base

Maintenance problems, and therefore expenditures are primarily a result of drainage problems in the road structure.

Excavations and trenching safety

Excavations and trenching safety

Excavations and trenching safety

Slope Safety

To Prevent Cave-In During Excavation,
Use the Proper Slope Angle for Different Soil Types

Soil Type: Stable Rock
Max. Slope (H:V) Vertical
Slope Angle (Degree): 90

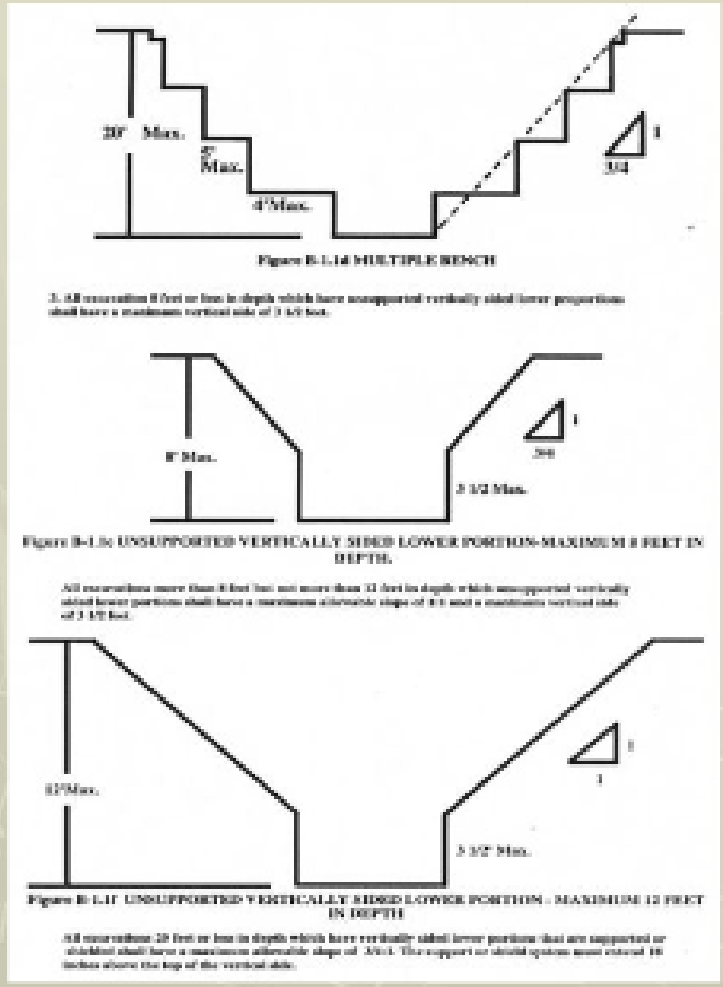
Soil Type: Type A
Max. Slope (H:V) 3:4 : 1
Slope Angle (Degree): 53

Soil Type: Type B
Max. Slope (H:V) 1 : 1
Slope Angle (Degree): 45

Soil Type: Type C
Max. Slope (H:V) 1-1/2 : 1
Slope Angle (Degree): 34

Means of Egress: Must be Within 25 FT From Where Employees are Working.

Benching



- Can stand alone or in combination with sloping
- Type C soils cannot be benched
- In multiple bench situations, max bench height of first bench is 4'
- In bench-slope combinations, max bench height of first bench is 3.5'

Culverts

Culverts

Culverts

Culverts

Roadway Drainage Concepts


IN LONDON THEY DRIVE
ON THE LEFT... IN MONTANA
WE DRIVE ON WHAT'S LEFT

Questions?

Matt Ulberg, Montana LTAP, 1-406-531-1142, matthew.ulberg@montana.edu

Get ready to face the challenges of maintaining gravel roads in the future!

Good Luck and Thank You!