Tahoe Unsurfaced Roads Workshop
UC Cooperative Extension / SAF / TRPA / LWQCB / CGS / USFS

Low-Volume Roads Engineering:

Best Management Practices

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OBJECTIVES

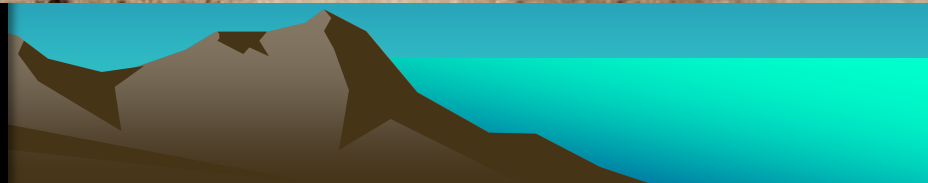
- Present key planning, design, & maintenance issues important to low-volume roads (LVR).
- Understand environmental mitigations and their importance.
- Discuss appropriate and new technologies for LVR.
- Present useful references on each topic.

SOME KEY POINTS

- Apply the Basics and BMPs.
- Use Appropriate, Innovative Technology.
- Protect Roads Against Storms.
- Eliminate/Close Un-needed Roads.
- People are Like Gold--Precious! Get Them and Keep Them.
- Use Specialists when Needed.

What is a Low-Volume Road?

ADT < 400 VPD



What is a Low-Volume Road?

USDA Forest Service

- 77,000,000 Hectares of Land
- 155 National Forests
  - Most Forests have 3-6 Districts
- More than 600,000 Km. Of Roads
  - 7% Paved
  - 18% Surfaced with Aggregate
  - 75% Native Soil Surfacing
- Responsible for Forest and Watershed Management

Roads Best Management Practices

Key Practices (Summary)

- Involve the Road Users
- Minimize Road Standards (but Be Safe)
- Avoid Wet, Unstable and Steep Areas
- Design Drainage Crossing Structures
- Control Road Surfaces Water
- Disconnect the Road from the Drainages
- Provide AOP and Wildlife Crossings on Roads
- Use Stable Cut and Fill Slope Angles

Roads Best Management Practices

Key Practices (Cont.)

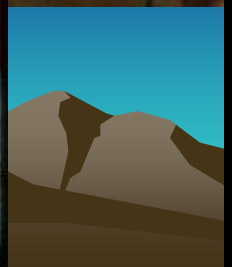
- Stabilize Failing Slopes
- Armor/Surface your Roads
- Develop, but Rehabilitate Quarries/Borrow Pits
- Apply Erosion Control Measures
- Maintain the Road!!!
- Involve and Train your Road Personnel!


THE BASICS

A Well Built Minimum Impact Road

- Planning/Environmental Analysis
- Location
- Design
- Construction
- Maintenance
- Road Closure or Obliteration

PLANNING



Road Planning

ENVIRONMENTAL ANALYSIS

An Environmental Analysis Process

1. Identification of the Project
2. Scoping
3. Data Collection and Interpretation
4. Design of Alternatives
5. Evaluation of Effects
6. Comparison of Alternatives
7. A Decision and Public Review
8. Implementation and Monitoring

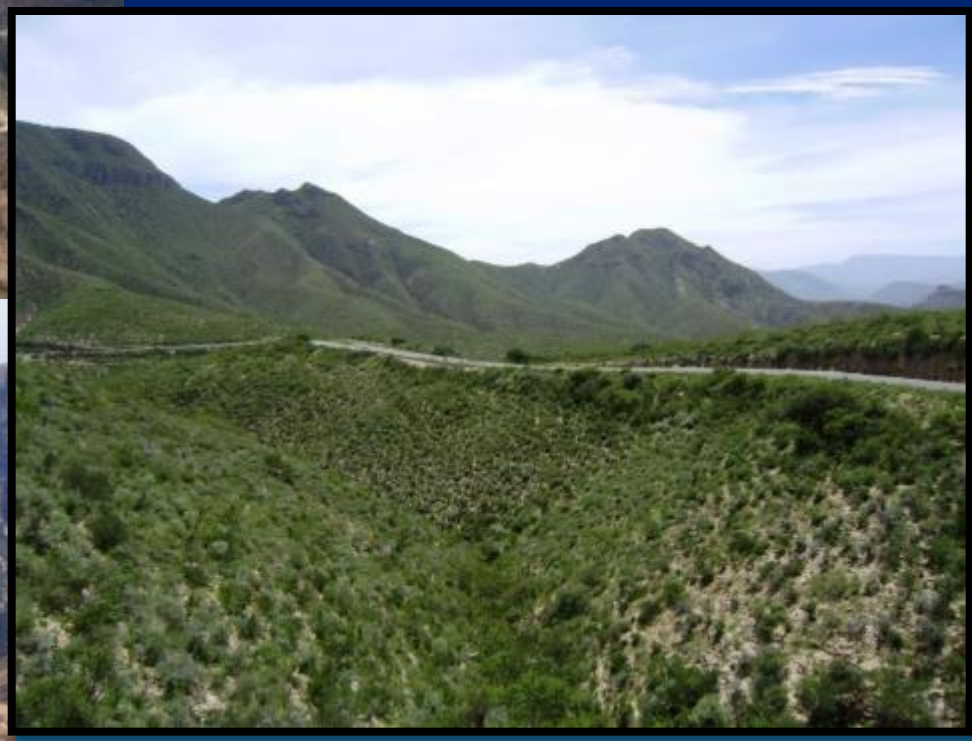

COMMUNICATION
COMMUNICATION
COMMUNICATION!

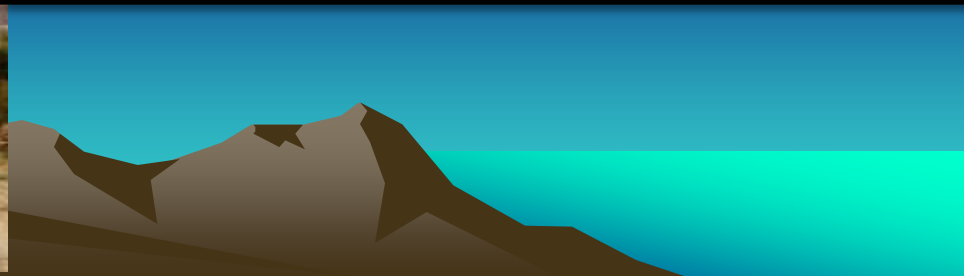
GOOD PLANNING AND DESIGN IS CRITICAL

Design may be relatively basic—

Today key issues are commonly:
-Social
-Financial
-Environmental
-Maintenance

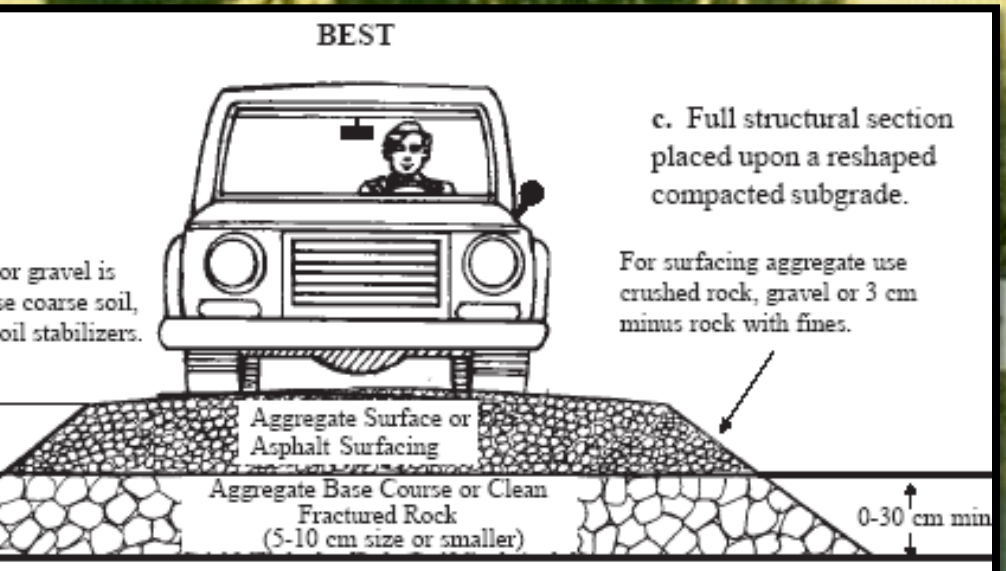
LOCATION

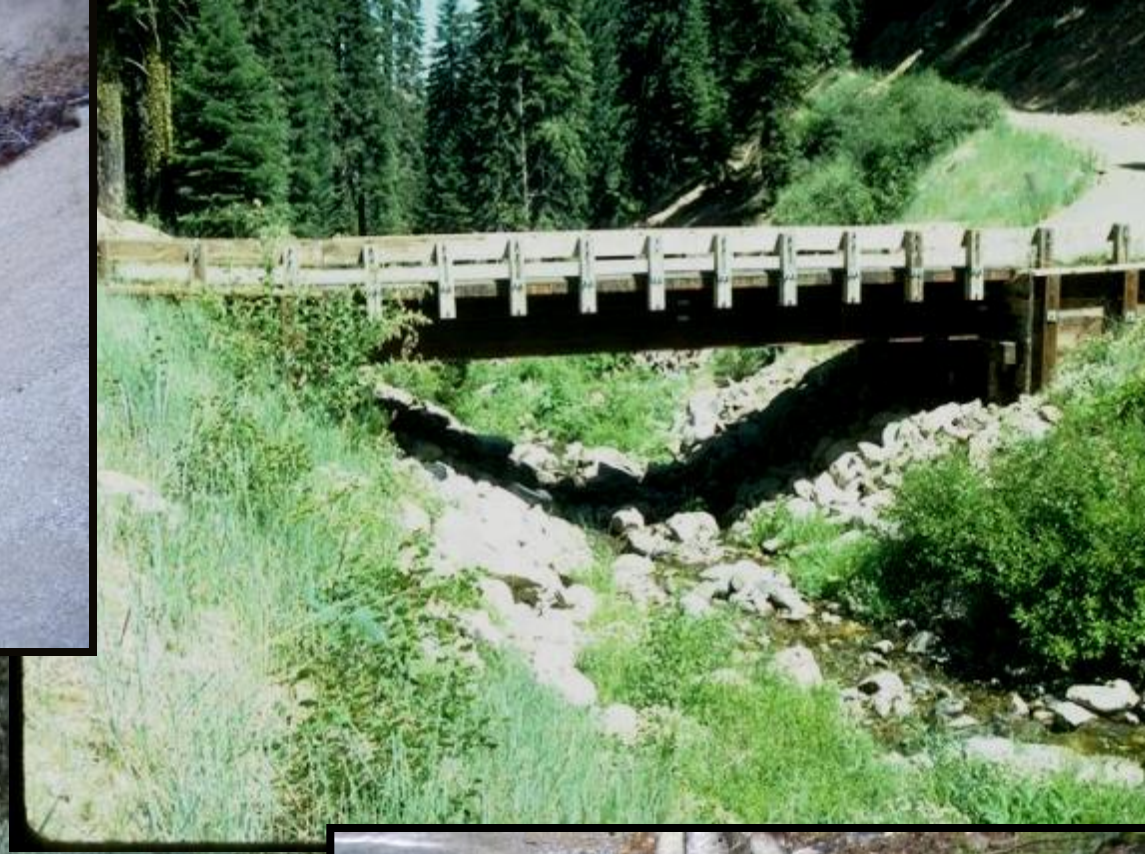




POOR LOCATIONS

DESIGN


BEST
c. Full structural section placed upon a reshaped compacted subgrade.
For surfacing aggregate use crushed rock, gravel or 3 cm minus rock with fines.
or gravel is
e coarse soil,
oil stabilizers.
Aggregate Surface or Asphalt Surfacing
Aggregate Base Course or Clean Fractured Rock (5-10 cm size or smaller)
0-30 cm min




CONSTRUCTION-
RECONSTRUCTION


AMANCO-Colombia

Oops!


SAMPLING & TESTING

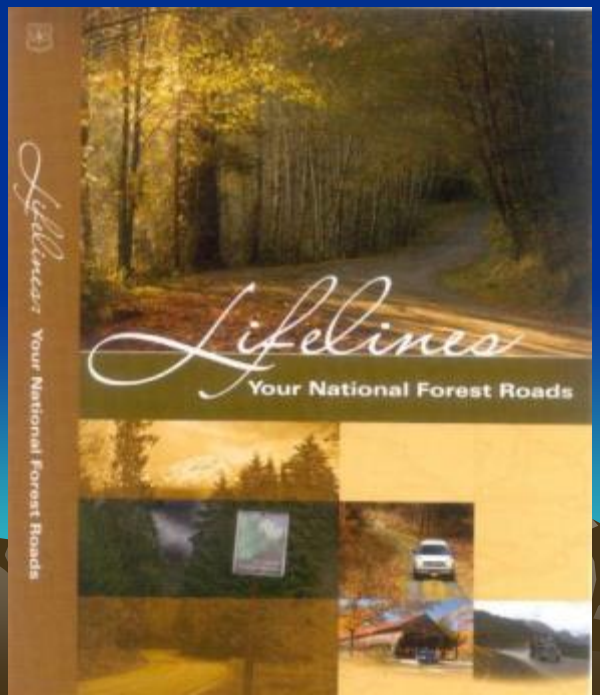
You Get What You Inspect,
Not What You Expect

MAINTENANCE

Road Maintenance Guides

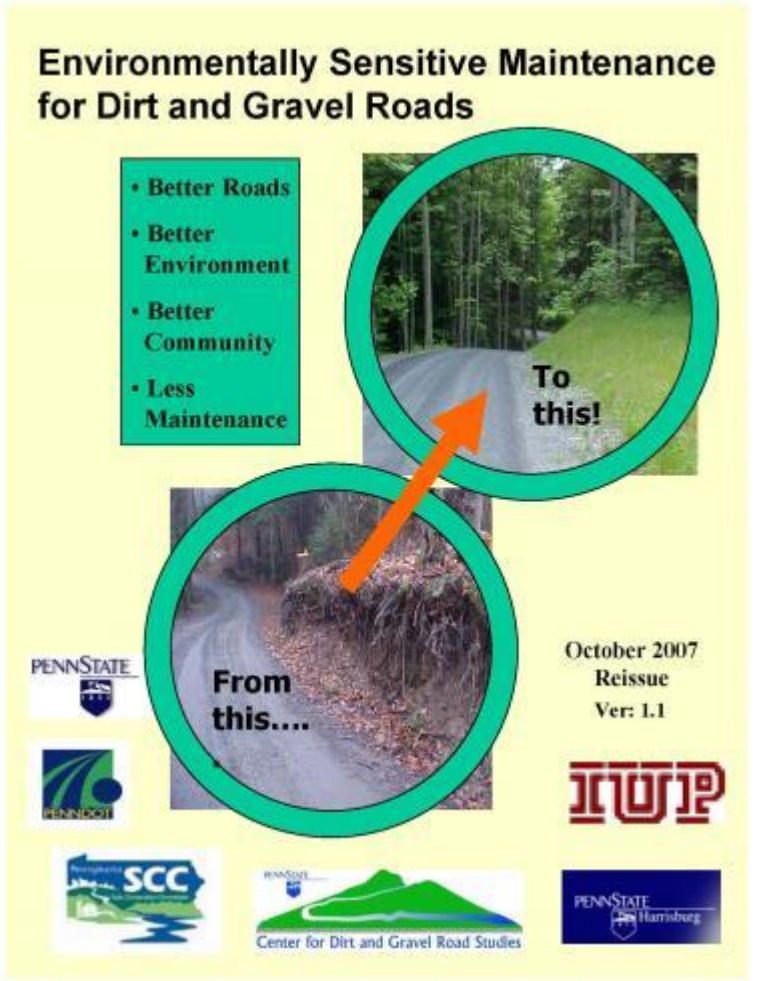
Video Titles

Forest Roads and the Environment
Reading the Traveled Way
Reading Beyond the Traveled Way
Smoothing and Reshaping the Traveled Way
Maintaining the Ditch and Surface Cross Drains



A Field Guide with

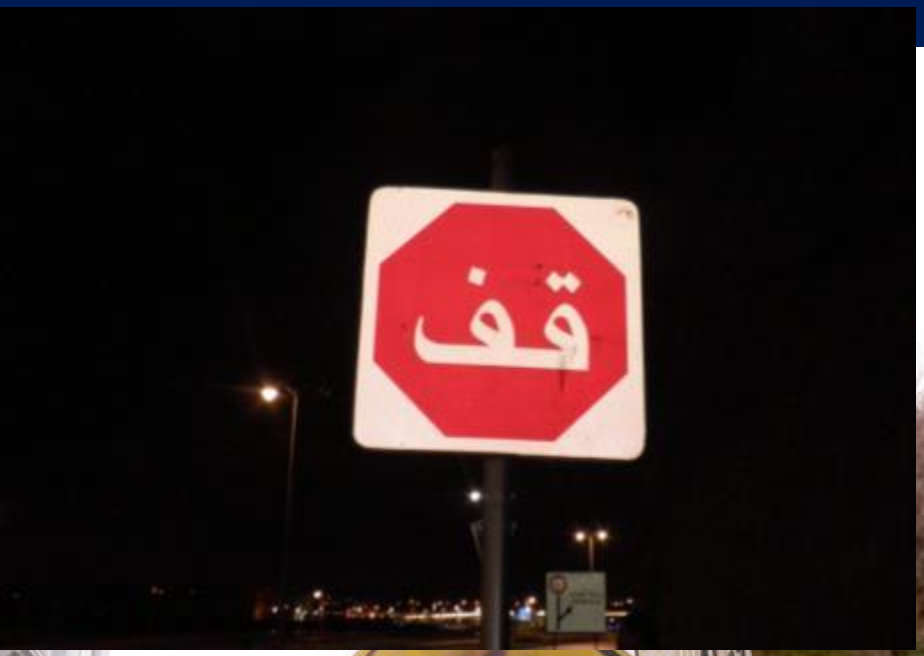
Penn State U, Penn DOT, EPA




SAFETY

-Road Safety Audits

POOR OR MISSING SIGNS



IMPROVING SIGHT DISTANCE

ROADSIDE HAZARDS

LACK OF DRIVER TRAINING

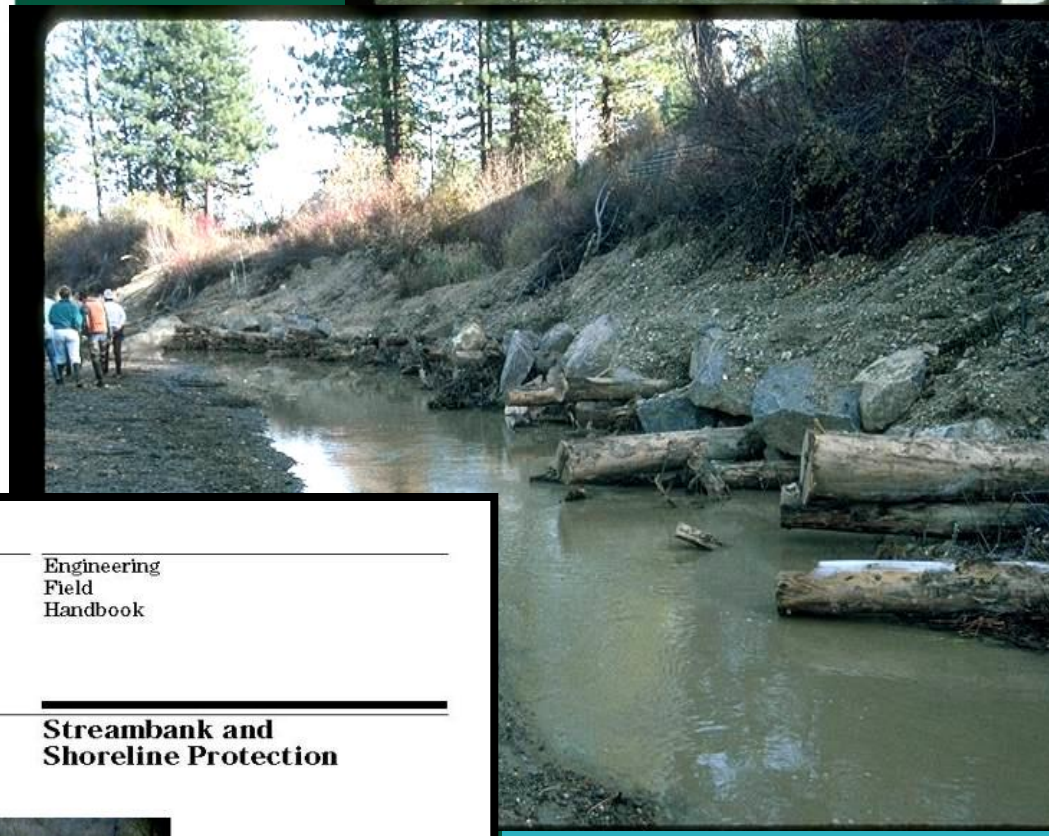
ROAD CLOSURE


"Ideas are a Dime a Dozen.
People who Put Them into Action
are Priceless"
That is YOU!

HYDRAULIC TOOLS

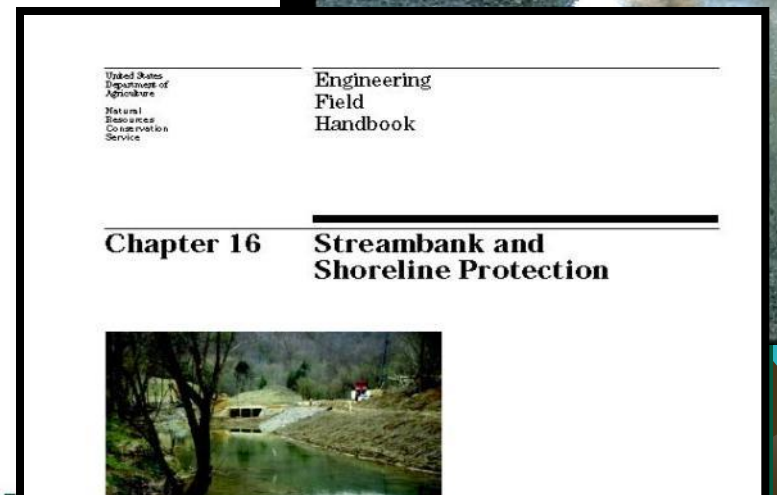
NCHRP
REPORT 544

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM



Environmentally Sensitive Channel- and Bank-Protection Measures

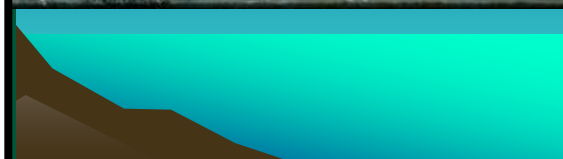
Donald Gray
John McCullah


United States Department of Agriculture

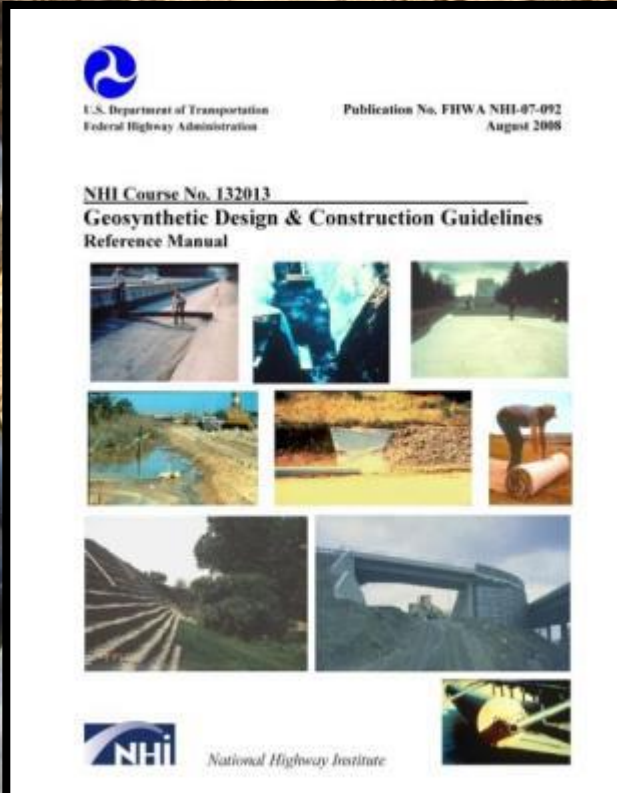
Natural Resources Conservation Service

Engineering Field Handbook

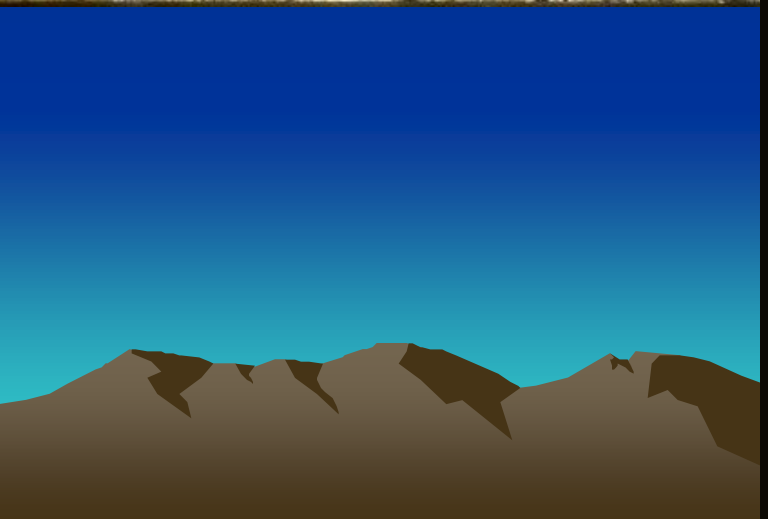
Chapter 16 Streambank and Shoreline Protection

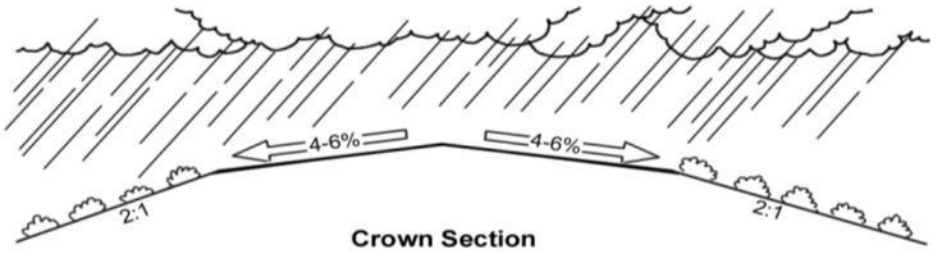


USE OF GEOSYNTHETICS

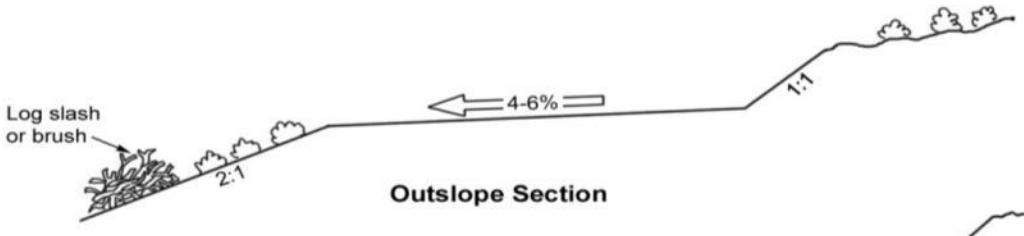


SURFACE DRAINAGE

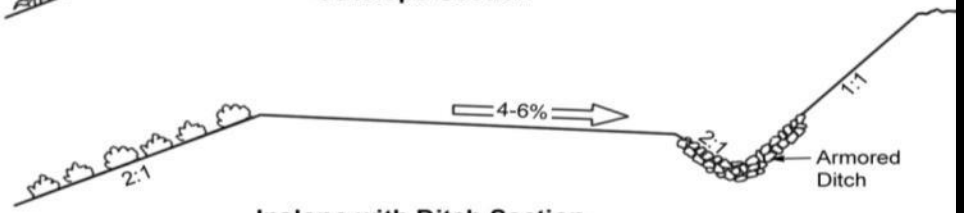




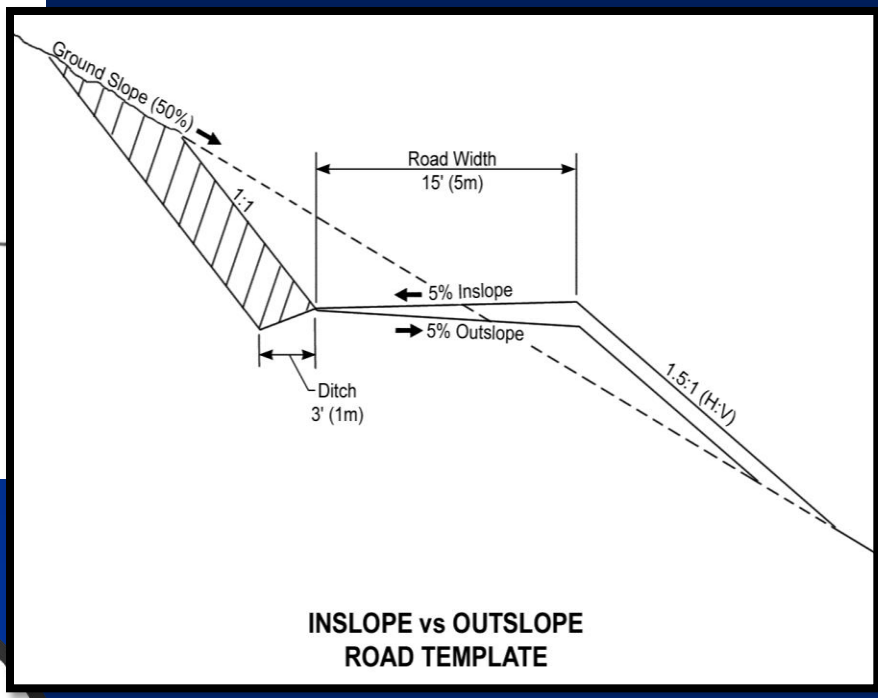
Crown Section



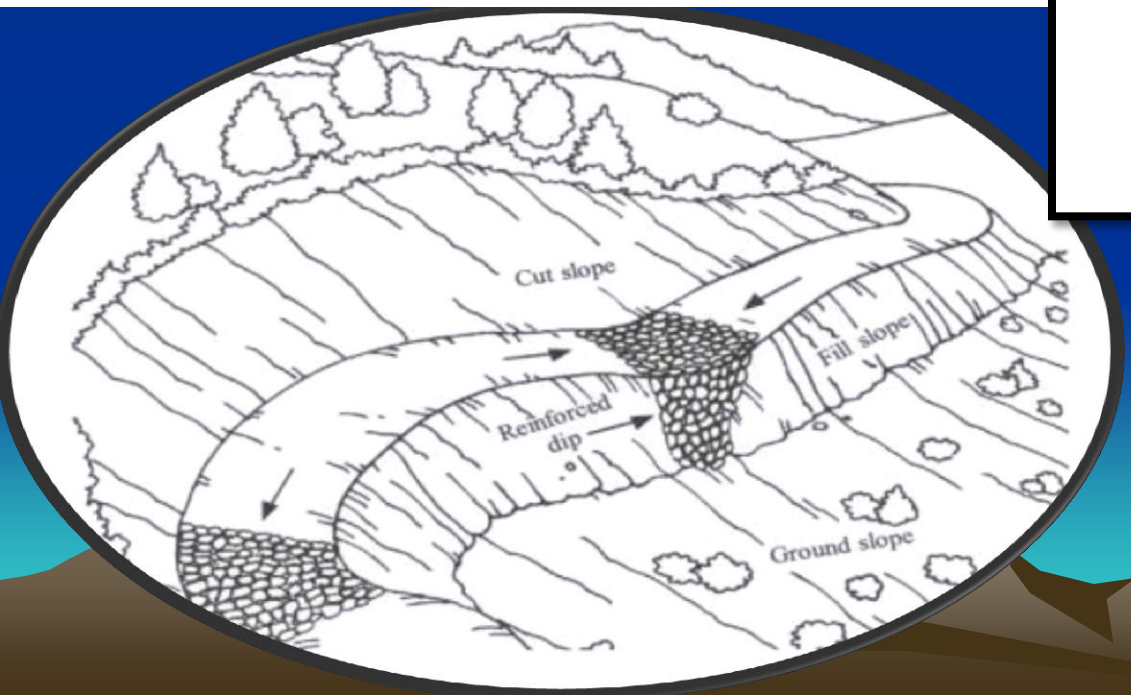
Outslope Section

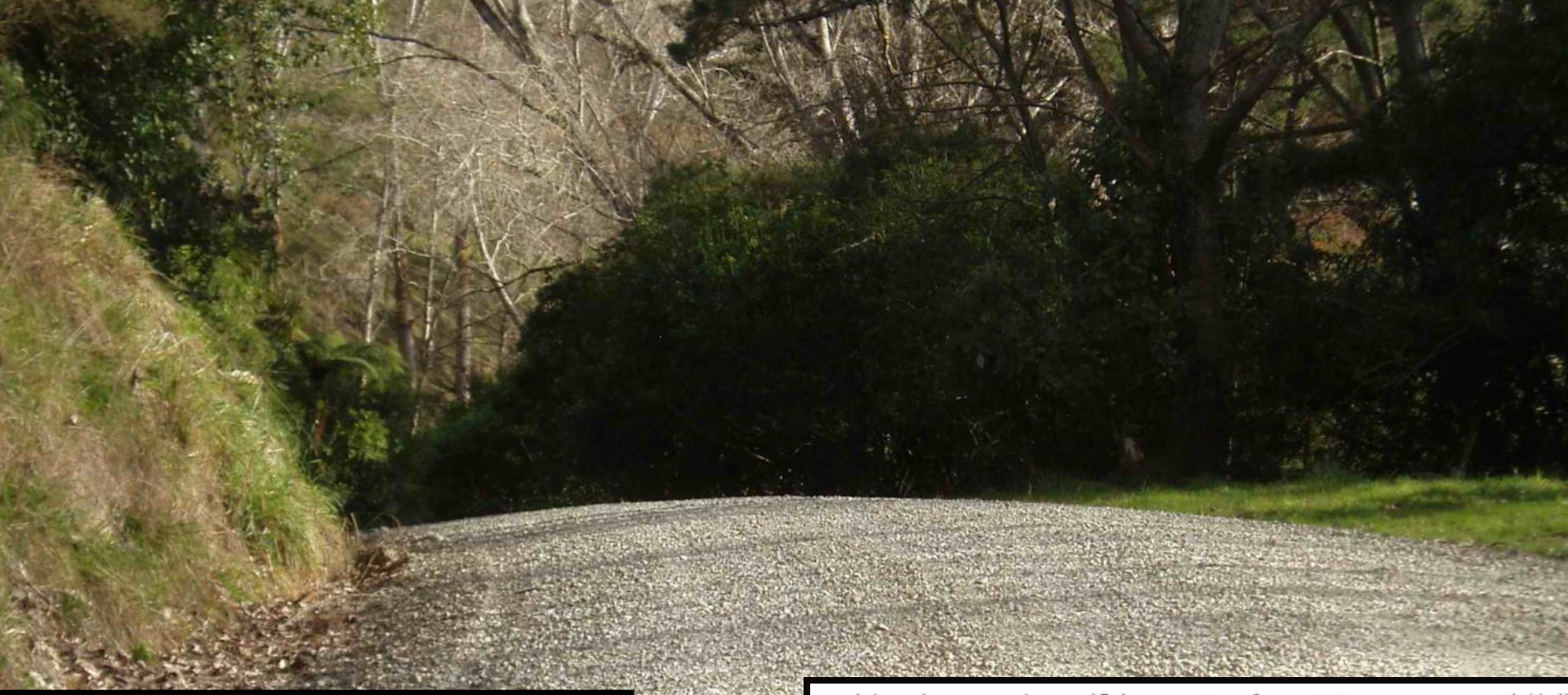


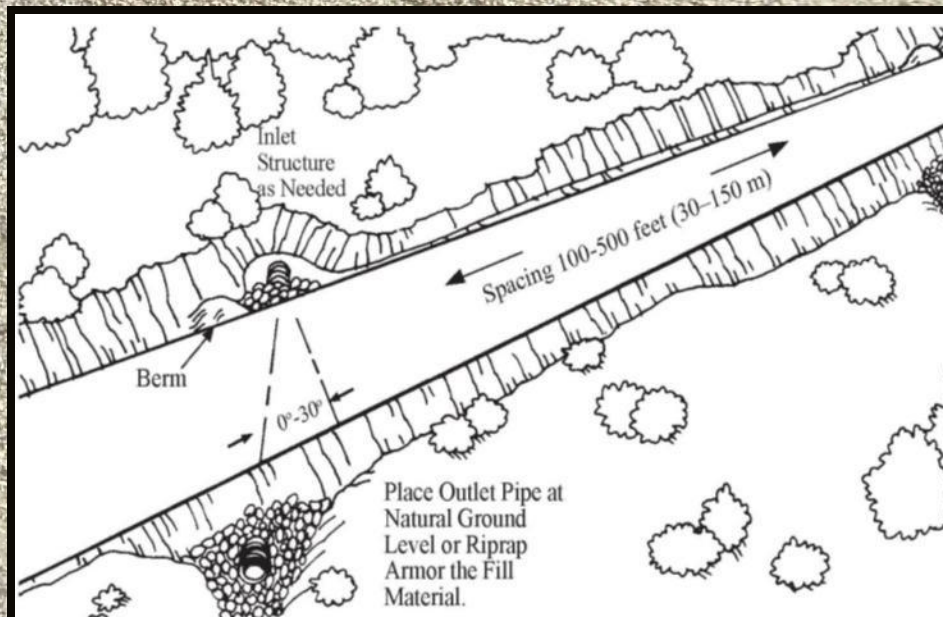
Inslope with Ditch Section



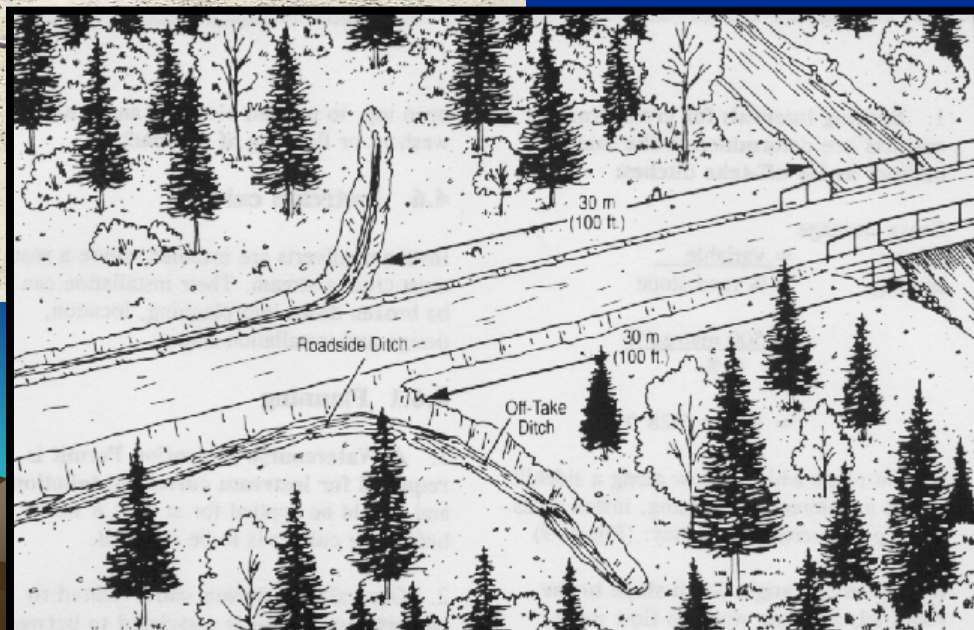
INSLOPE vs OUTSLOPE
ROAD TEMPLATE



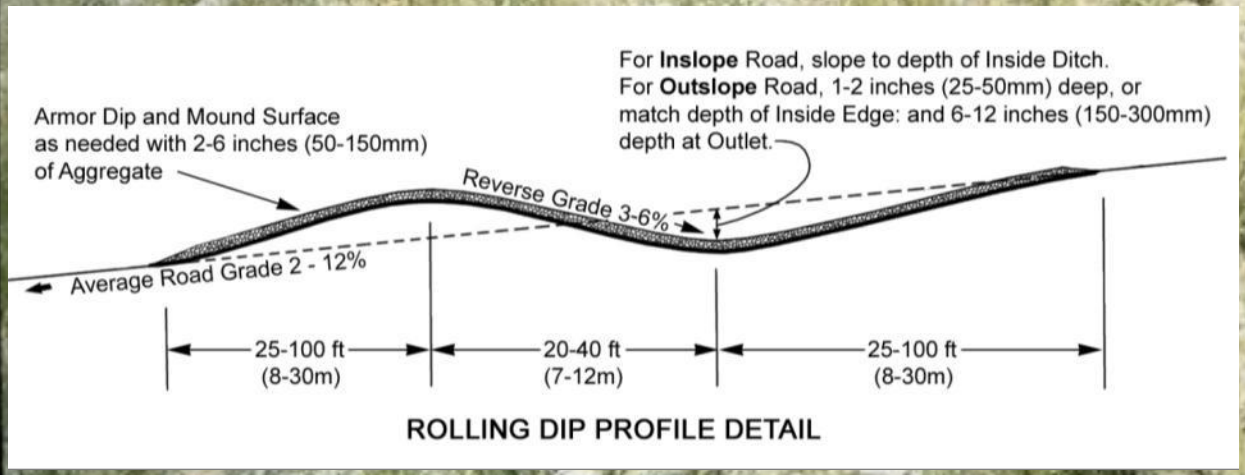



Inlet
Structure
as Needed
Spacing 100-500 feet (30–150 m)
Berm
0°-30°
Place Outlet Pipe at
Natural Ground
Level or Riprap
Armor the Fill
Material.

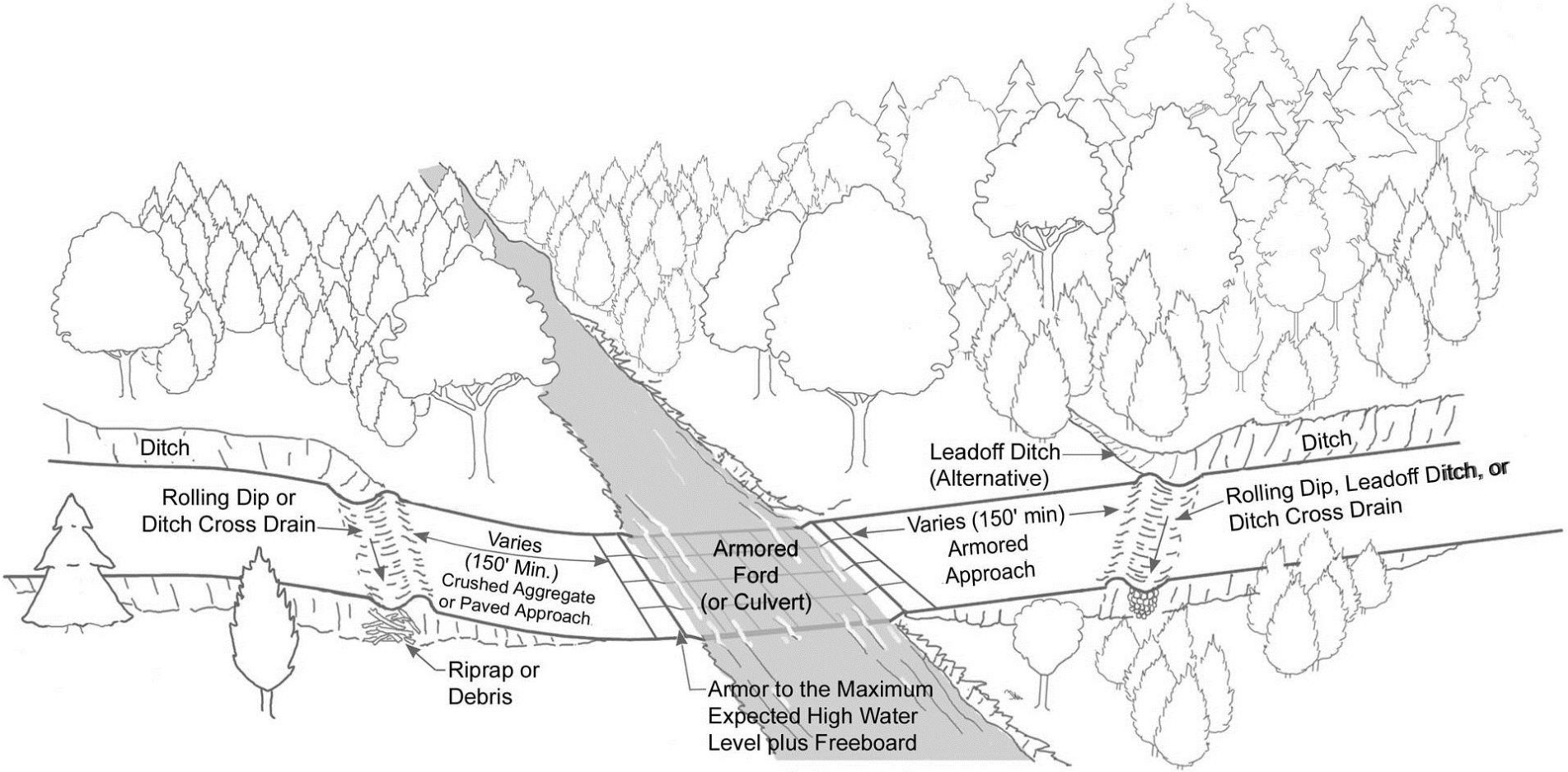
Get Water off the road!!
Disconnect the Road and Stream



Rolling Dips



ROLLING DIP PROFILE DETAIL



Armor or stabilize the actual stream crossing (ford) structure and add surface armoring to the roadbed and approach. Drain water off the road surface before reaching the crossing. Road surface armor should be a minimum of 150 feet and should extend to the nearest cross-drain structure. Actual distance depends on road grade, soil type, rainfall, etc.
For fords, set stream channel armoring at the elevation of the natural stream bottom. Armor outlets and fills as needed.

Figure 7.7.3 **SEDIMENT PROTECTION MEASURES AT STREAM CROSSINGS**


Keep Grades less than 12-15 %


SUZUKI
Sport

SUBSURFACE DRAINAGE

Drainage Crossing Structures

- Culverts
- Fords and LWX
- Bridges


CULVERTS

Types of Culverts

- Corrugated Metal Pipe

- Plastic

- Concrete

- Masonry Box Culverts
- Wood

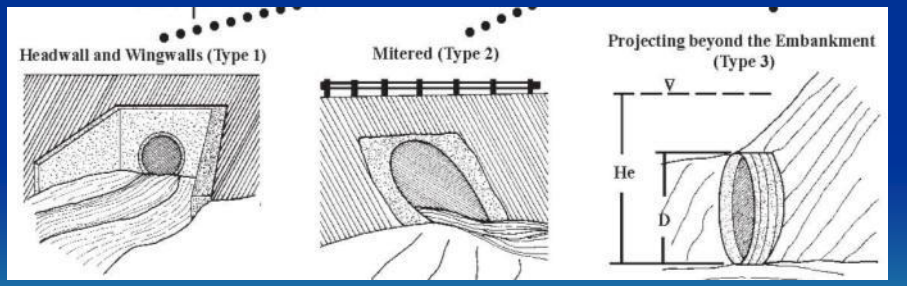
- Determining Design Flows
  - USGS Regression Equations
  - http://water.usgs.gov/osw/streamstats/
  - Gauging Data
  - Mannings-Slope-Area Method with High Water Marks
  - NRCS Programs Win TR-20
  - Rational Method

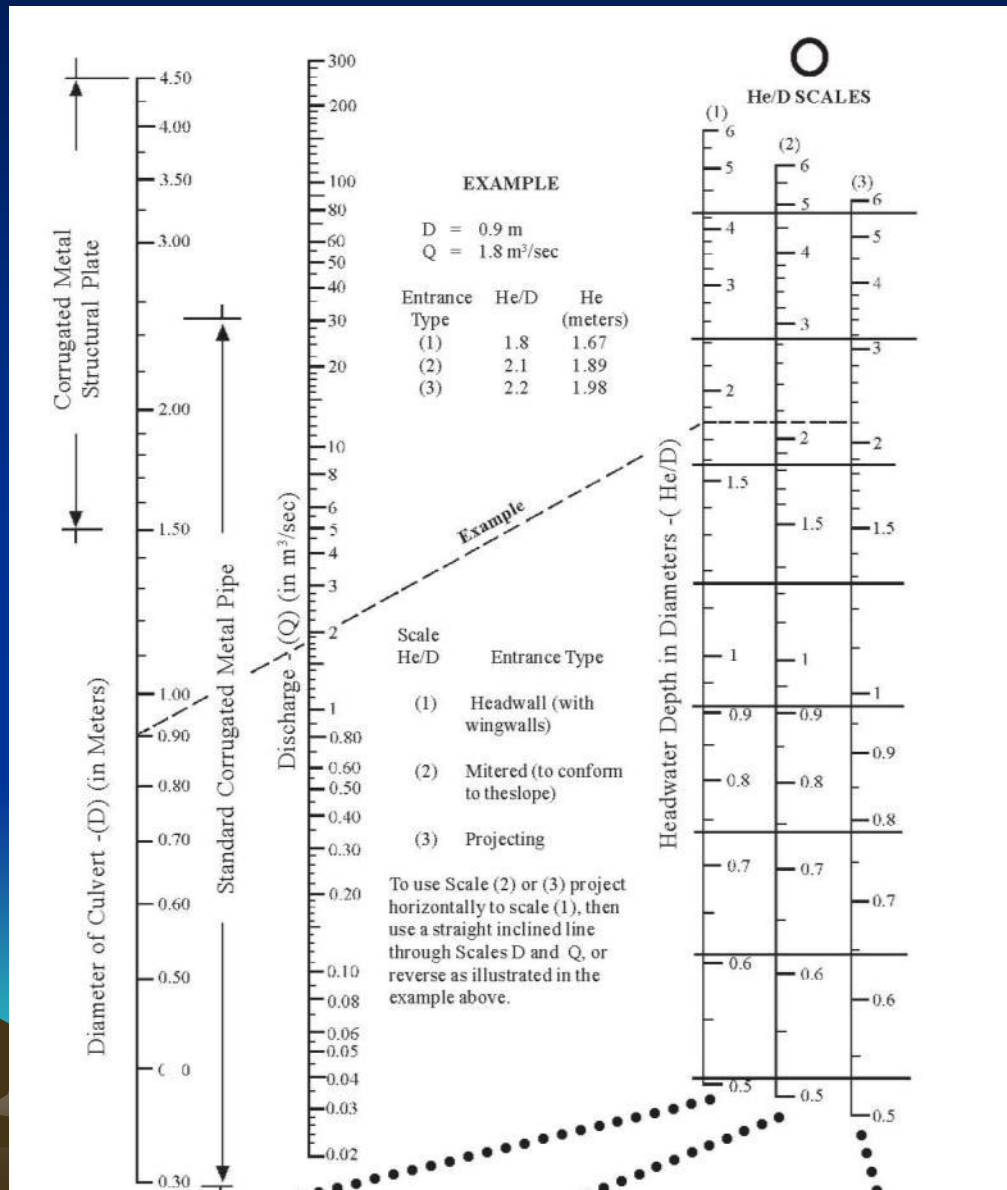
**Sediment and Debris

**Matching Channel Shape

Culvert Hydraulics

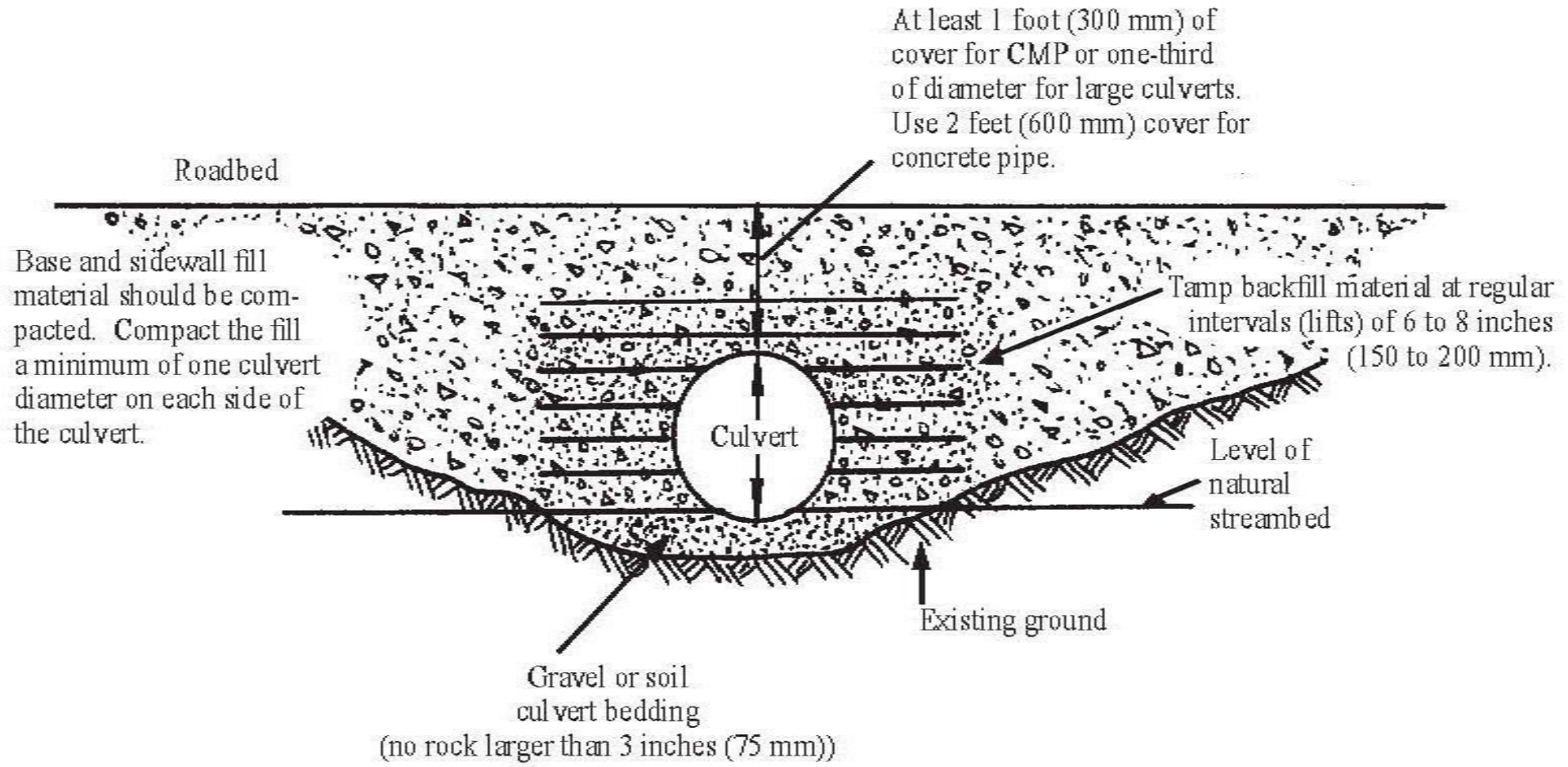
- **FHWA Nomographs**
  From FHWA -HDS 5
  "Hydraulic Design of Highway Culverts"





DESIGN ISSUES

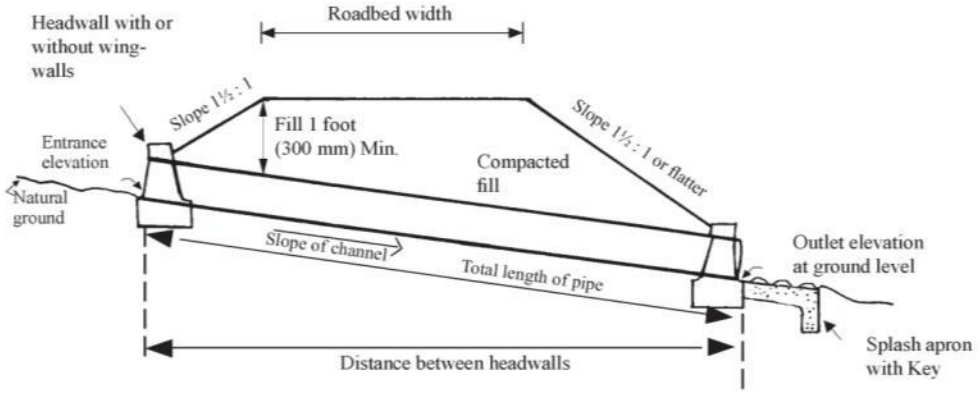
- Alignment
- Length
- Bedding, Backfill and Compaction
- Multiple Pipe Spacing
- Inlet / Outlet Protection
- Headwalls, Wingwalls, Inlets
- Dewatering


At least 1 foot (300 mm) of cover for CMP or one-third of diameter for large culverts. Use 2 feet (600 mm) cover for concrete pipe.
Roadbed
Base and sidewall fill material should be compacted. Compact the fill a minimum of one culvert diameter on each side of the culvert.
Tamp backfill material at regular intervals (lifts) of 6 to 8 inches (150 to 200 mm).
Culvert
Level of natural streambed
Existing ground
Gravel or soil culvert bedding (no rock larger than 3 inches (75 mm))

Multiple Pipes

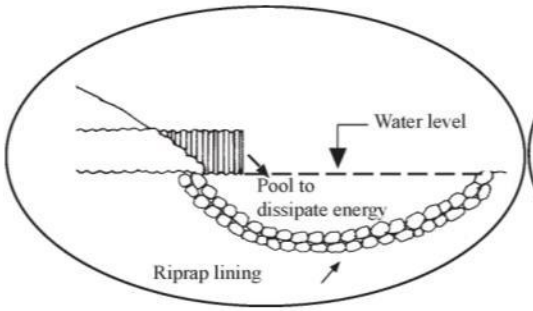
One Big Pipe is Better than Multiple Smaller Pipes!!

Installation-Inlet-Outlet Protection

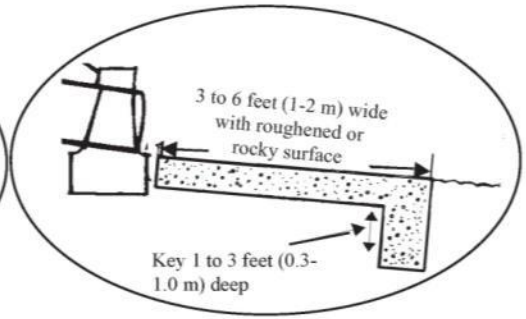


Typical culvert installation with headwalls and splash apron or plunge pool with riprap for energy dissipation and scour control.

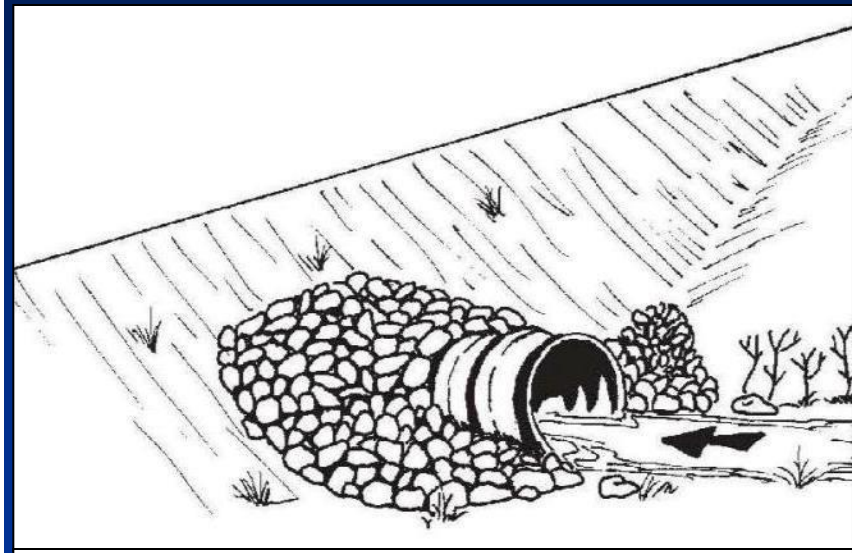
or

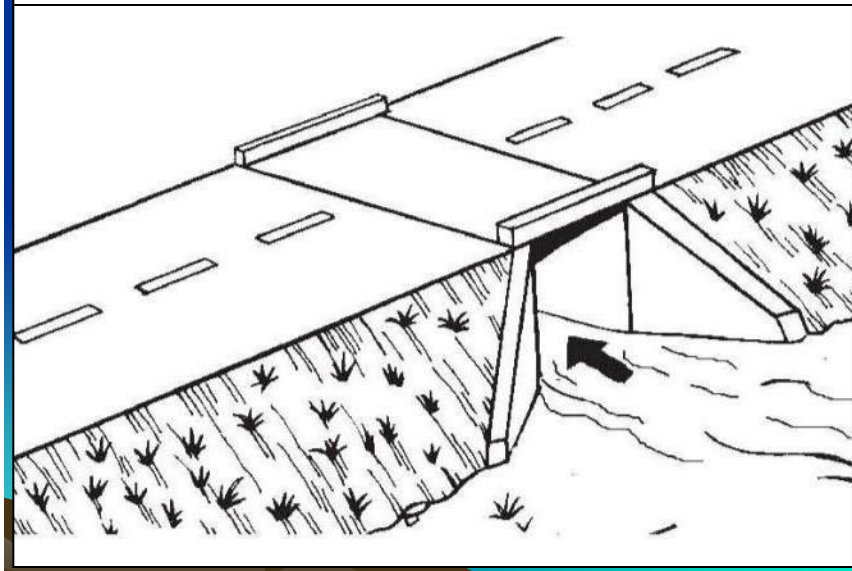


Detail of outlet with riprap and plunge pool.



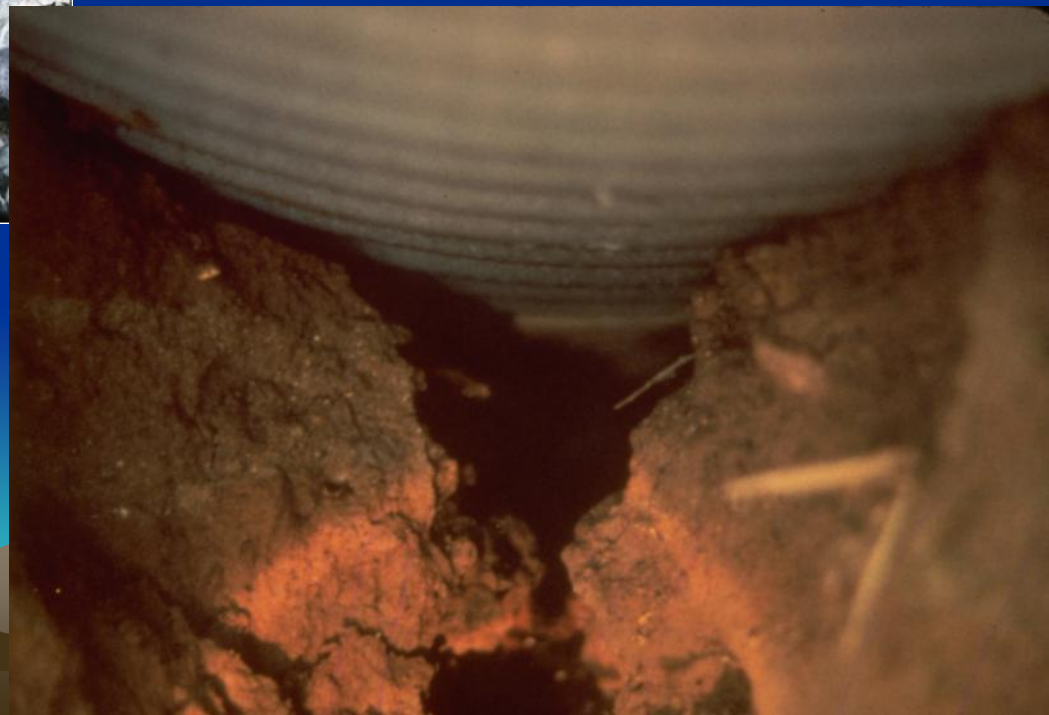
Detail of splash apron with scour cutoff key.

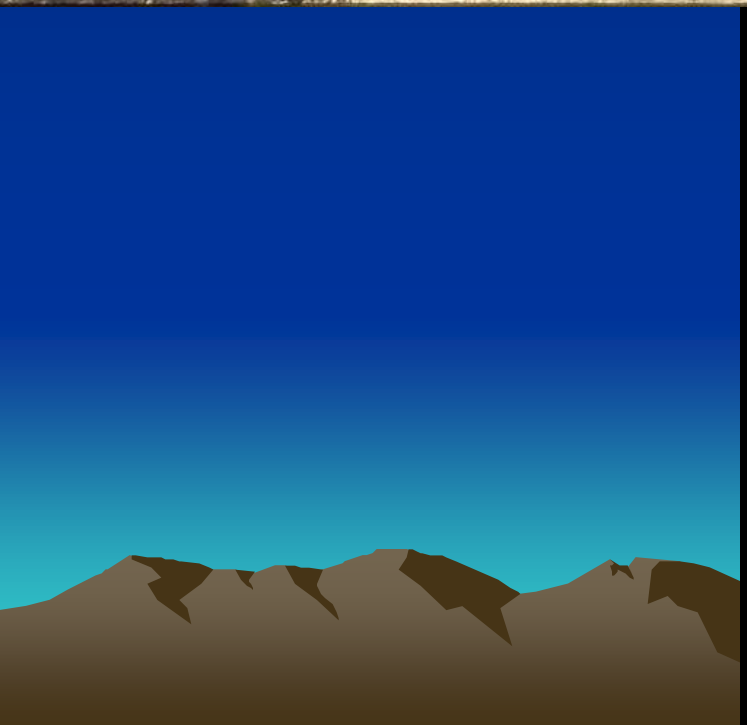




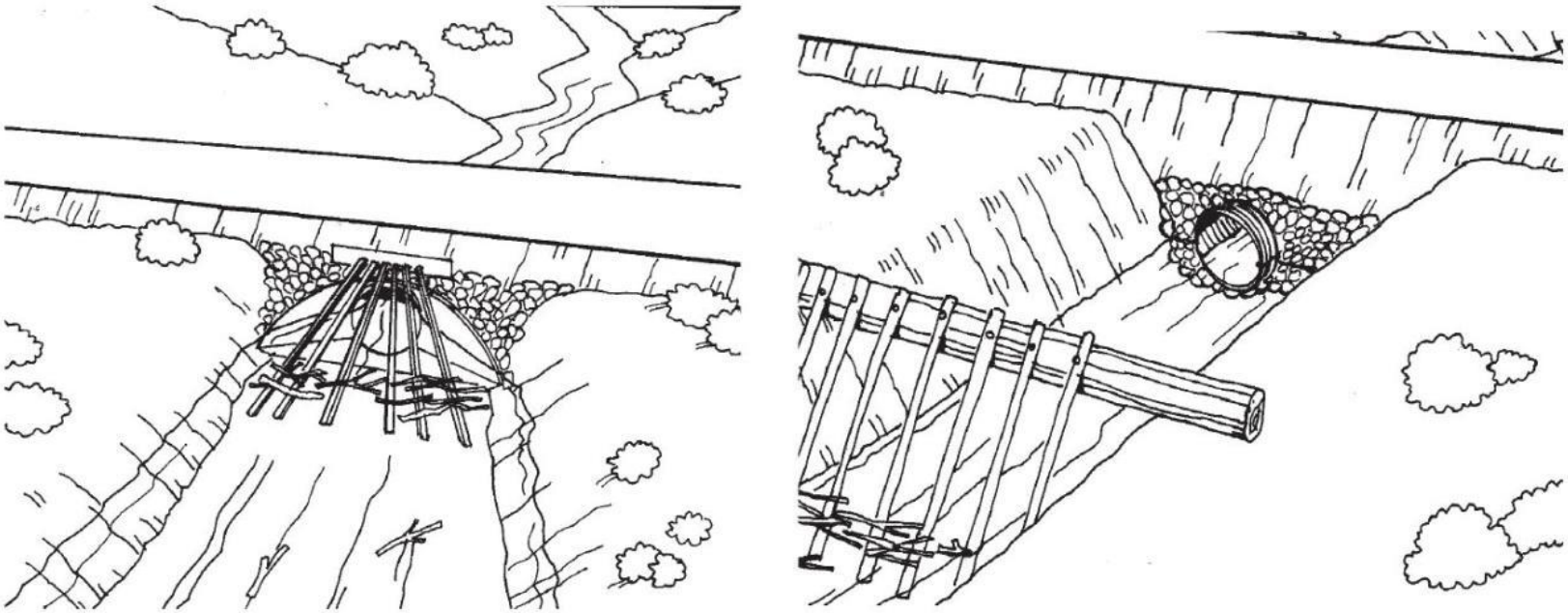
Installation-Dewatering

Problems and Mitigations-Piping





Problems and Mitigations- Plugging



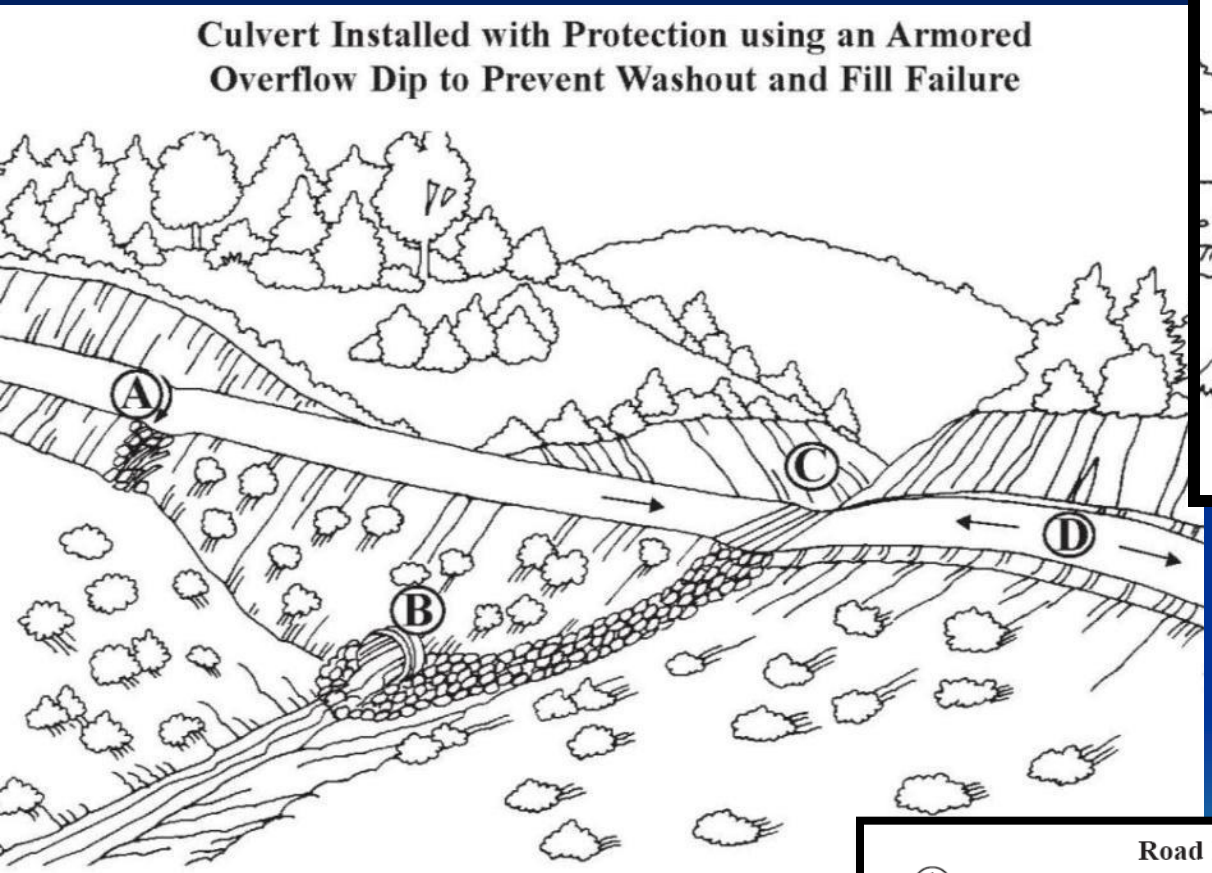
Trash rack options for culverts to prevent plugging from debris. Note that some trash racks are located at the pipe and others are located upstream of the pipe, depending on site conditions, height of the fill, and access for cleaning and maintenance. Location at the pipe is typically preferred.

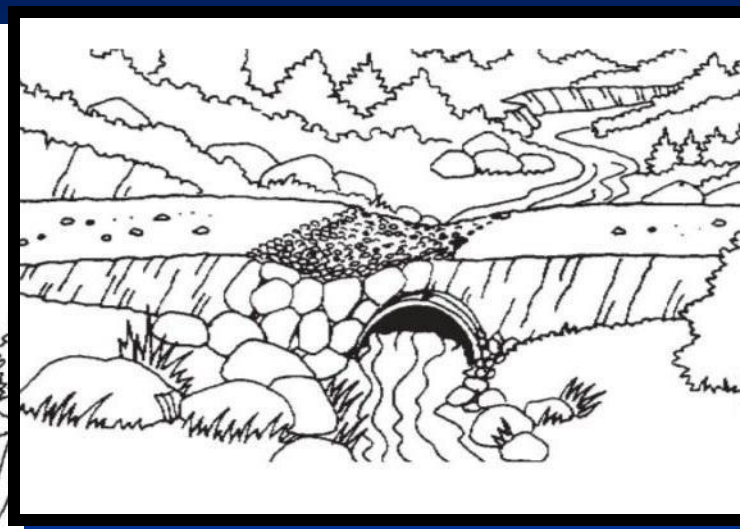
Problems and Mitigations-Plugging

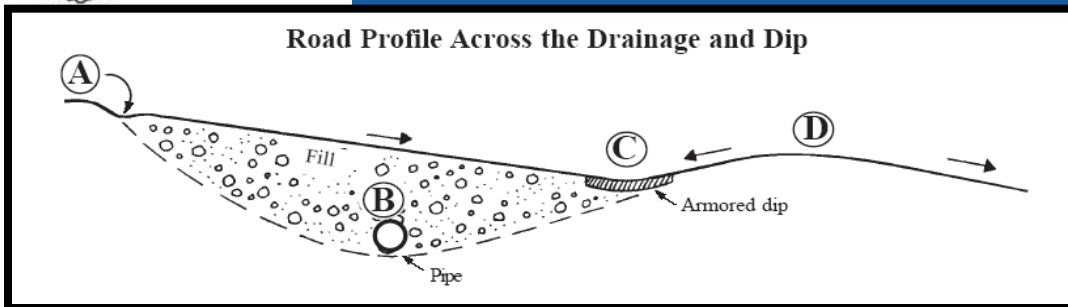
Problems/Mitigations
Stream Diversion

Photos From:
Robbin Stoddard

Problems/Mitigations- Diversion Prevention



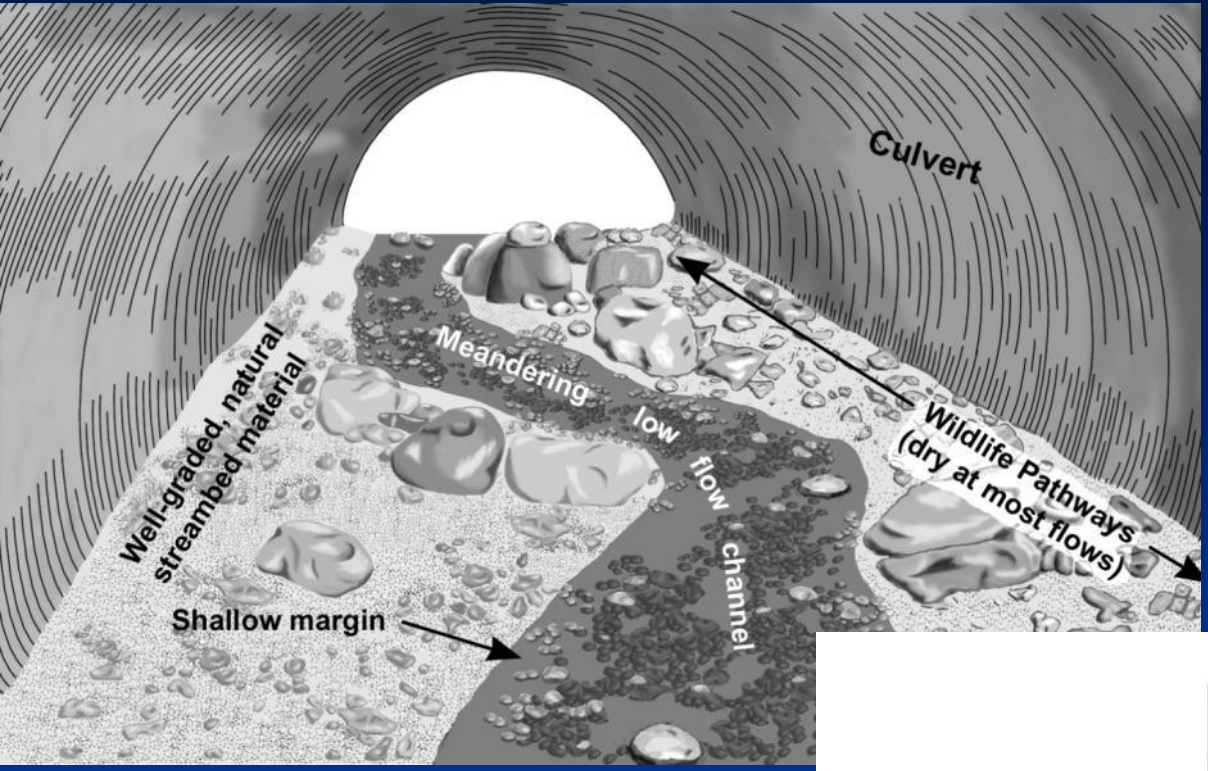


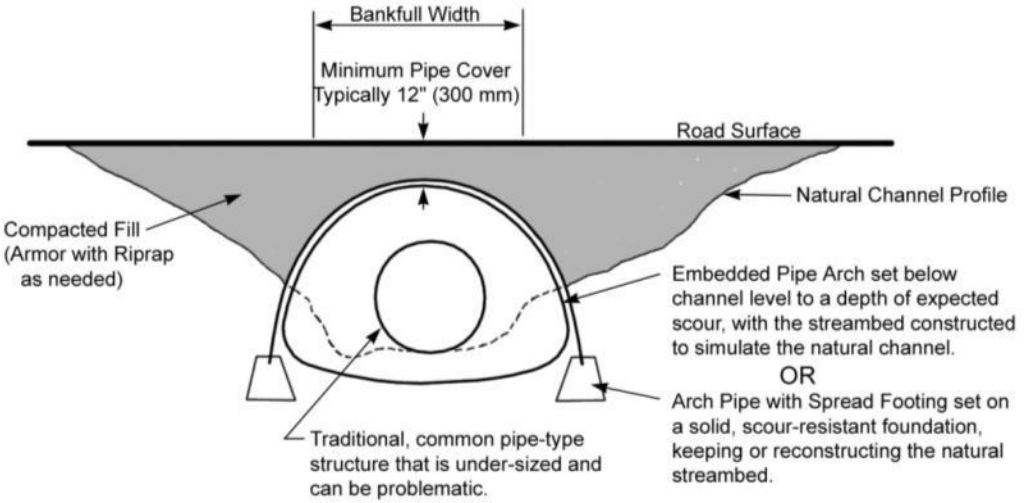


FISH PASSAGE

A Fish Passage Barrier

Fish Passage





TRADITIONAL CULVERT vs STREAM SIMULATION PIPES

U.S. Department of Agriculture

Forest Service

National Technology and Development Program

7700—Transportation Management

0877 1801—SDTDC

May 2008

STREAM SIMULATION: An Ecological Approach to Providing Passage for Aquatic Organisms at Road-Stream Crossings

Publication No. FHWA-HIF-11-008
October 2010

U.S. Department of Transportation
Federal Highway Administration

Hydraulic Engineering Circular No. 26, First Edition

CULVERT DESIGN FOR AQUATIC ORGANISM PASSAGE

http://www.fhwa.dot.gov/engineering/hydraulics/pubs/11008/hif11008.pdf

Federal Lands Highways

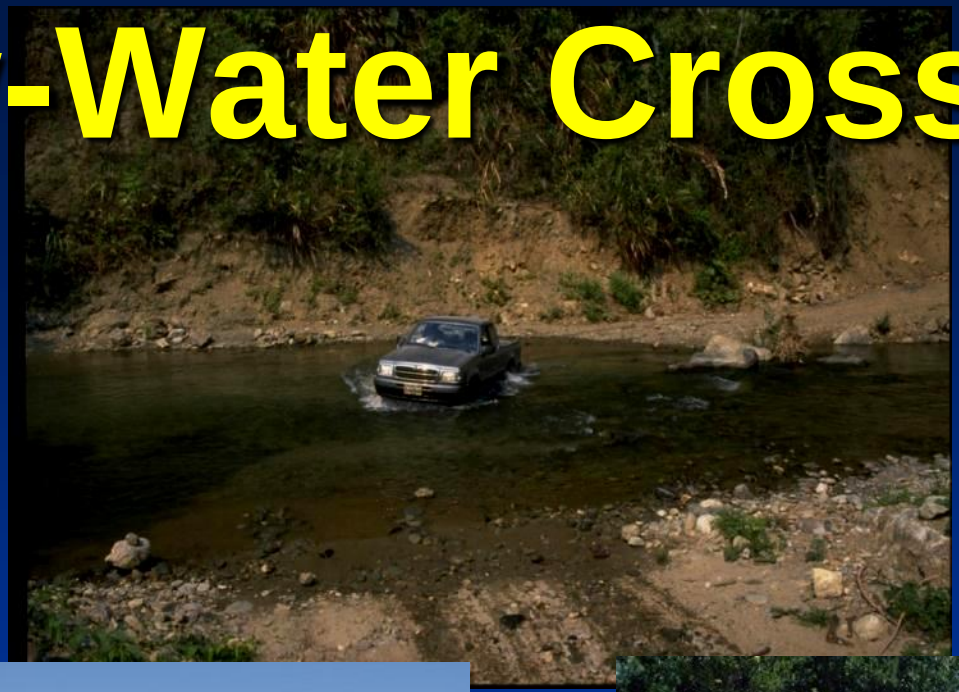
http://www.stream.fs.fed.us/fishxing/aop_pdfs.html

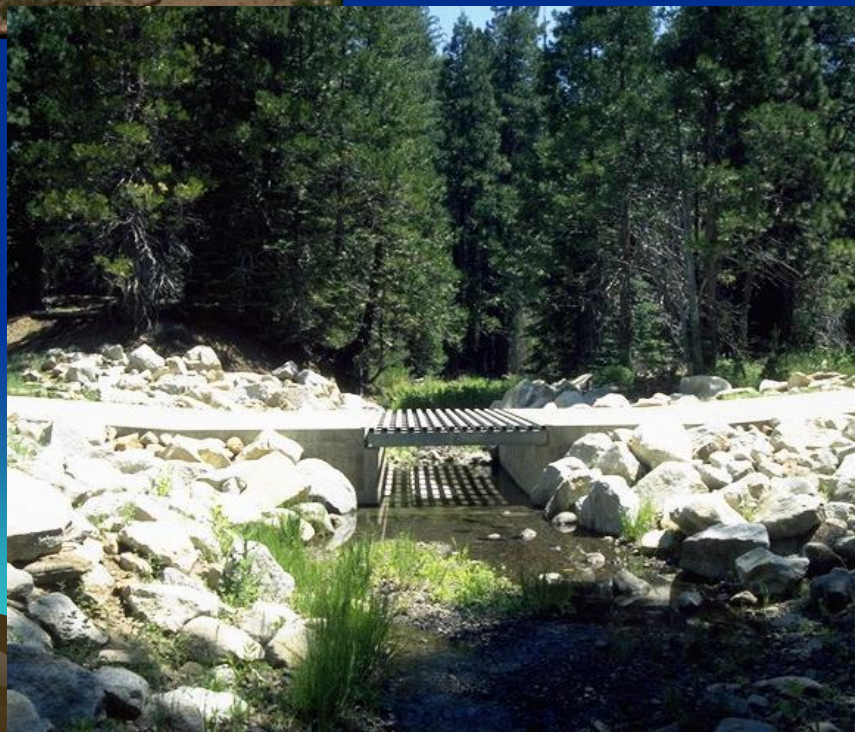
Select Useful References

- **FHWA HDS-5. 2005. Hydraulic Design of Highway Culverts.**
- **http://www.fhwa.dot.gov/engineering/hydraulics/pubs/hds5si.pdf**
- **CDF. 2004. Designing Watercourse Crossings for Passage of 100 Year Flood Flows, Wood, and Sediment. Cafferata, et al.**
- **http://www.fire.ca.gov/resourcemanagement/PDF/100yr32links.pdf**

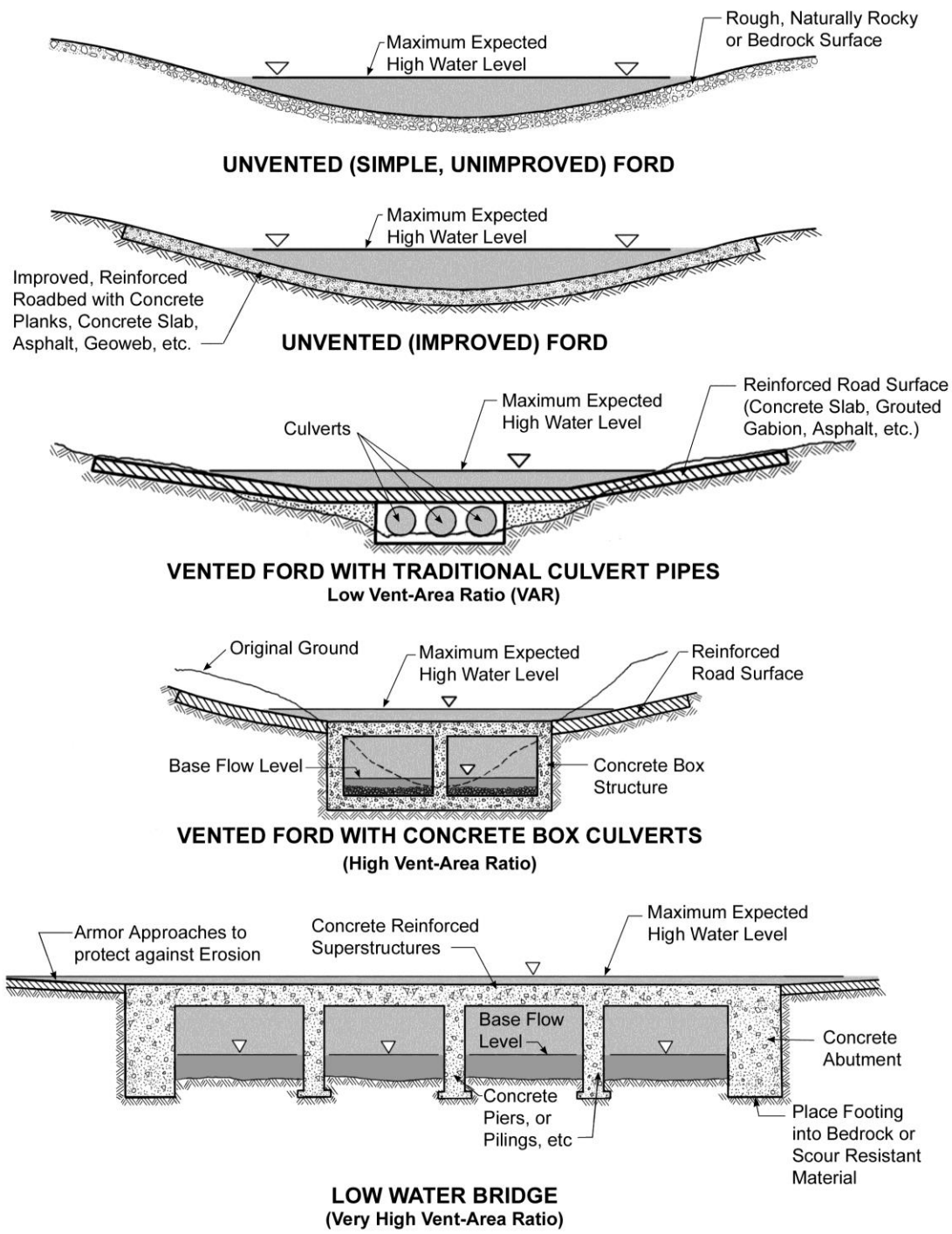

PHEW !!

Low-Water Crossings





Types of Low-Water Crossings



Where to Use Low-Water Crossings

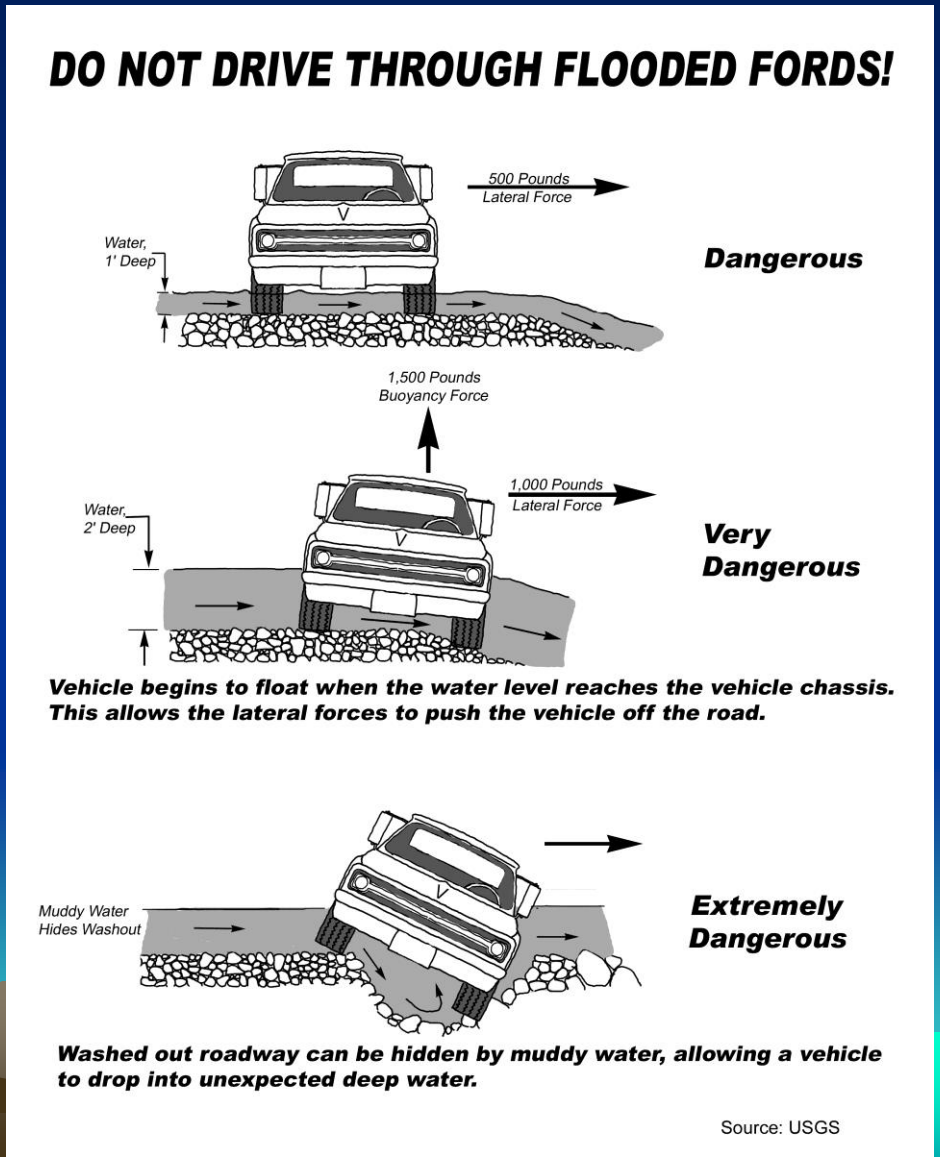
- Flashy Flows-High Flow Fluctuation
- Low Traffic Use
- Traffic Delays are Acceptable
- Debris Prone Channels
- Broad, Flat Channels
- Least Cost Alternative

Design Issues

- Structure-Site Compatibility
- Roadway and Site Geometry
- Aquatic Organism Passage
- Hydrology-Low and High Flows
- Hydraulics-Capacity, Velocity, Scour
- Driving Surface Structural Design
- Traffic Safety


TWarhol

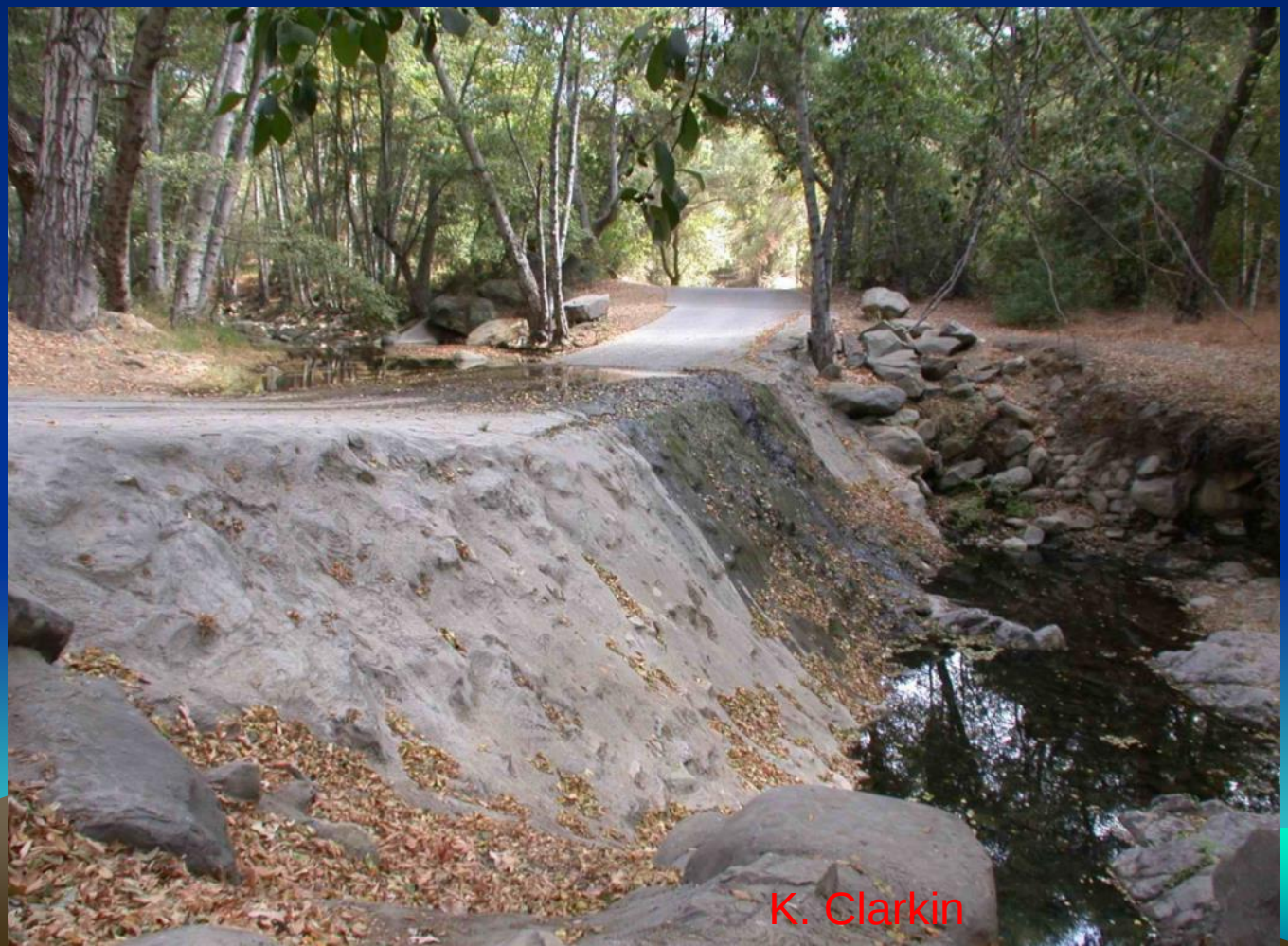
Design Issues-Traffic Safety



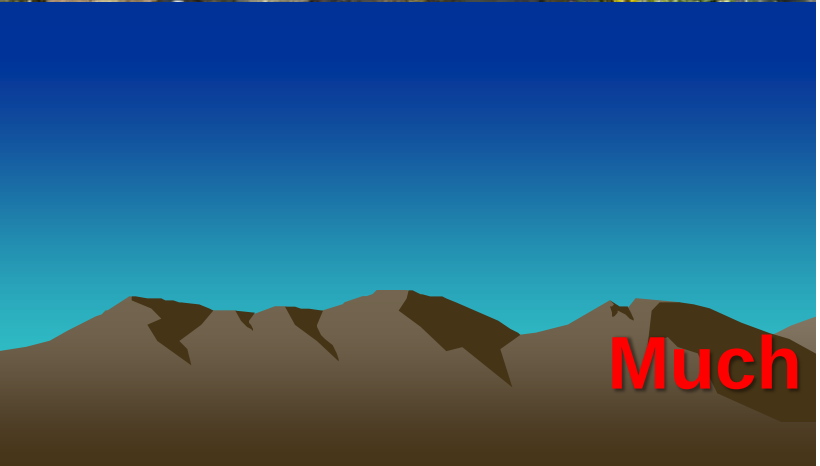
Design Issues-Traffic Safety

Problematic Designs

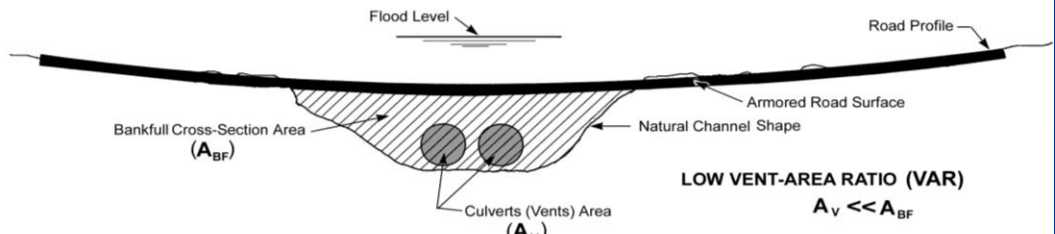
- Channel Barriers

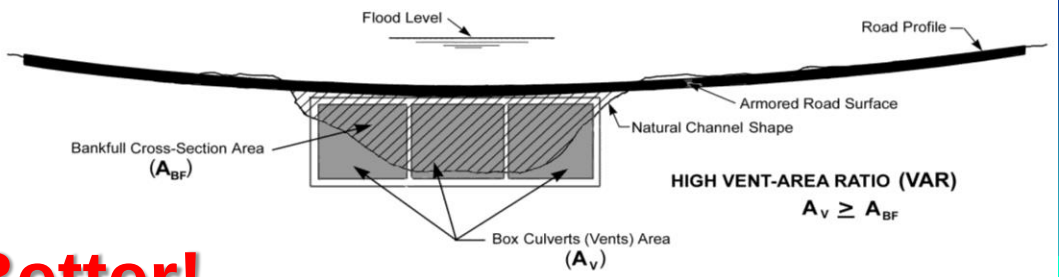


Problematic Designs



Much Better!





VENT - AREA RATIO (VAR)

Useful References

Low Water Stream Crossings:
Design and Construction Recommendations

Final Report

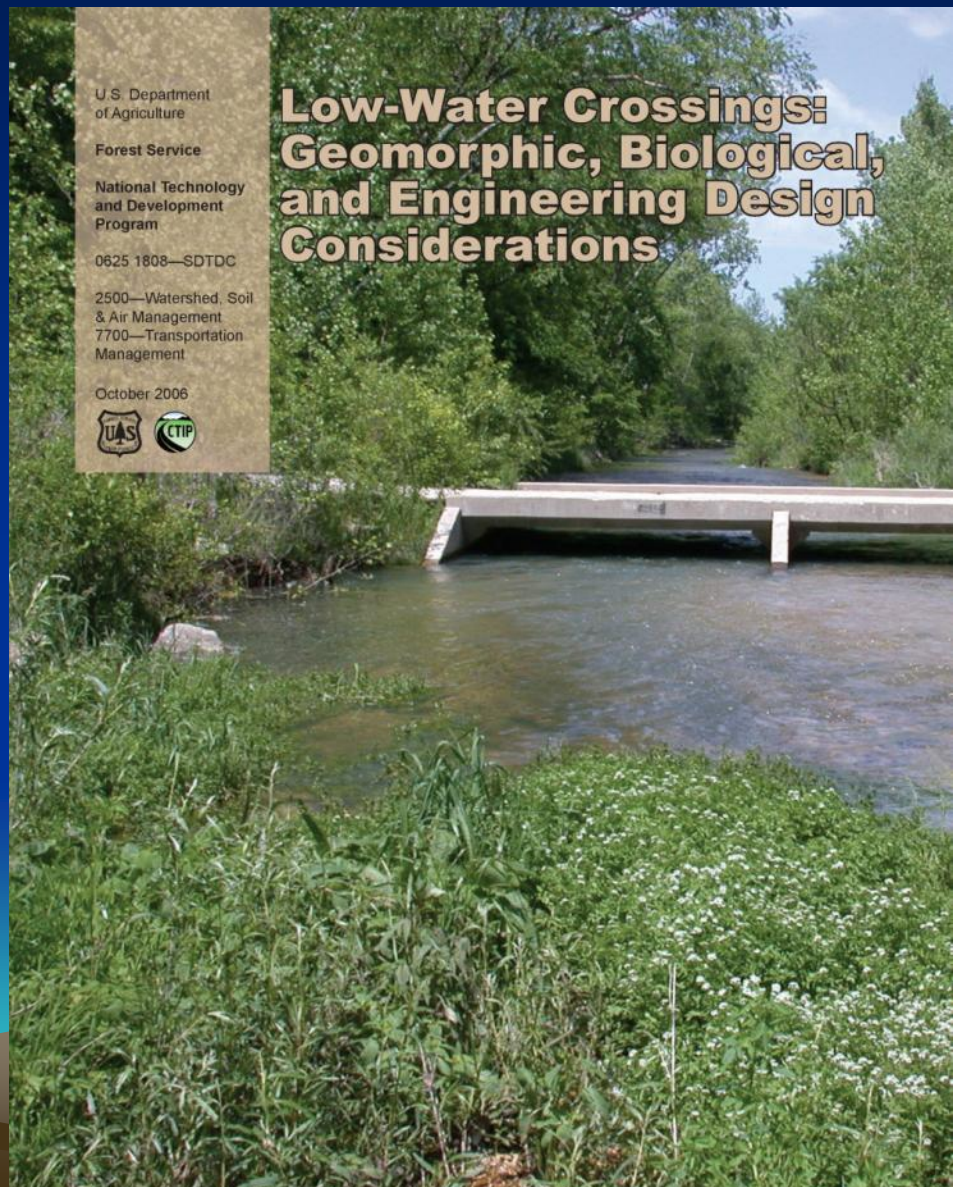
Sponsored by
the Iowa Department of Transportation
and the Iowa Highway Research Board
CTRE Project 01-78
Iowa DOT Project TR-453

December 2001

CTRE
Center for Transportation Research and Education

Department of Civil and Construction Engineering
Iowa State University

Iowa Department of Transportation

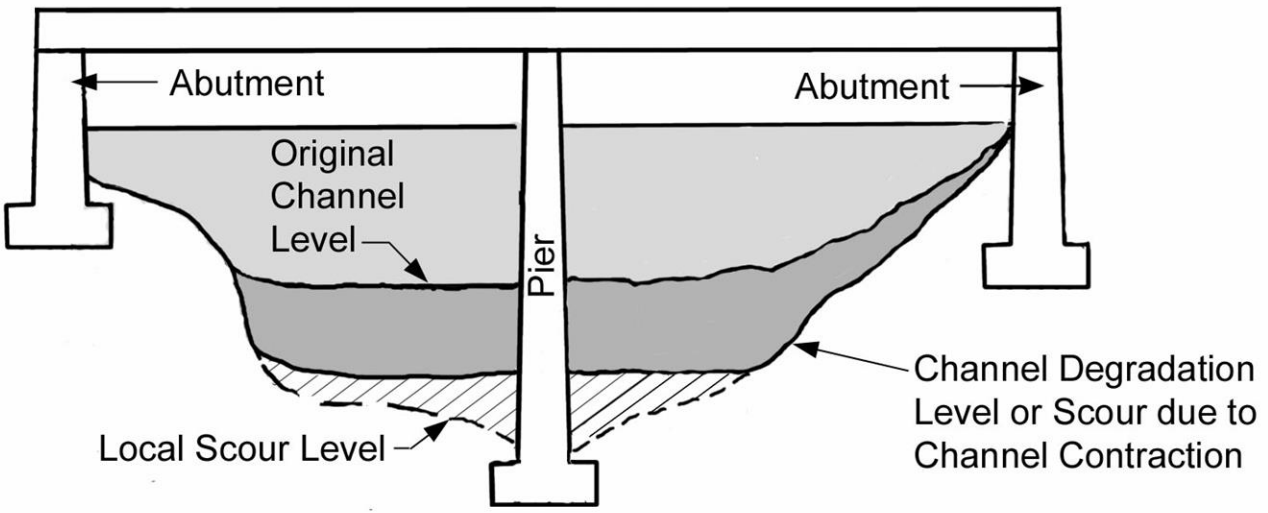


BRIDGES


GZietlow


WEIGHT
LIMIT
3 T
13 T

SCOUR PROBLEM AREAS



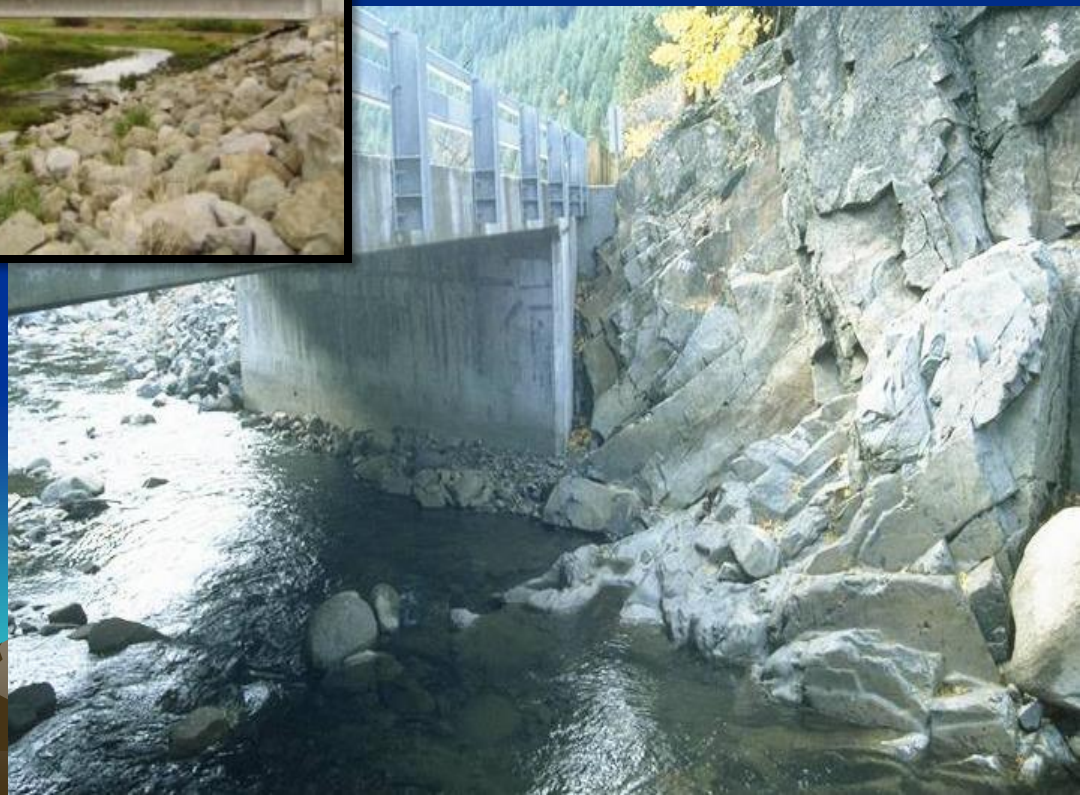
SCOUR THROUGH A STRUCTURE CAUSED BY NATURAL CHANNEL DEGRADATION, CONTRACTION, OR LOCAL SCOUR AROUND PIERS

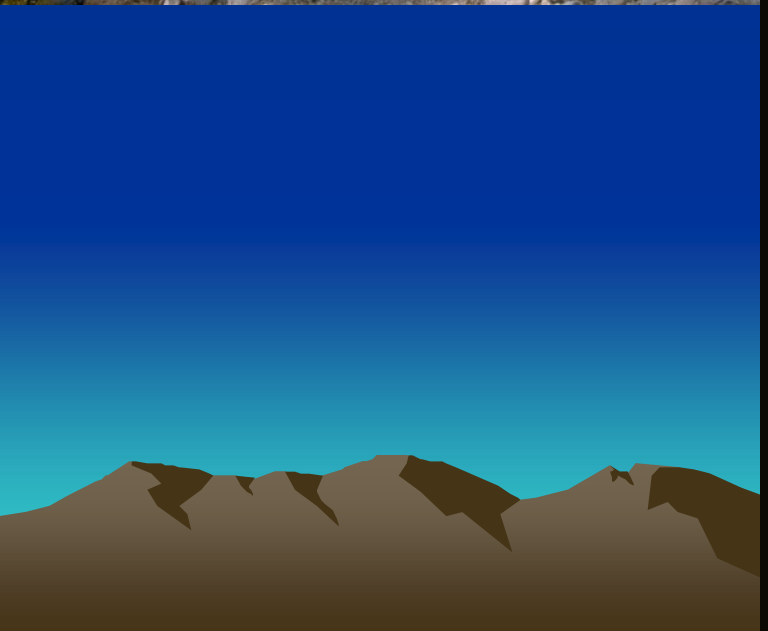
I-90 over Schoharie Creek Failure

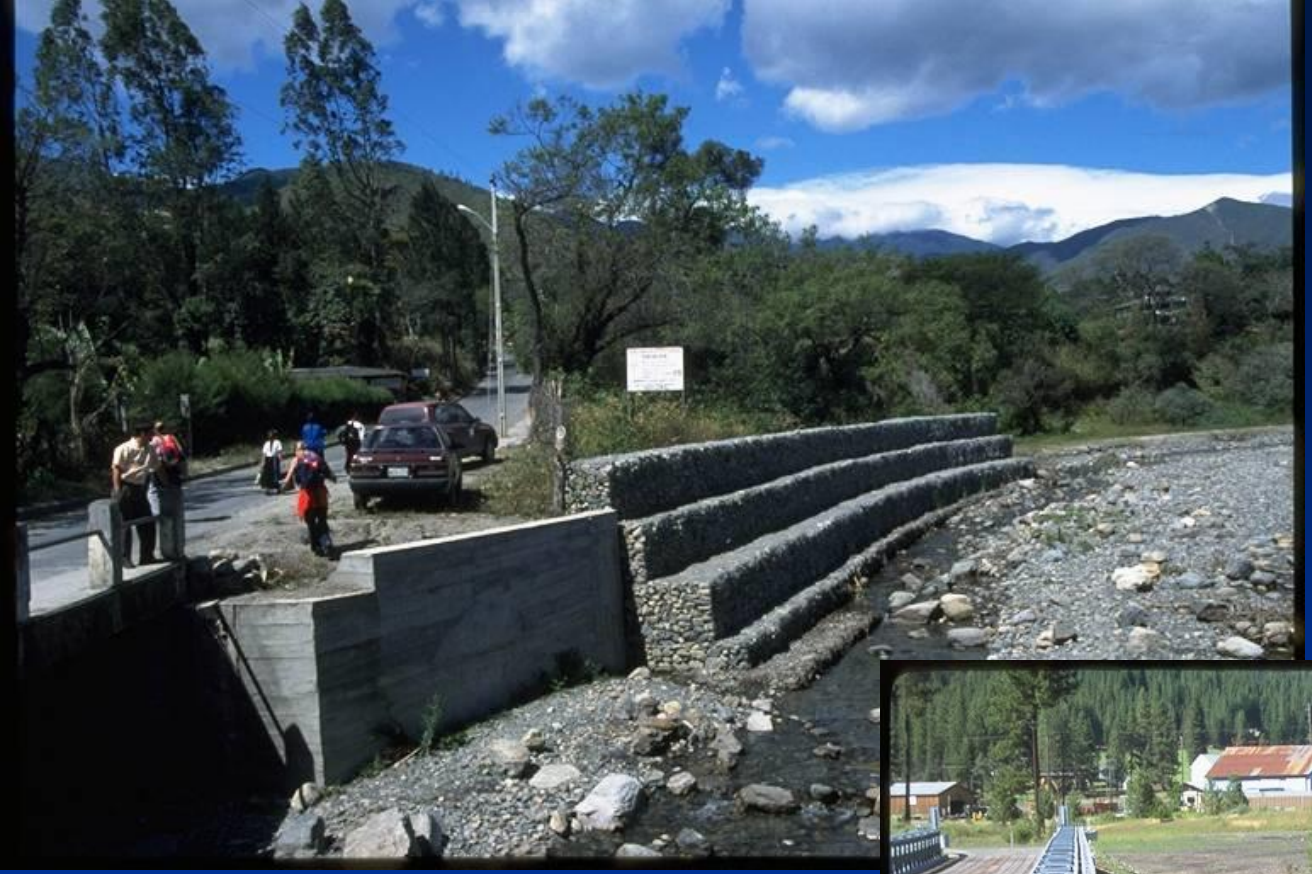
New York- (1955- 1987)
150 Meters long- 5 Spans

Failed during 6” Storm
(50 Year Event)
10 Killed

Protect Against Scour

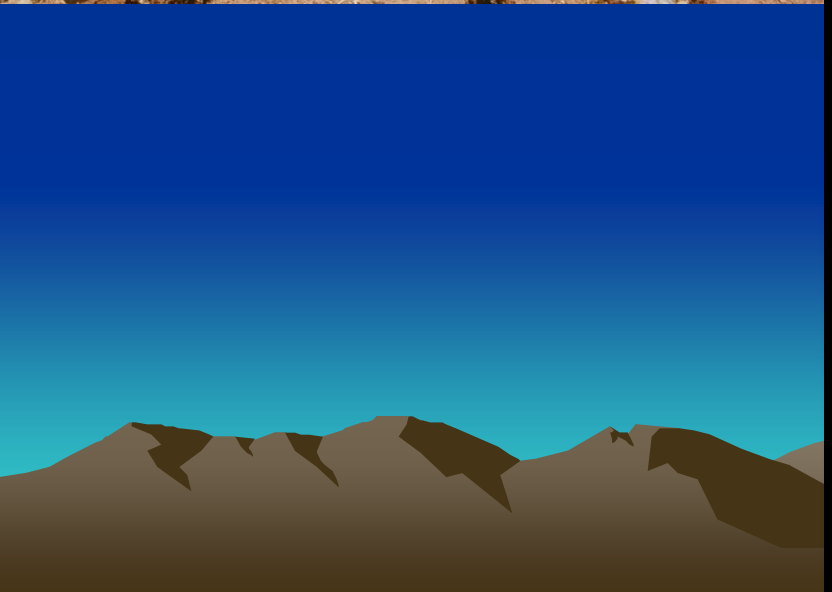






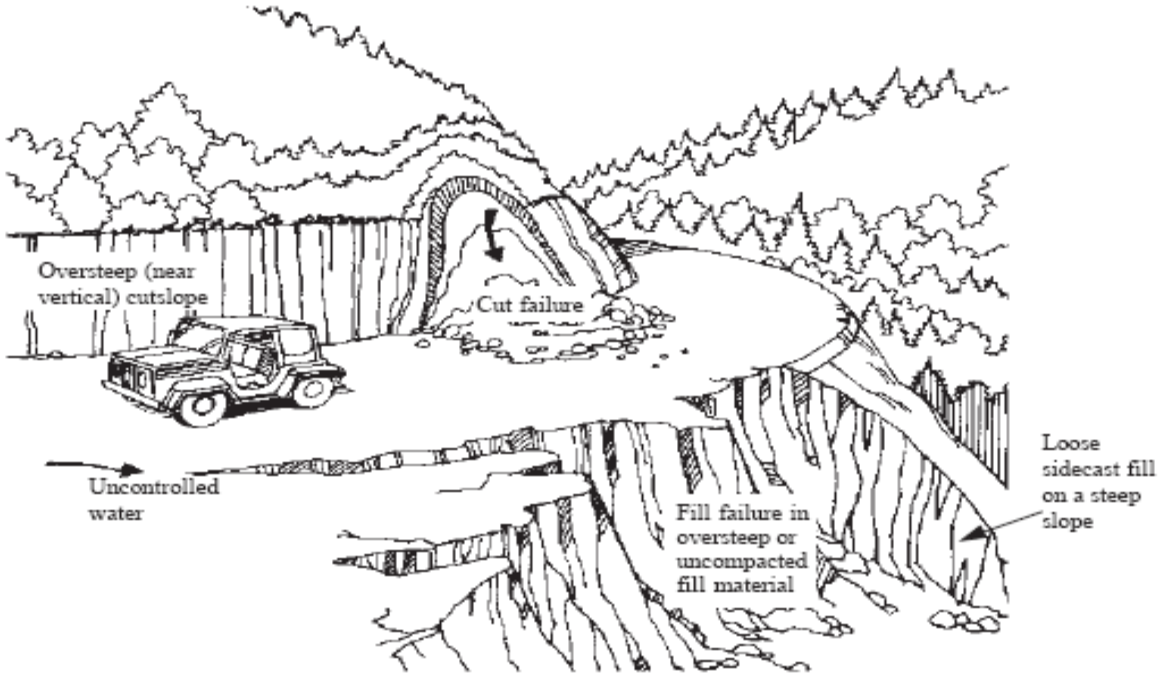
SLOPE STABILIZATION


ROAD
CLOSED

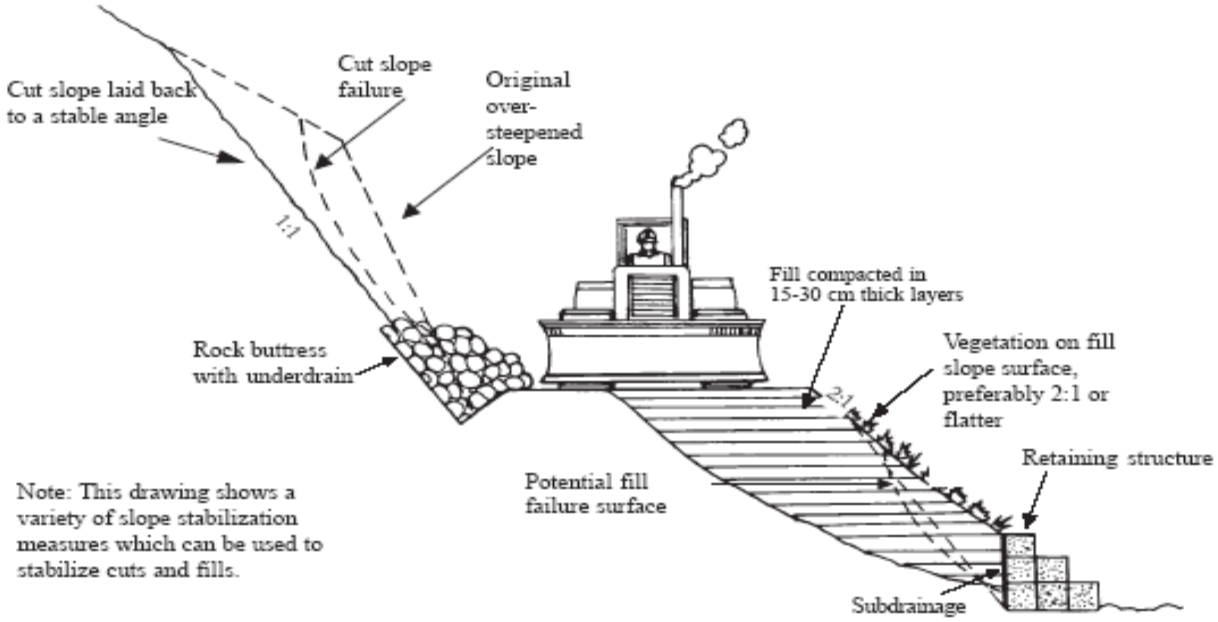



8 %
GRADE

The Problem



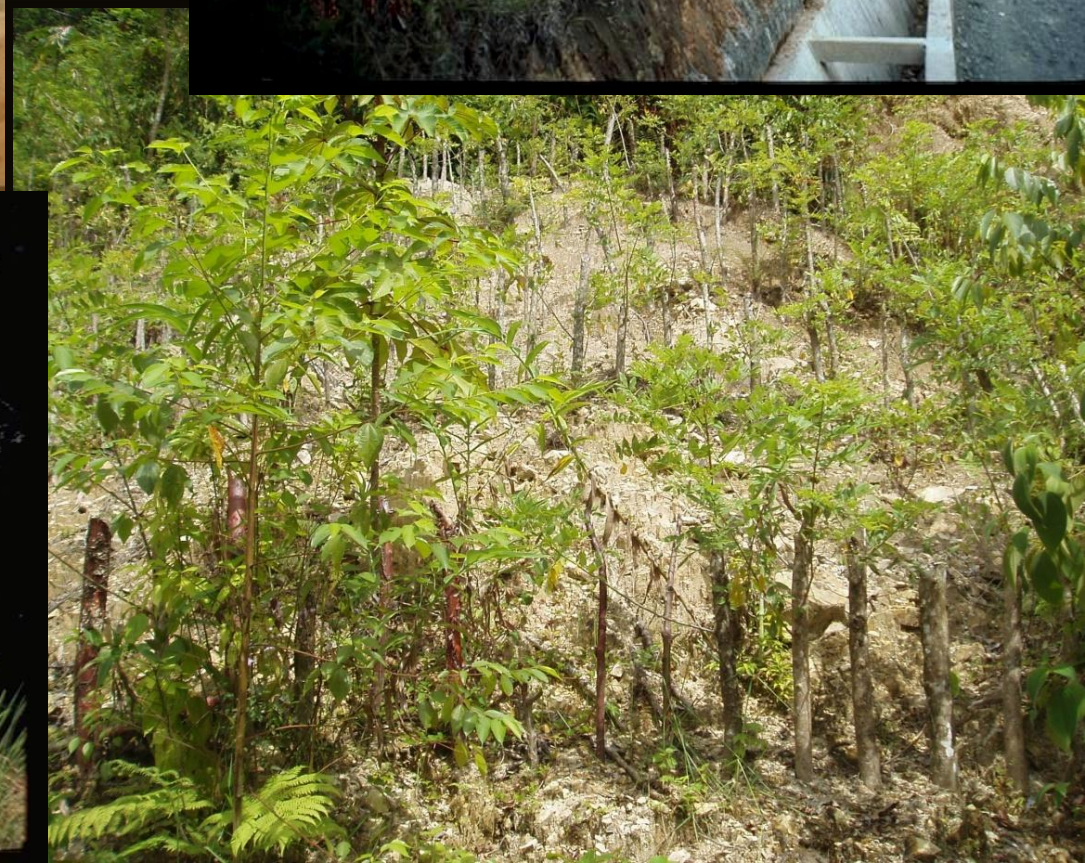
Solutions



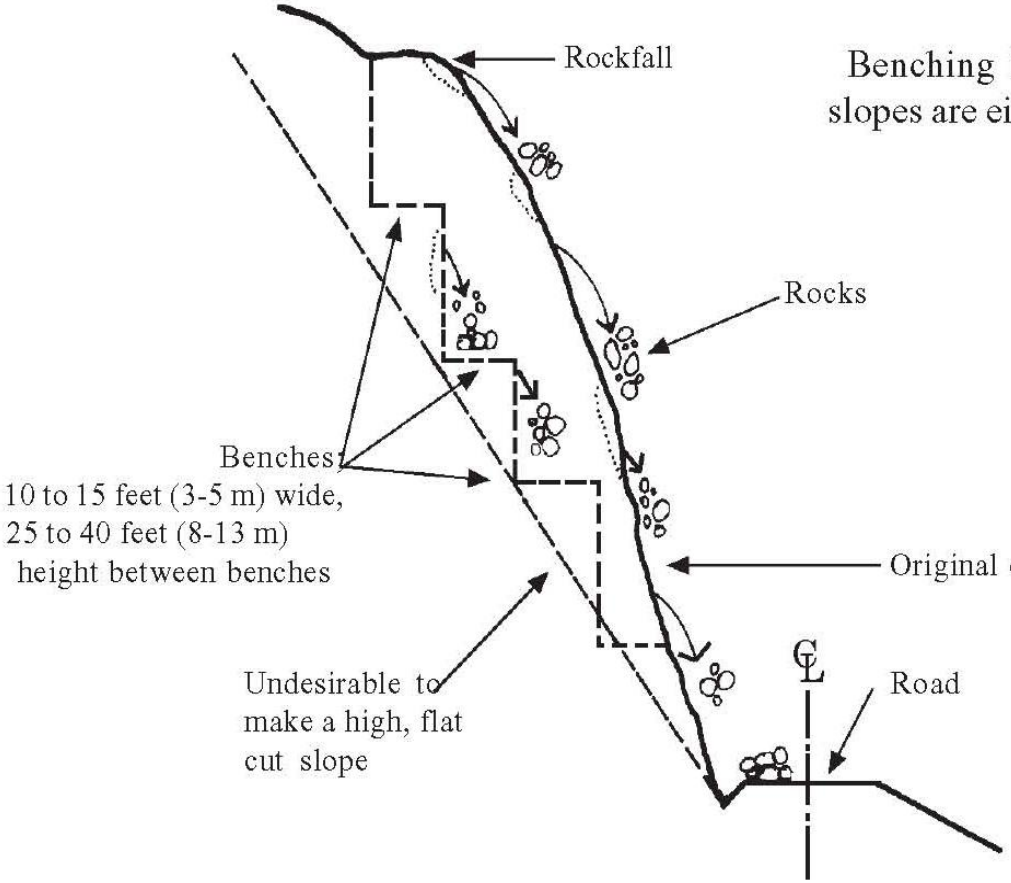
Note: This drawing shows a variety of slope stabilization measures which can be used to stabilize cuts and fills.

Common Stable Slope Ratios for Varying Soil/Rock Conditions

	Soil/Rock Condition	Slope Ratio (Hor:Vert)
C	Most rock	¼:1 to ½:1
U	Very well cemented soils	¼:1 to ½:1
T	**Most in-place soils**	**¾:1 to 1:1**
S	Very fractured rock	1:1 to 1 ½:1
	Loose coarse granular soils	1 ½:1
	Heavy clay soils	2:1 to 3:1
	Soft clay rich zones or wet seepage areas	2:1 to 3:1
F	**Fills of most soils**	**1 ½:1 to 2:1**
I	Fills of hard, angular rock	1 1/3:1
L	Low cuts and fills (<2-3 m. high)	2:1 or flatter
L		(for revegetation)



MSE WALLS



Benching is used when cut slopes are either high or steep

Alternatively, use:

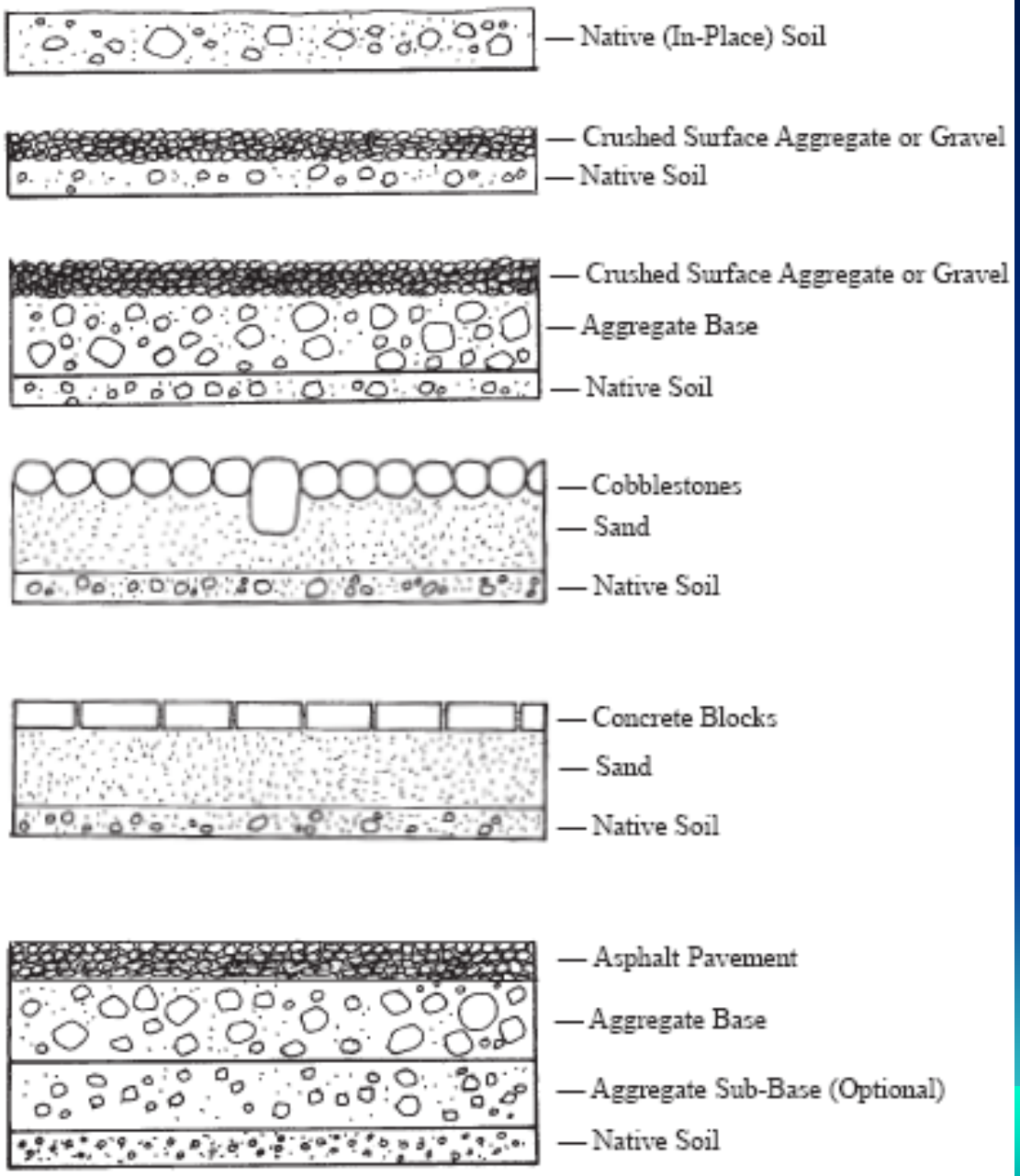
1. Rock netting,
2. Fencing to trap rockfall.
3. Construct a wider road shoulder.

Figure B - Terraces (benches) built into a high rock cut.

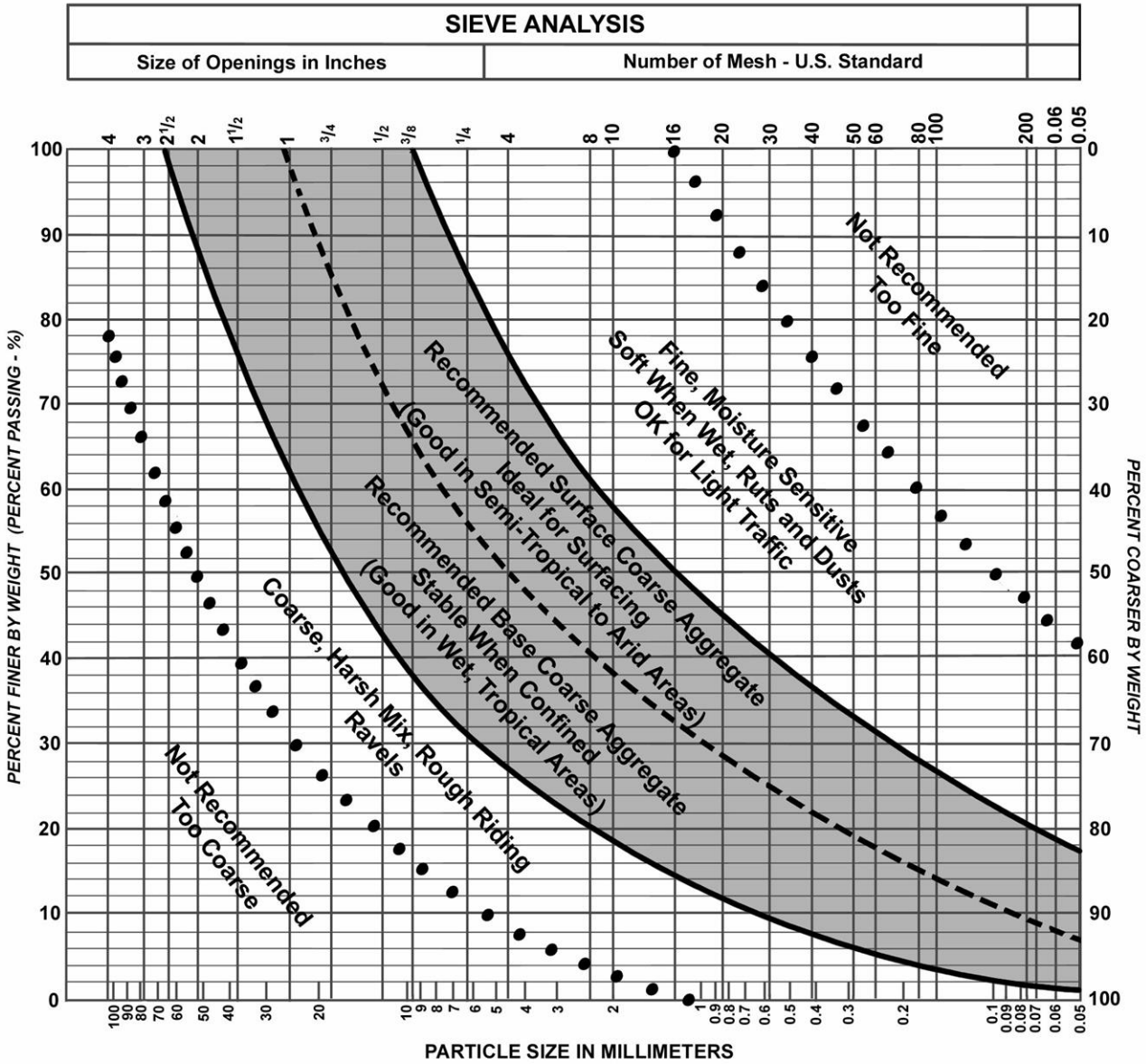
Figure 11.2.1. Solutions for cuts in fractured and solid rock.


MATERIALS

Figure 12.1 Commonly used low-volume road surfacing types and structural sections.



GRAIN SIZE DISTRIBUTION
(Gradation Curve)



COBBLE	Coarse	Fine	Coarse	Medium	Fine	SILT
	GRAVEL		SAND			

U.S. Department of Transportation

Federal Highway Administration

Gravel Roads

Maintenance and Design Manual

South Dakota Local Transportation Assistance Program (SD LTAP)

Report No. LTAP-02-002 November 2000

United States Department of Agriculture

Forest Service

Engineering Staff

Washington, DC

EM-7170-16

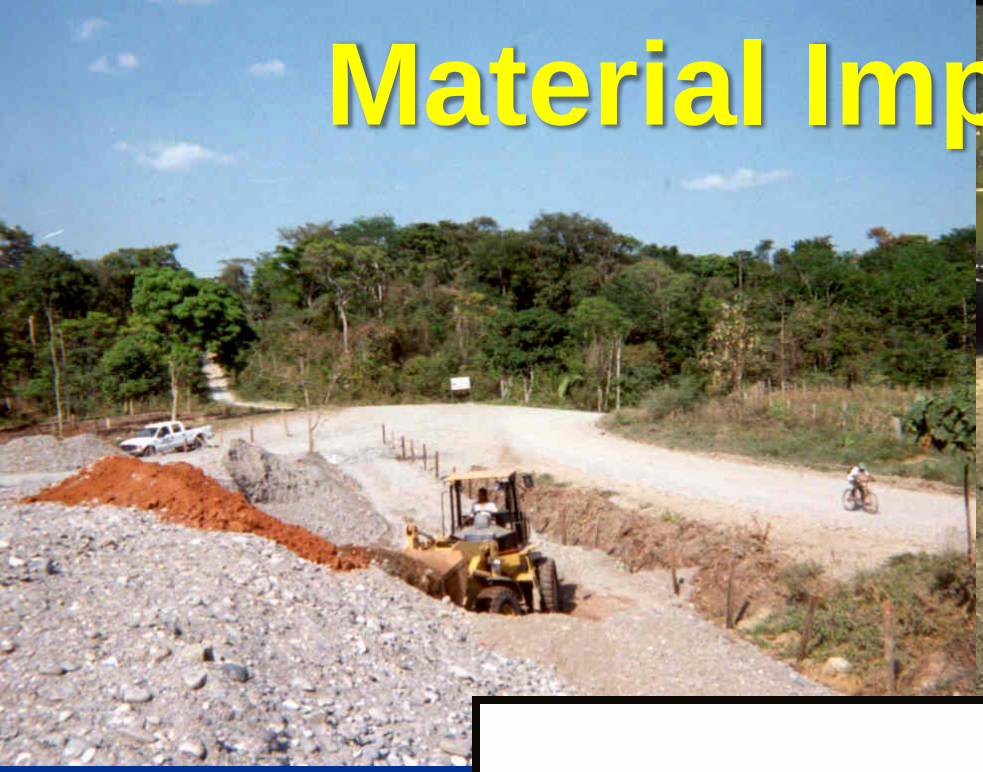
September 1996

Earth and Aggregate Surfacing Design Guide for Low Volume Roads

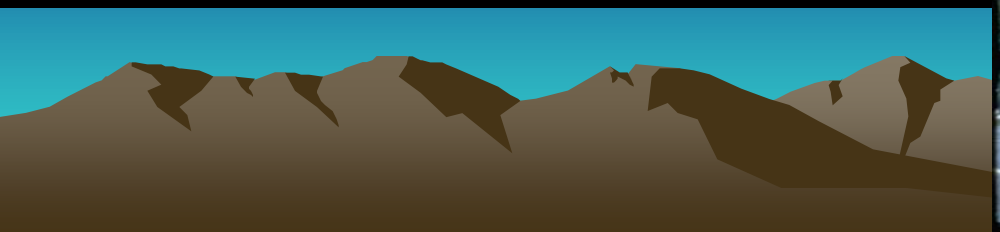
P. Bolander et al.

Quality Control

Material Improvements



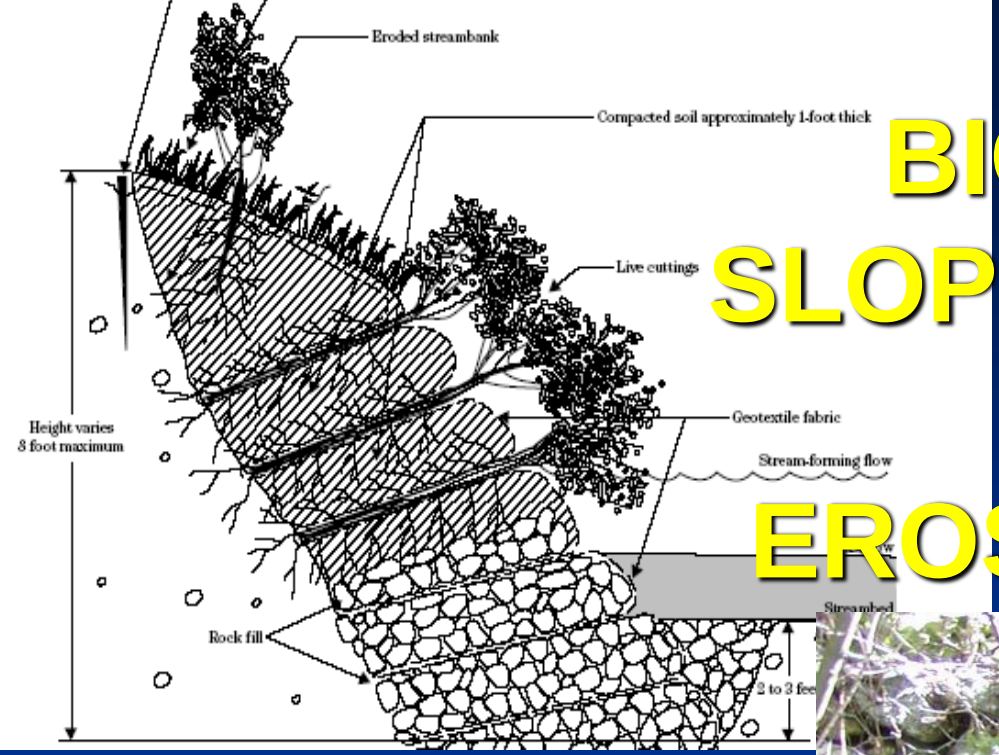
Quarry Development and Reclamation




EROSION CONTROL

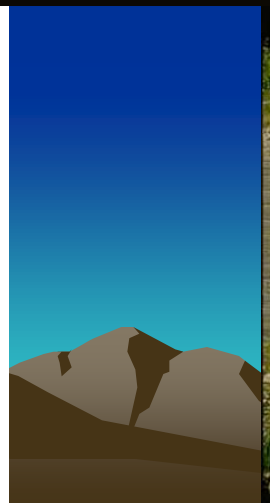

R. Sotir

BIOTECHNICAL SLOPE STABILIZATION AND EROSION CONTROL



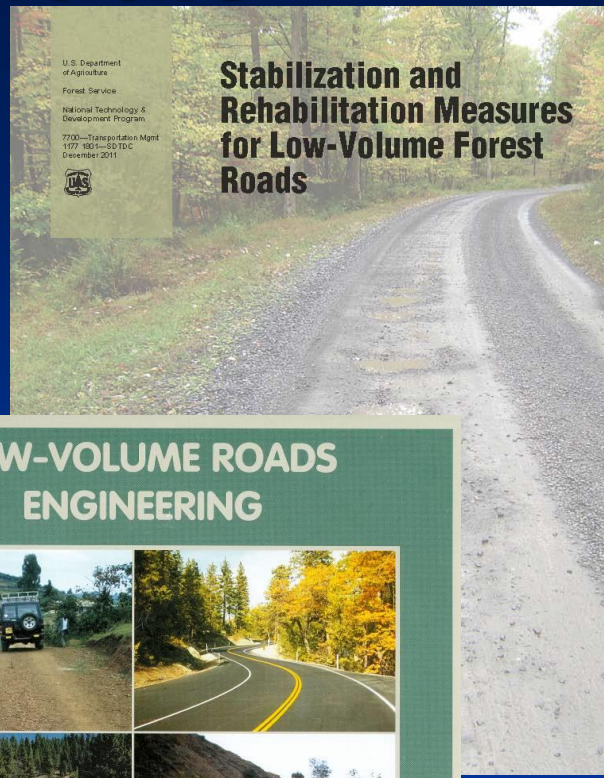
J. McCullah

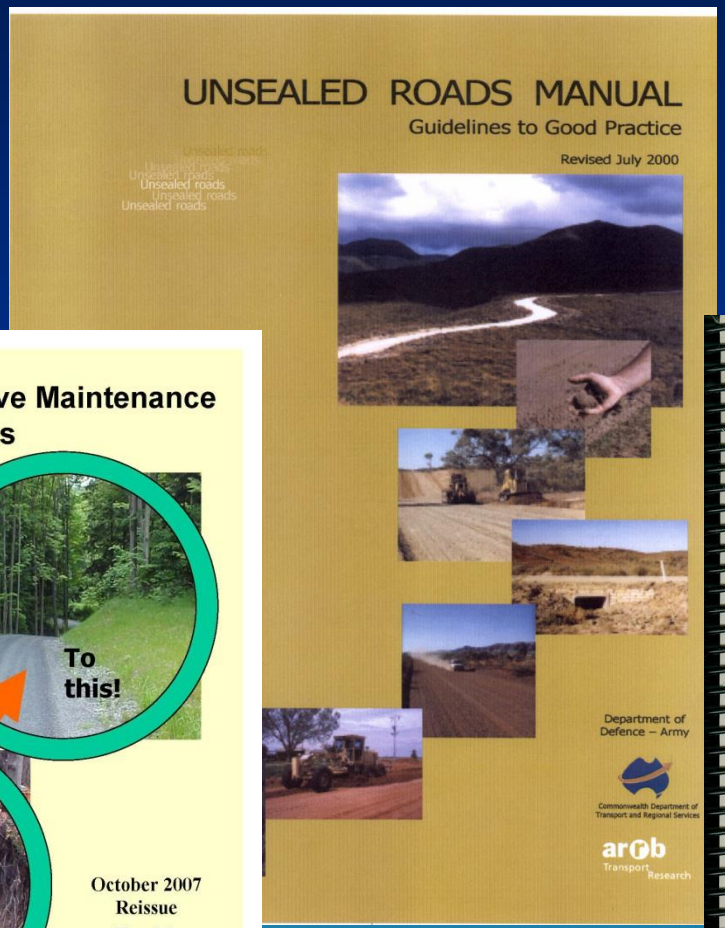
INNOVATIVE APPROPRIATE TECHNOLOGIES

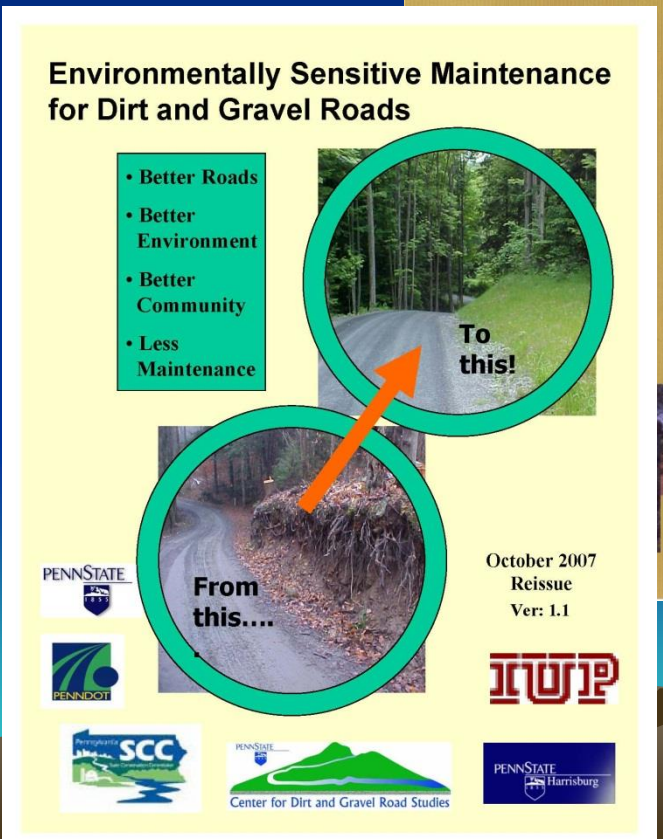


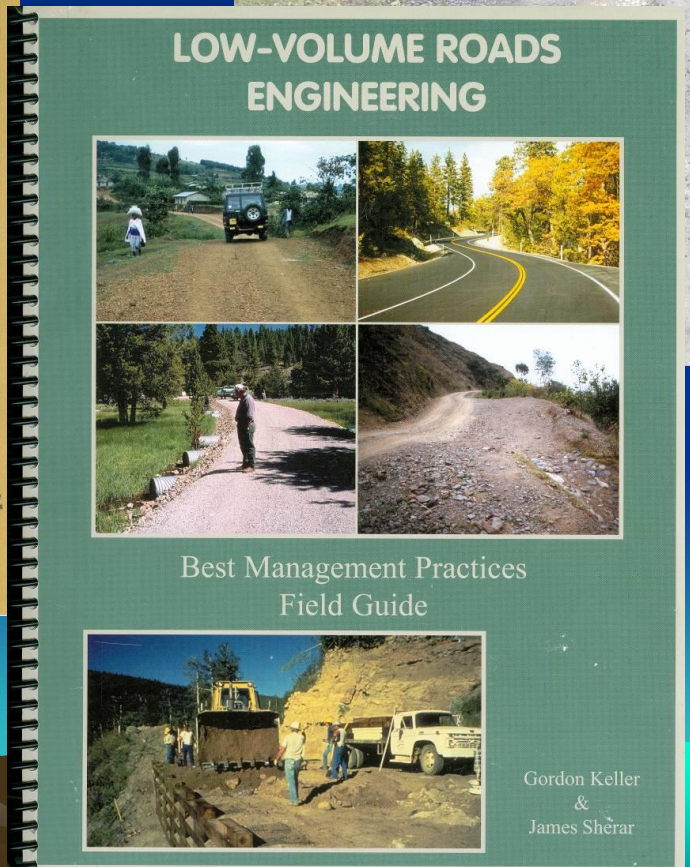
ENVIRONMENTAL PROTECTION

Local Roads Manuals









INFORMATION TECHNOLOGY

Useful Websites for Low-Volume Roads Issues

Roads-General

http://www.worldbank.org/transport/publicat/reh/toc.htm
http://www.fs.fed.us/news/roads
http://www.fs.fed.us/t-d/ (Use "t-d" for the user name and password)
http://www.fs.fed.us/rm/RRR/Technologies/Technologies.HTML
http://www.fs.fed.us/eng/pubs/
http://www.ruraltransportation.org
http://www.usace.army.mil/publications/eng-manuals/em.htm
http://www.fhwa.dot.gov/bridge
http://nace.org
http://www.ifgworld.org/
http://www.transport-links.org/transport_links/publications/publications_search.a
http://www.dirtandgravelroads.org
http://www.arrb.co.au/
http://www.roads.co.nz/
http://www.zietlow.com/

Hydrologic Analysis

http://water.usgs.gov/software/nff.html

Why BMPs?


And What Makes it All Work?
YOU!!


thank
you