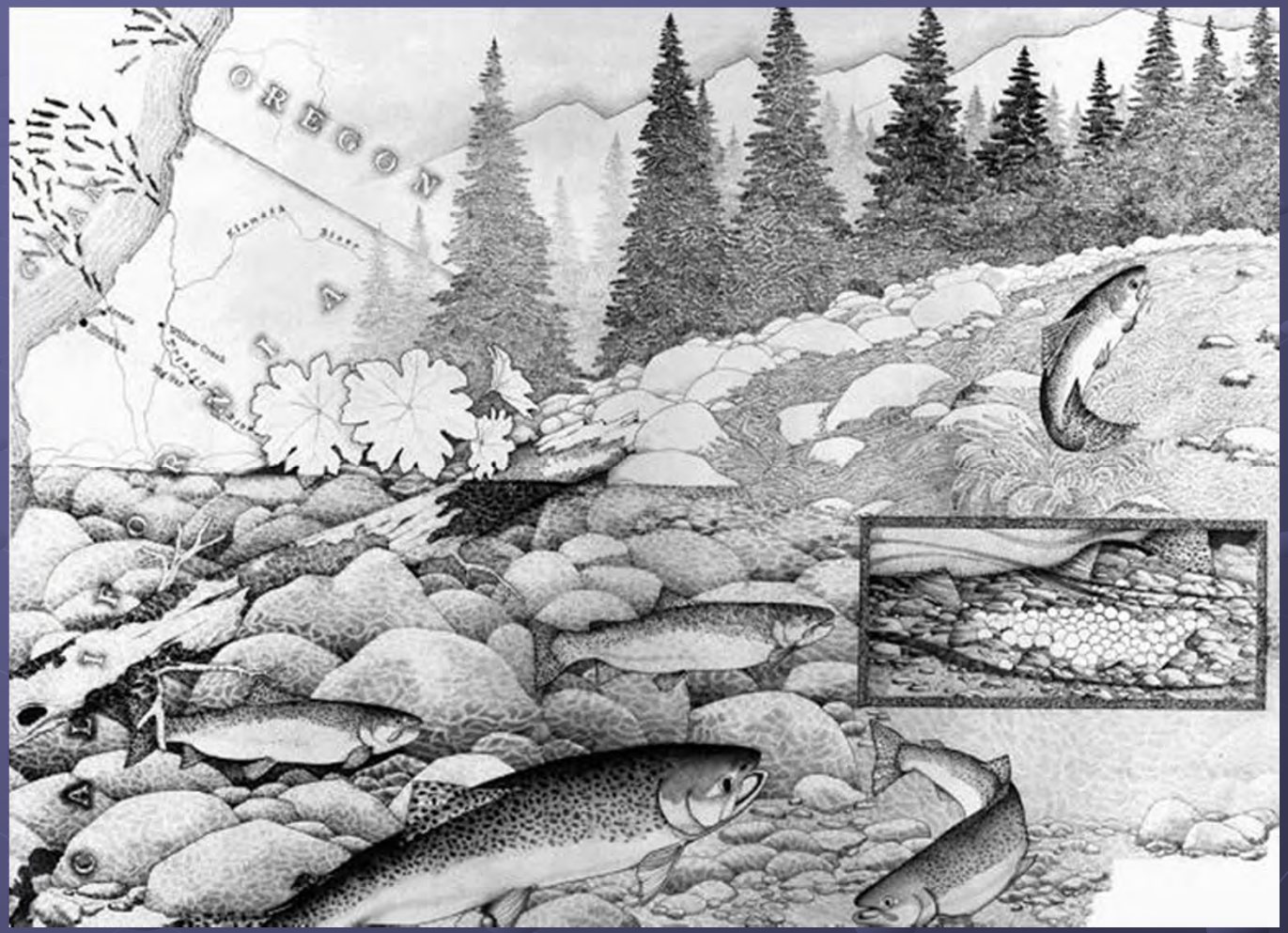
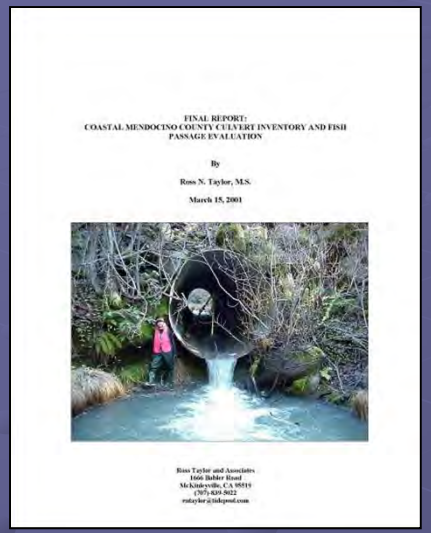
Five Counties Salmonid Conservation Program



BMP Implementation
Roads Webinar, July 16th, 2012

mlancaster@5counties.org

Watershed Planning Tools


FINAL REPORT:
COASTAL MENDOCINO COUNTY CULVERT INVENTORY AND FISH PASSAGE EVALUATION

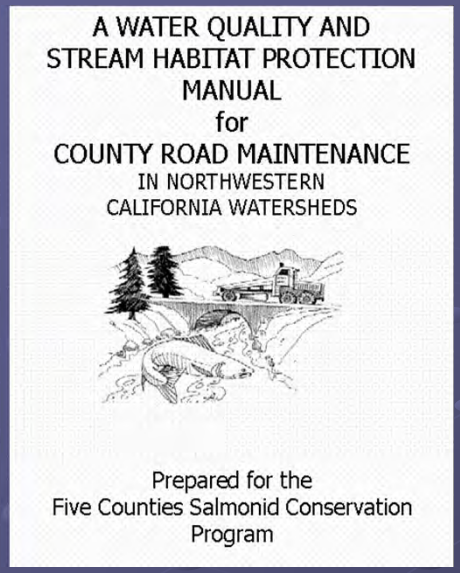
By

Ross N. Taylor, M.S.

March 15, 2001

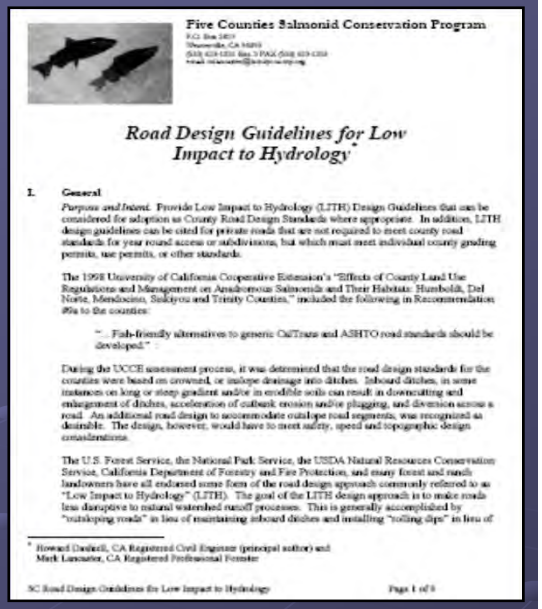
Ross Taylor and Associates
1666 Bahler Road
McKinleyville, CA 95519
(707) 839-5022
rntaylor@sbcglobal.com

Migration Barrier Inventories & Prioritization


A WATER QUALITY AND STREAM HABITAT PROTECTION MANUAL for COUNTY ROAD MAINTENANCE IN NORTHWESTERN CALIFORNIA WATERSHEDS

Prepared for the Five Counties Salmonid Conservation Program

Roads Manual


Five Counties Salmonid Conservation Program

Road Design Guidelines for Low Impact to Hydrology

1. General

Purpose and Intent. Provide Low Impact to Hydrology (LITH) Design Guidelines that can be considered for adoption as County Road Design Standards where appropriate. In addition, LITH design guidelines can be cited for private roads that are not required to meet county road standards for year round access or subdivisions, but which must meet individual county grading permits, use permits, or other standards.

The 1998 University of California Cooperative Extension's "Effects of County Land Use Regulations and Management on Anadromous Salmonids and Their Habitats: Humboldt, Del Norte, Mendocino, Siskiyou and Trinity Counties," included the following in Recommendation #9a to the counties:

"... Fish-friendly alternatives to generic CalTrans and AASHTO road standards should be developed."

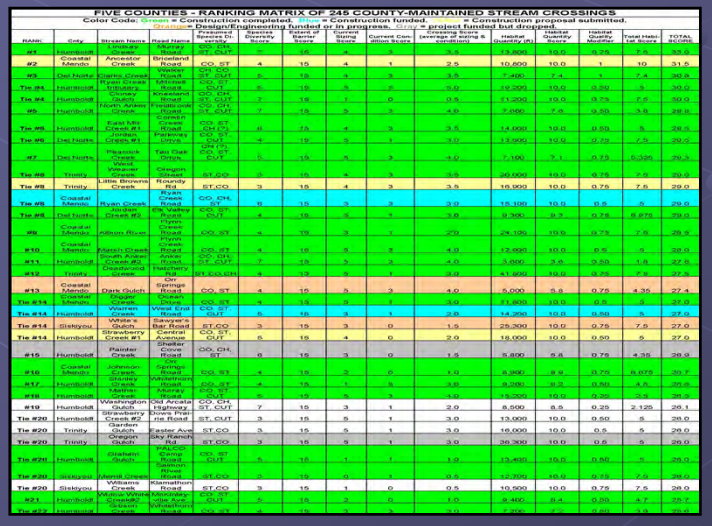
During the UCCE assessment process, it was determined that the road design standards for the counties were based on crowned, or inslope drainage into ditches. Inboard ditches, in some instances on long or steep gradient and/or in erodible soils can result in downcutting and enlargement of ditches, acceleration of outbank erosion and/or plugging, and diversion across a road. An additional road design to accommodate outslope road segments, was recognized as desirable. The design, however, would have to meet safety, speed and topographic design considerations.

The U.S. Forest Service, the National Park Service, the USDA Natural Resources Conservation Service, California Department of Forestry and Fire Protection, and many forest and ranch landowners have all endorsed some form of the road design approach commonly referred to as "Low Impact to Hydrology" (LITH). The goal of the LITH design approach is to make roads less disruptive to natural watershed runoff processes. This is generally accomplished by "outsloping roads" in lieu of maintaining inboard ditches and installing "rolling dips" in lieu of

Howard Dashiell, CA Registered Civil Engineer (principal author) and Mark Lancaster, CA Registered Professional Forester

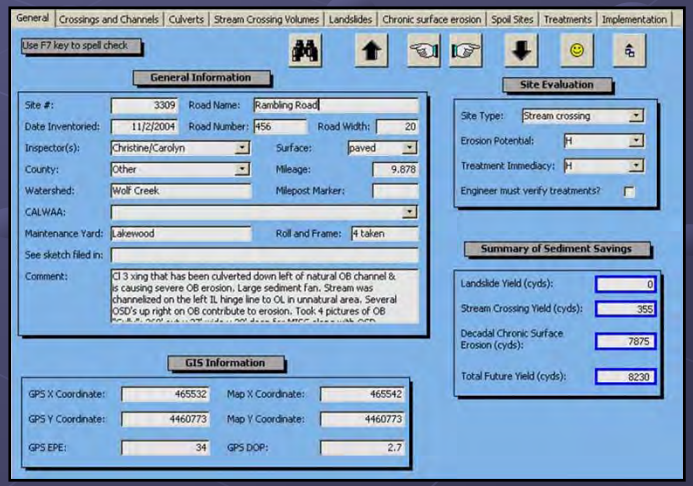
5C Road Design Guidelines for Low Impact to Hydrology Page 1 of 9

LITH Standards


FIVE COUNTIES - RANKING MATRIX OF 245 COUNTY-MAINTAINED STREAM CROSSINGS

Color Code: Green = Construction completed, Blue = Construction funded, Yellow = Construction proposal submitted, Orange = Design/Engineering funded or in progress, Gray = project funded but dropped

RANK	Cnty	Stream Name	Road Name	Previous Species Diversity Score	Extent of Barrier Score	Current Sizing Score	Current Con. Bind Score	Crossing Score (average of sizing & condition)	Habitat Quantity Score	Habitat Quality Modifier	Total Habitat Score	TOTAL SCORE
#1	Humboldt	Lindsay Creek	Shelter Cove Road	ST, CUT	?	15	4	3	3.5	13,800	10.0	0.75	7.5	33.0
#2	Coastal Mendo	Ancestor Creek	Birtcliand Road	CO, ST	4	15	4	1	2.5	10,800	10.0	1	10	31.5
#3	Del Norte	Agate Creek	Wonder Road	ST, CUT	5	15	3	3	3.0	7,400	7.4	1	7.4	30.4
Tie #4	Humboldt	Ryan Creek Tributary	Mitchell Road	CO, ST, CUT	5	15	3	2	5.0	19,000	10.0	0.50	5	30.0
Tie #4	Humboldt	Cooley Gulch	Kneeland Road	CO, CH, ST, CUT	7	15	1	0	0.5	21,200	10.0	0.75	7.5	30.0
#5	Humboldt	North Arkley Creek	Panamint Road	ST, CUT	7	15	5	2	4.0	7,000	7.0	0.55	3.8	28.8
Tie #6	Humboldt	East Mtn Creek #1	Jordan Creek Road	CO, ST, CH (?)	6	15	4	3	3.5	14,000	10.0	0.85	5	29.5
Tie #6	Del Norte	Jordan Creek #1	Parkway Drive	CO, ST, CUT	4	15	5	1	3.0	13,900	10.0	0.75	7.5	29.5
#7	Del Norte	Pilgrim Creek	Wild Weaver Road	CO, ST, CUT	5	15	5	3	4.0	7,100	7.1	0.75	5.326	29.3
Tie #8	Trinity	Little Browns Creek	Oregon Gulch Road	ST,CO	3	15	4	3	3.5	16,000	10.0	0.75	7.5	29.0
Tie #8	Trinity	Little Browns Creek	Roundy Rd	ST,CO	3	15	4	3	3.5	16,000	10.0	0.75	7.5	29.0
Tie #8	Coastal Mendo	Ryan Creek	Ryan Creek Road	CO, CH, ST	9	15	3	3	3.0	15,100	10.0	0.5	5	29.0
Tie #8	Del Norte	Ellen Creek #2	Elkhorn Road	CO, ST, CUT	4	15	5	1	3.0	9,300	9.3	0.75	6.975	29.0
#9	Coastal Mendo	Hilton Rock	Hyrin Creek Road	CO, ST	3	15	3	1	2.0	24,100	10.0	0.75	7.5	28.5
#10	Coastal Mendo	Klamath Creek	Hyrin Creek Road	CO, ST	3	15	5	2	4.0	12,600	10.0	0.5	5	28.0
#11	Humboldt	South Arkley Creek #2	Arkley Road	CO, CH, ST, CUT	7	15	5	3	4.0	5,600	9.8	0.50	4.9	27.9
#12	Trinity	Deadwood Creek	Hatchery Rd	ST,CO,CH	3	15	5	1	3.0	41,600	10.0	0.75	7.5	27.5
#13	Coastal Mendo	Dark Gulch	On Springs Road	CO, ST	4	15	5	3	4.0	5,000	5.8	0.75	4.35	27.4
Tie #14	Coastal Mendo	Kiger Creek	Owen Road	CO, ST	4	15	3	1	3.0	21,600	10.0	0.5	5	27.0
Tie #14	Humboldt	Wilder Creek	Wilder Road	CUT	5	15	3	1	2.0	14,200	10.0	0.50	5	27.0
Tie #14	Siskiyou	Wiltse Gulch	Sawyers Bar Road	ST,CO	3	15	3	0	1.5	25,300	10.0	0.75	7.5	27.0
Tie #14	Humboldt	Strawberry Creek #1	Central Avenue	CO, ST, CUT	5	15	4	0	2.0	18,000	10.0	0.50	5	27.0
#15	Humboldt	Painter Creek	Shelter Cove Road	CO, CH, ST	6	15	3	0	1.5	5,800	5.8	0.75	4.35	26.9
#16	Coastal Mendo	Johnson Creek	On Springs Road	CO, S1	4	15	2	0	1.0	8,992	8.9	0.75	6.675	30.7
#17	Humboldt	Shively Creek	Mattole Road	CO, ST	4	15	1	1	1.0	8,200	8.2	0.80	6.5	30.5
#18	Humboldt	Mattole Creek	Mattole Road	CO, ST	5	15	3	1	1.0	19,000	10.0	0.35	3.5	30.2
#19	Humboldt	Washington Gulch	Old Arcata Highway	CO, CH, ST, CUT	7	15	3	1	2.0	8,500	8.5	0.25	2.125	26.1
Tie #20	Humboldt	Garden Gulch	Cherry Creek Rd	ST, CUT	3	15	5	1	3.0	13,000	10.0	0.50	5	26.0
Tie #20	Trinity	Garden Gulch	Easter Ave	ST,CO	3	15	5	1	3.0	16,000	10.0	0.5	5	26.0
Tie #20	Trinity	Oregon Gulch	Sky Ranch Rd	ST,CO	3	15	5	1	3.0	26,300	10.0	0.5	5	26.0
Tie #20	Humboldt	Gibbon Gulch	On Dyerville Road	CO, ST, CUT	5	15	1	1	1.0	13,400	10.0	0.80	5	26.0
Tie #20	Siskiyou	Horse Creek	Wilderness Road	ST,CO	5	15	0	1	0.5	12,200	10.0	0.75	7.5	26.0
Tie #20	Siskiyou	Williams Creek	Klamathon Road	ST,CO	3	15	1	0	0.5	10,500	10.0	0.75	7.5	26.0
#21	Humboldt	Wilkins-Weber Crossing	Mattole Valley Rd	CO, ST, CUT	5	15	3	0	1.5	9,400	9.4	0.50	4.7	25.7
Tie #22	Humboldt	Nelson Creek	Wilder Ridge Road	CO, ST	3	15	3	1	2.0	7,900	7.9	0.65	5.2	25.2


General | Crossings and Channels | Culverts | Stream Crossing Volumes | Landslides | Chronic surface erosion | Spoil Sites | Treatments | Implementation

Use F7 key to spell check

General Information

Site #: 3309 Road Name: Rambling Road

Date Inventoried: 11/2/2004 Road Number: 456 Road Width: 20

Inspector(s): Christine/Carolyn Surface: paved

County: Other Mileage: 9.878

Watershed: Wolf Creek Milepost Marker:

CALWAA:

Maintenance Yard: Lakewood Roll and Frame: 4 taken

See sketch filed in:

Comment: CI 3 xing that has been culverted down left of natural OB channel & is causing severe OB erosion. Large sediment fan. Stream was channelized on the left IL hinge line to OL in unnatural area. Several OSD's up right on OB contribute to erosion. Took 4 pictures of OB

GIS Information

GPS X Coordinate: 465532 Map X Coordinate: 465542

GPS Y Coordinate: 4460773 Map Y Coordinate: 4460773

GPS EPE: 34 GPS DOP: 2.7

Site Evaluation

Site Type: Stream crossing

Erosion Potential: H

Treatment Immediacy: H

Engineer must verify treatments?

Summary of Sediment Savings

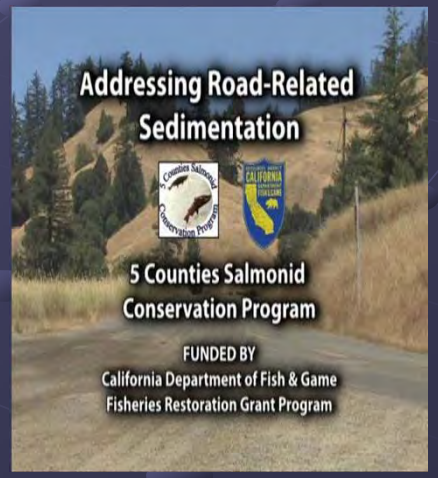
Landslide Yield (cyds): 0

Stream Crossing Yield (cyds): 355

Decadal Chronic Surface Erosion (cyds): 7875

Total Future Yield (cyds): 8230

DIRT Inventories & Prioritization



Workshops & Training Tools

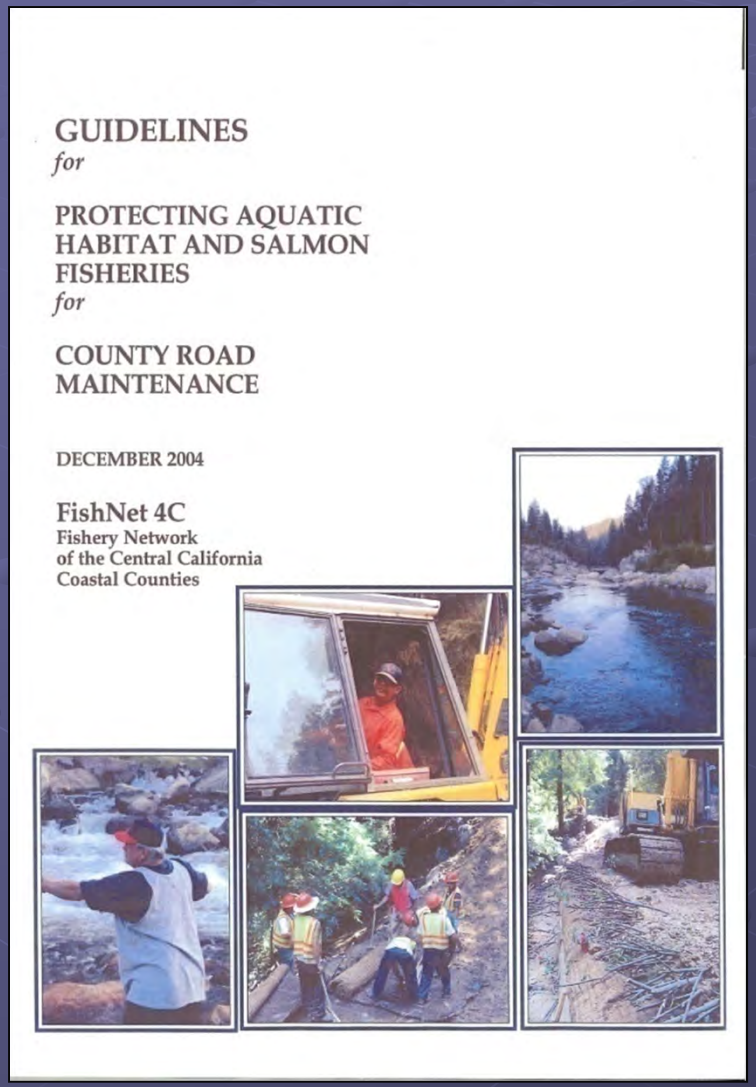
BMPs Are Essential For Effective Management

What Is A BMP?

"Best Management Practice" (BMP) is a vague term, broadly used to describe the most effective, feasible method that does the job. In the context of storm water management, it is often used to mean a structure or technology used to manage or treat the water such as a hooded catch basin, detention basin, or a filter system. The term BMP is also used for behavioral practices such as timely cleaning of catch basins, or habitual closing of the lid on a dumpster (avoiding dumpster brew when it rains). A BMP can even be restraint of a specific behavior such as minimizing the use of lawn fertilizer, or of road salt and sand.

Water Drafting BMPs Chapter 3-B-3

CA Counties Roads and Water Quality Approaches



A WATER QUALITY AND STREAM HABITAT PROTECTION MANUAL
for
COUNTY ROAD MAINTENANCE
IN NORTHWESTERN CALIFORNIA WATERSHEDS

Prepared for the
Five Counties Salmonid Conservation Program

5C Roads Manual Chapters:

Background
1 – Introduction
2 – Regulations & Permits

Implementation
3- Maintaining the Road
4 – Culverts
5 – Disposing of Spoils
6 – Maintenance Yards
7 - Maintaining Bridges
8 – Emergencies
9 – Snow and Ice

Adaptive Management
10 –Monitoring and Reporting
11- Training

Appendices
BMP Tool Box
Glossary
Technical References

Fish Net 4C Roads Manual Chapters:

Background

1 – Introduction
2 – Regulations & Permits
3 – Watershed Basics
4 – Salmon Fisheries

Implementation

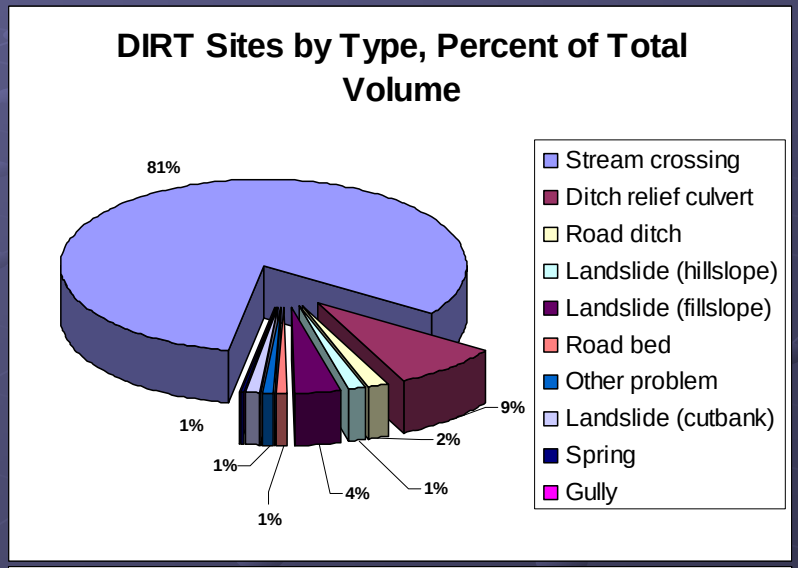
5 – Road Design & Maintenance
6 – Working Near Streams
7 – Sediment Control
8 – Vegetation Management
9 – Maintenance Facilities
10 – Emergency Work & BMPs

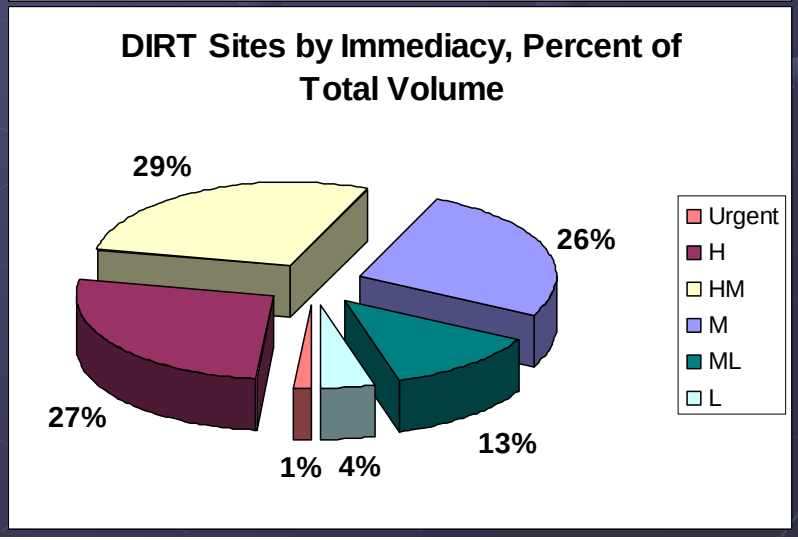
Appendices

BMP Tool Box
Glossary
Technical References

County Road Direct Inventory of Roads and Treatments (DIRT) Sediment Source Inventory

	Volume Yd^3	Sites
Stream crossing	2,958,981	6299
Ditch relief culvert	315,775	2454
Road ditch	61,378	381
Landslide (hillslope)	44,385	24
Landslide (fillslope)	134,563	76
Road bed	31,593	217
Other problem	33,282	89
Landslide (cutbank)	36,490	32
Spring	7,249	80
Gully	2,511	9
Total	3,626,205	9,661





BMP Inventory and Planning

- Citizen and Board Complaints
- Training and Recognition (Like This Webinar)
- Annually Inspect Roads Early Enough To Do Work
- Schedule Maintenance Based on All Factors:
  - Protection of the Environment
    - Water Quality
    - T&E Species (e.g. Nesting)
    - Stream Flow
  - Staffing Schedules
  - Materials and Equipment Available
  - Accessibility
- Determine When Maintenance Is Excessive and Upgrading is Necessary

BMP Training (Chapter 11

Chapter 11 Roads Trainings

Training Program Elements for road crews, supervisors, engineers, and managers include:

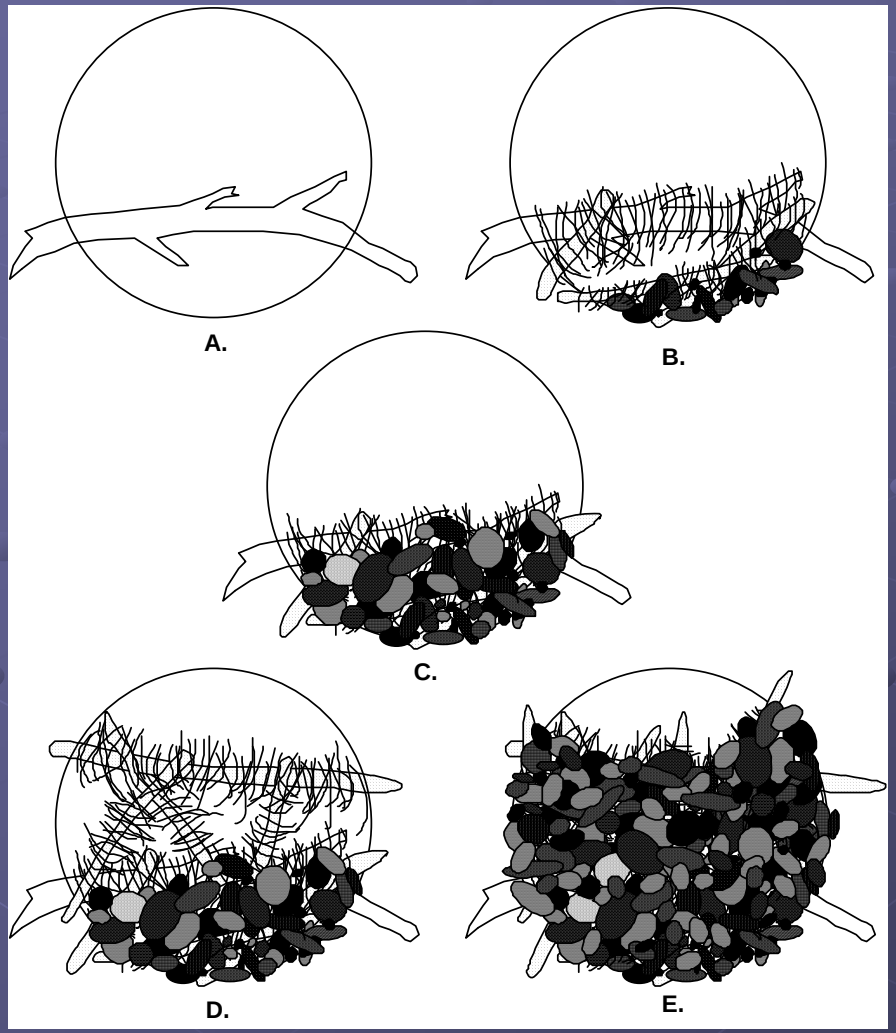
A. Internal Employee Training
- Hazardous materials training *
- Training video sessions (See: 11-B Training Resources)
- Field-based training

B. Regional Training
- Manual Implementation Training Workshops / Modules:
- Watershed & Fish Basics: Chapter 1
- BMP training: Chapters 3 through 9, such as:
- Fish Passage at Road Crossings *
- Water Drafting BMPs
- Maintenance Yard Practices
- Vegetation Management
- Bridge Maintenance Practices
- Monitoring Basics: Chapter 10

BMP Inventory and Planning
Annual Culvert Surveys

Annually Inspect Roads Early Enough To Do Work- 16,000 Culverts on 5C County Roads

BMP Maintenance Inventory: Culvert Surveys



(Flanagan 2004)

Annually Inspect Roads Early Enough To Do Work- 16,000 Culverts on 5C County Roads

Maintenance Inventory and Planning
Conduct Culvert Surveys

Monitor, Call and Plan For Winter

Maintenance Inventory and Planning
Conduct Culvert Surveys

"This pipe was laying in the ditch. It is packed full of Marijuana (there are benefits to cleaning culverts). I called the Sheriff dept they will pick it up when they have time."

Maintenance Inventory and Planning: Identify Land Use Changes

- Increase Ditch Width and Depth
- Require Remedial Actions of Owner
- Increase Ditch Relief Culvert Size
- Notify Water Board of Potential Discharge

Implement Maintenance

- Schedule Maintenance Based on All Factors:
  - Protection of the Environment
    - Water Quality
    - T&E Species (e.g. Nesting)
    - Stream Flow
  - Staffing Schedules
  - Materials and Equipment Available
  - Accessibility
- Determine When Maintenance Is Excessive and Upgrading is Necessary

DITCH SHAPING AND CLEANING 3-A-3

Definition: Ditch: a facility, typically parallel to the road, which carries stormwater runoff from a county facility and/or adjacent properties; it is not a channelized stream or a fish-bearing stream.

Description: This action includes the use of equipment for cleaning, reshaping, and stabilizing ditches. Ditches are needed along insloped roadways to intercept and carry non-stream flows to a location where the flow can be safely dispersed downslope, predominantly by way of ditch relief culverts (see section 4-E). Drainage options from county roads are often quite restricted due to potential conflicts with downslope property owners and land uses. The goal of routine ditch maintenance is to keep the ditchline free flowing. Subsequent actions include loading, hauling, and disposing of excess materials. This activity is performed in all weather. Material is removed to an appropriate location for disposal or storage (see Chapter 5).

Environmental Concerns:

- Discharge of sediment into a ditch, which may discharge into a stream or storm water drainage system that contains fish or contributes resources that support fish.
- Discharge of sediment into a stream from erosion within the ditch.
- Road surface erosion or roadway failure due to a plugged ditch or ditch relief culvert.
- Rerouting water into a stream above its normal carrying capacity and causing channel adjustments.
- Removal of riparian vegetation or damage to aquatic habitat.

Best Management Practices:

1. Grade ditches only when and where necessary, since frequent routine mechanical grading can cause erosion of the ditch, undermine banks, and expose the toe of the cutslope to erosion. Do not remove more grass and weeds than necessary to keep water moving, as vegetation prevents scour and filters out sediment.

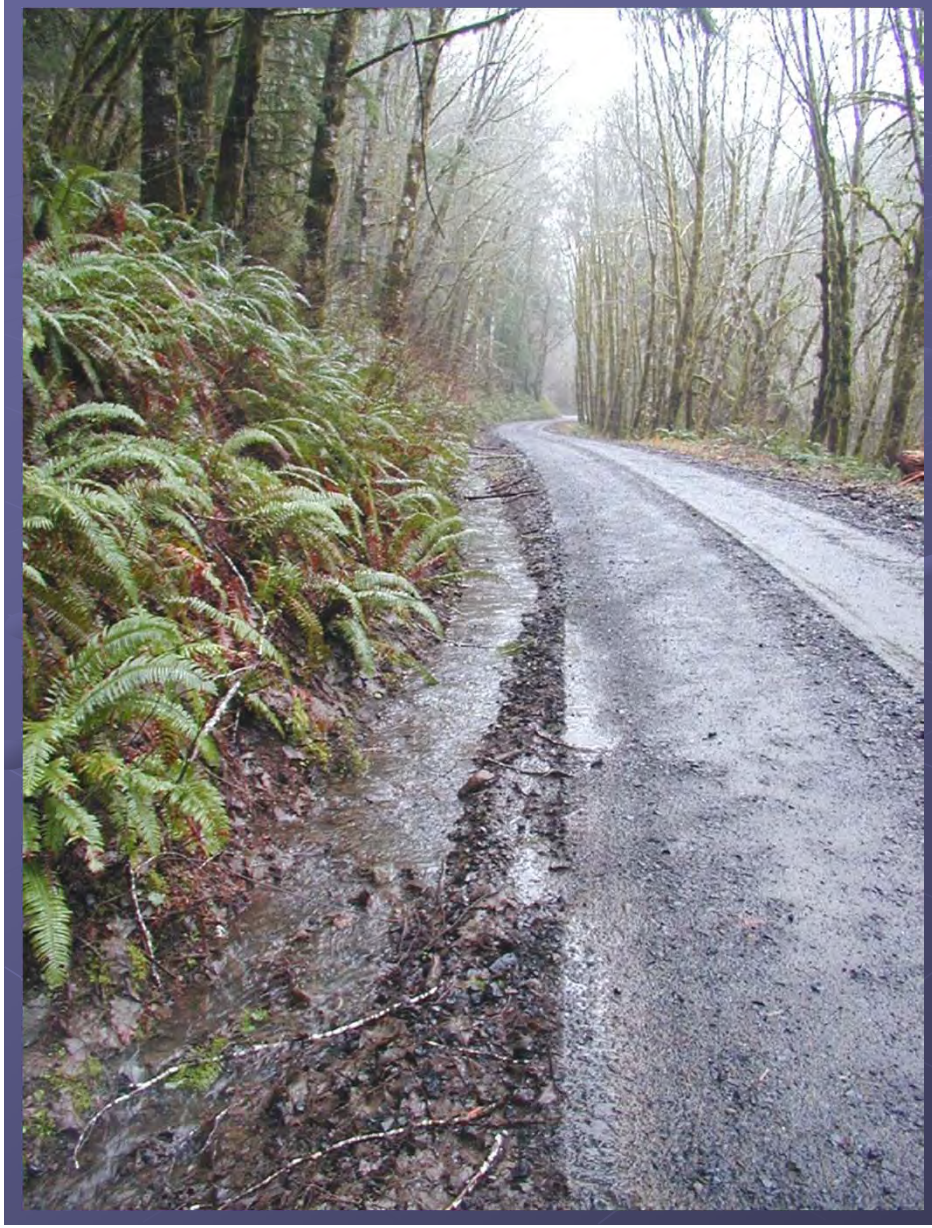
2. Ditch spoil can be windrowed at the inside road shoulder for later endhauling by loader, backhoe, and/or truck. Never sidecast material into a waterway or the adjacent riparian area. Dispose of removed material at safe spoil disposal sites and not within any waterway, wetland, or riparian area. [See: Chapter 5 – Disposing the Spoil].

3. Adjust BMPs for ditch cleaning according to the area in which the work is being performed, that is, more stringent for an area near or hydrologically connected to a stream or drainage system (including lower order watercourses), and less for areas not connected. [See: Figure 1-2.]

4. Use erosion control devices, such as check dams, sand/gravel bag barriers, and other acceptable techniques, when it is neither practical nor environmentally sound to disperse ditch water immediately before the ditch reaches a stream. These sediment catchment facilities require routine maintenance to be effective. [Appendix B-9]

Chapter 3 Roads Maintenance: Ditch Shaping and Cleaning

Ditch Maintenance: What is a Ditch?



- In theory a ditch systems is a water conveyance system with only two components:
  - The ditch
  - The discharge point
- In actuality, they are side hill stream systems that take on all of the geomorphic and hydrologic characteristics of streams, except they we try to make them defy gravity.
- Some ditches actually divert streams and develop biological features of streams, wetlands and riparian areas

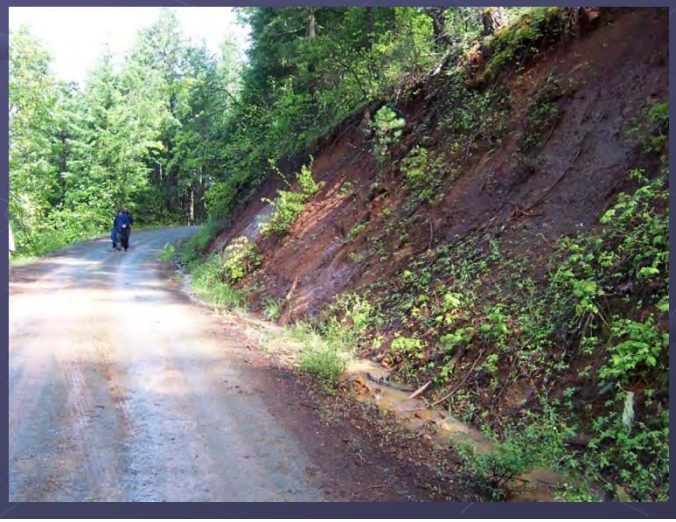
Chapter 3 Roads Maintenance BMPs: Ditches, Cutbanks, and Fill Slopes

- Disconnect Excessive Ditch Flow
- Reconnect Streams to Natural Channels

Ditch Relief Culvert Installation

BMP Ditch Relief Culvert Installation

Ditch Shaping and Cleaning- Cutbank Management



Add ditch maintenance from China Gulch Road

DITCH SHAPING AND CLEANING 3-A-3

5. Minimize impact to existing vegetation on the cutbank above the ditch. If erosion from the cutbank is causing the ditch to fill with sediment, perform appropriate erosion control measures. Ditches functioning as rock fall areas, as opposed to drainage facilities, do not need to be treated. [Appendix B-4.]

6. When possible, perform ditch work in dry weather to minimize environmental impacts, and consult with appropriate county staff members if silt devices are inadequate to filter water prior to draining to watercourses.

7. Recycle excavated material when feasible. [See: Chapter 5 – Spoil Disposal]

8. Add filtering devices along the ditches or at the ditch relief culvert inlets. [Appendix B]

9. Retain water in its drainage of origin, to the extent practical, to avoid creating unwanted downstream impacts, using downslope opportunities that may be available.

10. Maintain artificial drainage ditches to prevent development of new wetlands by keeping water moving and preventing establishment of wetland plants, which can impede the permitting of ditch maintenance practices.

Permits Possibly Needed:

- Jurisdiction under CWA 404 may depend upon the following:
  - When a natural drainage channel (even an ephemeral stream) flows into a drainage ditch, then the ditch becomes a "water of the U.S." and requires 404 permitting.
  - Tidal drainage ditches and ditches through wetlands are "waters of the US" also.
  - If the ditch only collects rainfall off of the road, then it is not a jurisdictional water.
- If not reshaping the ditch but cleaning only (including removal of sediment, debris and vegetation), then the practice may be considered maintenance only and is exempt from the 404 permit process. See Corps' definition of maintenance exemption (33 CFR 323.4) if needed.
  - Ditch must be returned to its original dimensions and configuration.
- If reshaping a ditch, County may need CWA 404 permit from COE – General Nationwide Permit No. 41 – "Reshaping Existing Drainage Ditches".
  - Design capacity or area drained cannot be expanded.
  - Centerline of reshaped drainage ditch must be essentially in the same location as the centerline of the existing ditch.
  - Does not authorize reconstruction of drainage ditches that have become ineffective through lack of regular maintenance.
  - Notify COE if greater than 500 feet in length.
  - No mitigation required.
- CWA 401 Water Quality Certification permit from RWQCB
- Coastal Zone: Exempt from coastal development permit unless subject to review under Section 1601 of the Fish and Game Code, or excavation or disposal of fill is outside of the roadway prism.

Ditch Cleaning

Roadside Vegetation & Ditches as Wetlands ?

Contact Department or Resource Agency biologist prior to working in ditches that exhibit wetland characteristics

Ditch Cleaning Timing

<u>Timing</u>:
Do not conduct vegetation maintenance in wet weather (*unless an emergency)

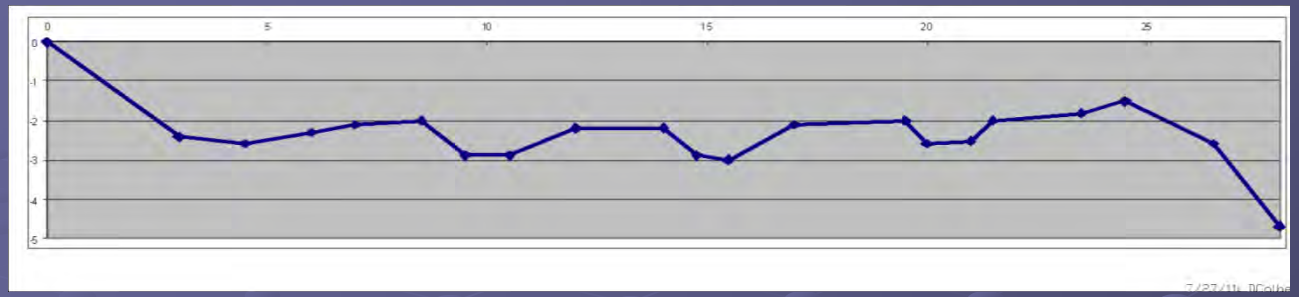
Ditch Cleaning Management BMPs

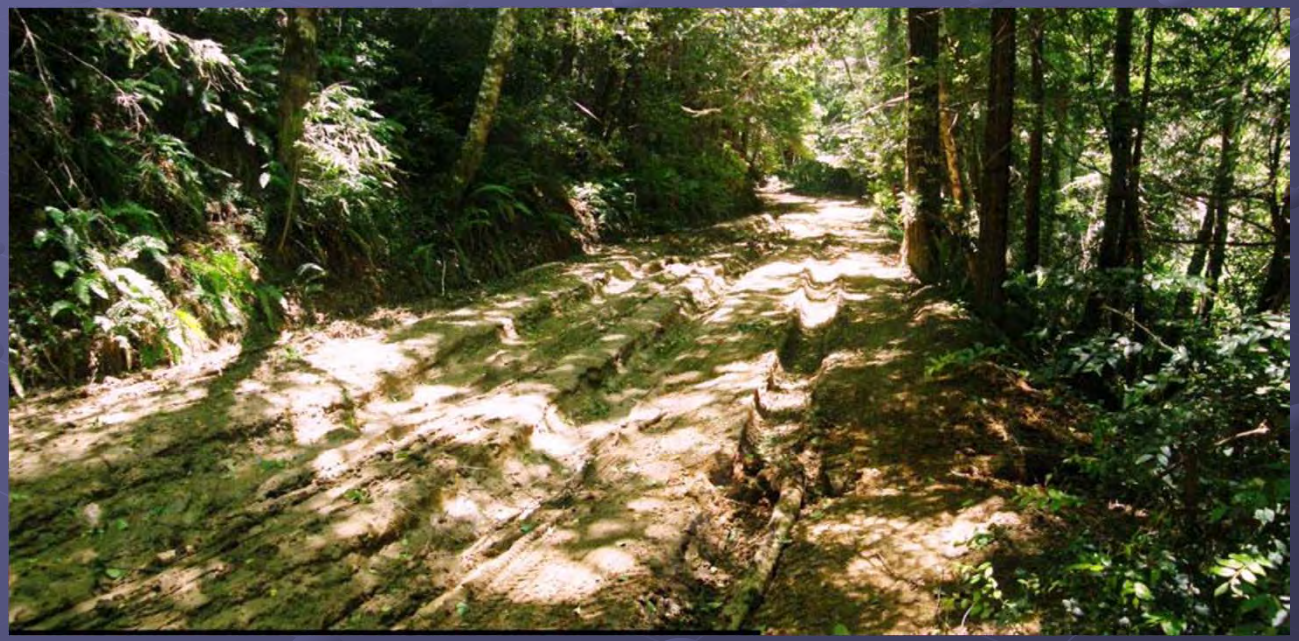
- Timing of Cleaning
- Equipment
- Habitat Considerations

Ditch Vegetation Maintenance Options

Ditch Management- Overside Drains

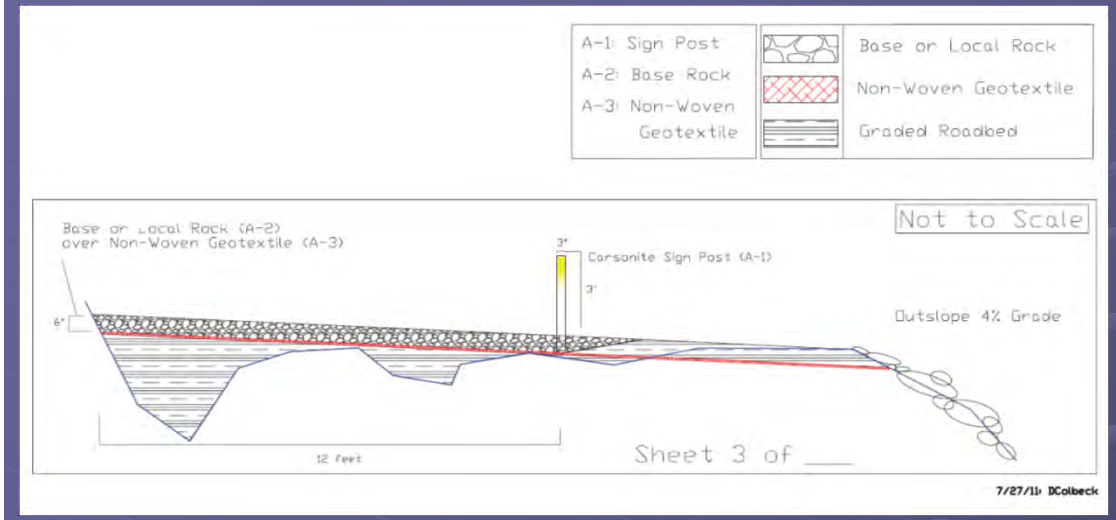
Ditches and Through Cuts

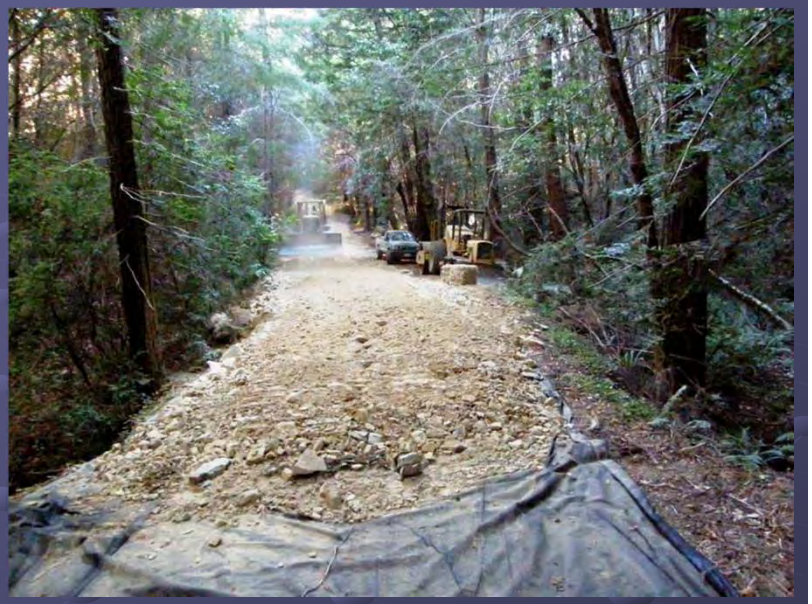




In Board Ditches Combined with Out Board Berms Trap Water in the Road

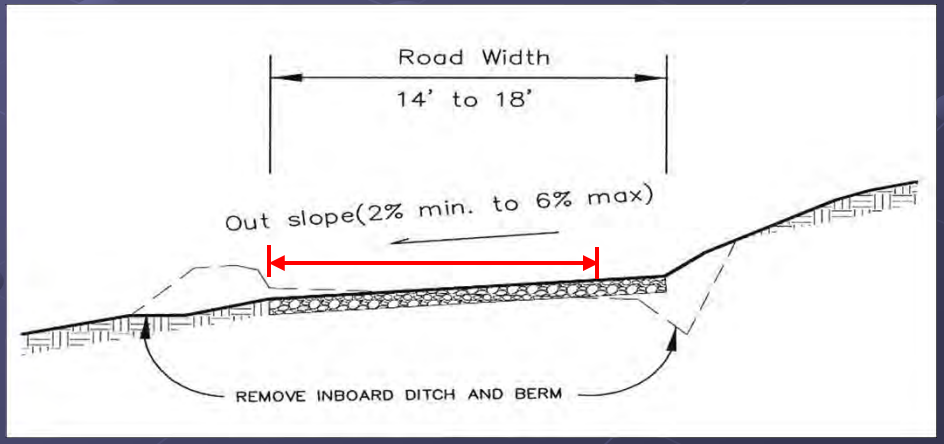
Through Cut Treatments





Fill the In Board Ditch, Outslope the Road, Remove the Berm, Breach the Berm, Add Geo Fabric & Rock Surface

Low Impact To Hydrology Road Designs- Outsloped Roads



Road Surfacing

Recycled Asphalt Grindings

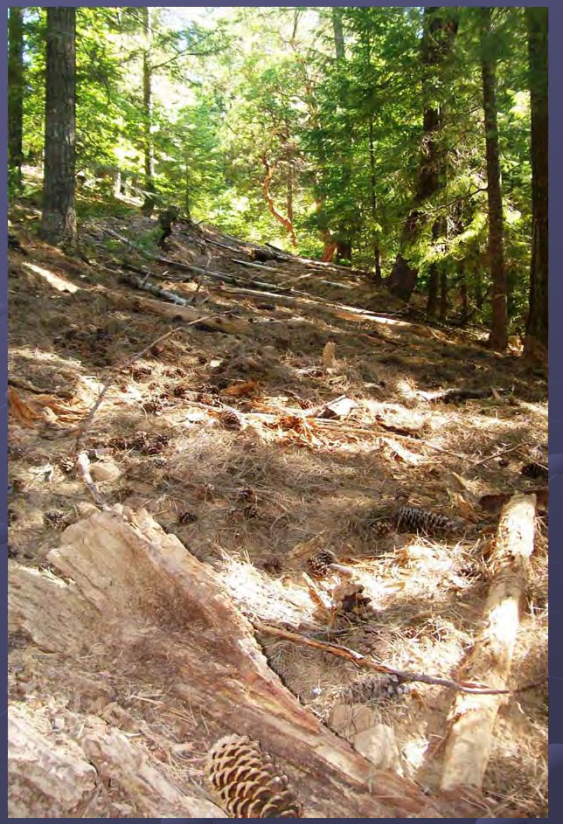
Concrete Washout

Erosion Control

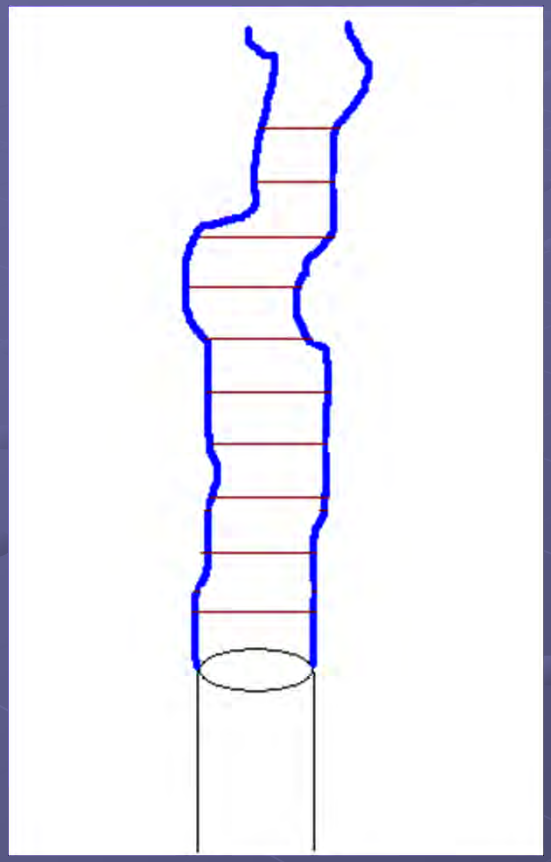
Erosion Control- Typically straw mulch at least 2” thick is applied over native seed . Used for mulching for erosion control & weed management BMP

Erosion Control

Non-Traditional Erosion Control Options



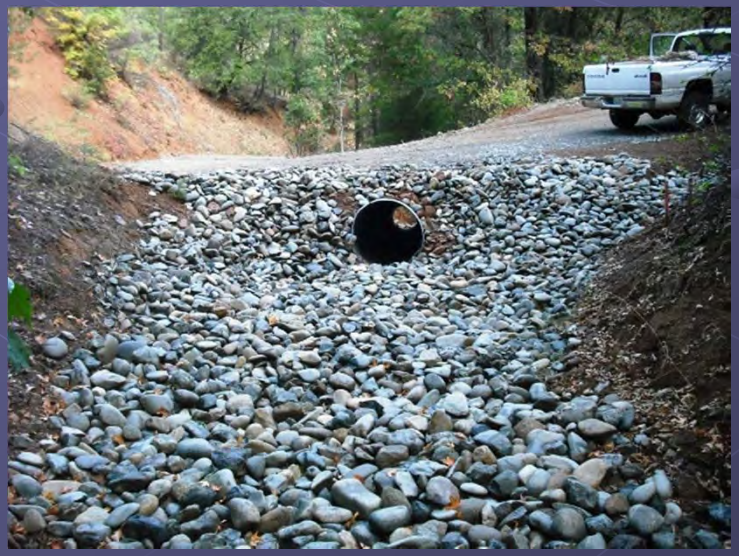
Chapter 4 Culverts and Stream Crossings
Upgrading Class III Stream Crossing



Make systematic measurements of active channel width. 20 ft intervals, beginning 20 ft above the pipe inlet. Calculate average width.

For Culvert Sizing (4-C-1), 100-year culverts are now the County's design standard that convey natural drainage, as the BMP states.

Chapter 4 Culverts and Stream Crossings
Upgrading Class III Stream Crossing

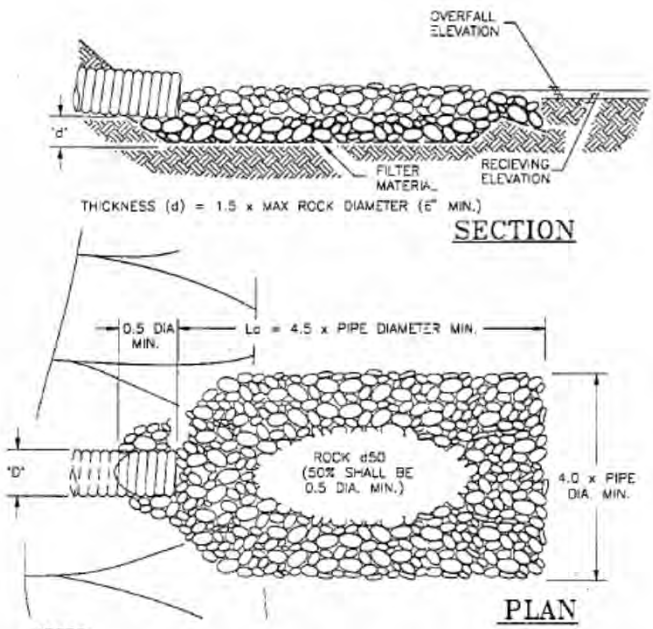


- Properly Size- 100 Yr Flow
- No Shot Gun Placements
- Place at Proper Angle
- Plastic vs. Metal Culverts
- Critical Dips
- Downspouts and Energy Dissipaters

Chapter 4 Culverts and Stream Crossings
Upgrading Class III Stream Crossing

Chapter 4 Culvert BMP Implementation

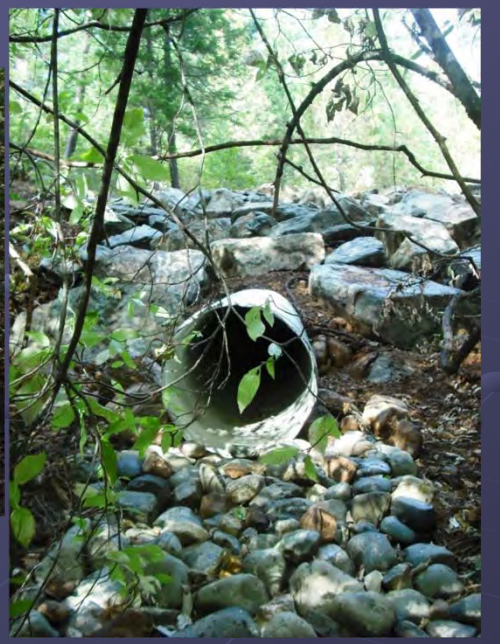
Energy Dissipator B-3.7



NOTES:

1. 'La' = LENGTH OF APRON. DISTANCE 'La' SHALL BE OF SUFFICIENT LENGTH TO DISSIPATE ENERGY. APRON SHALL BE SET AT A ZERO GRADE AND ALIGNED STRAIGHT.
2. FILTER MATERIAL SHALL BE FILTER FABRIC OR 6" THICK (MIN.) GRADED GRAVEL LAYER.

Source: McCullah, J. 1992. Erosion and Sediment Control Standards Design Manual – County of Shasta. Prepared for the Western Shasta Resource Conservation District (RCD). Redding CA. 187 p.



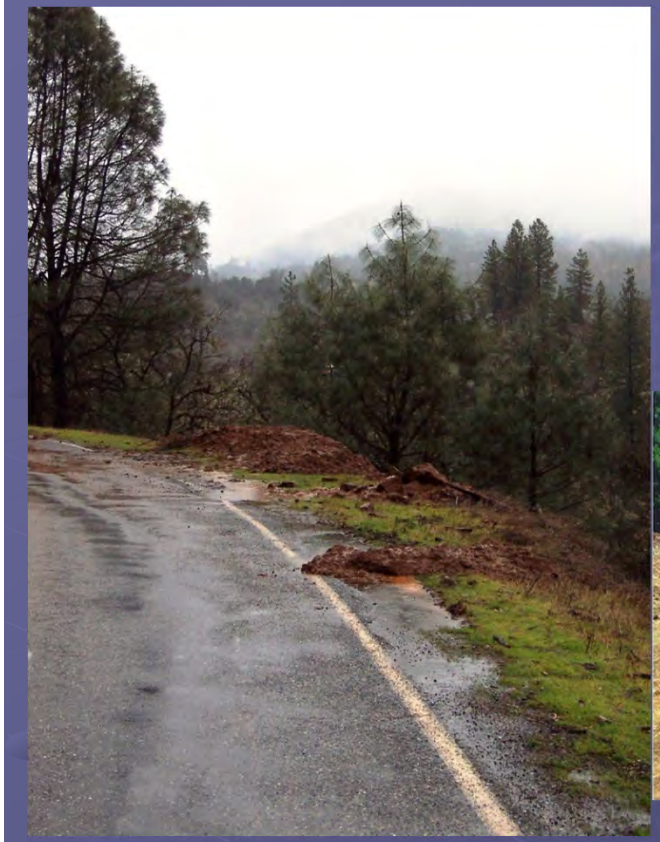
Chapter 4 Culvert BMP Implementation

Chapter 5- Spoils Management: Reduce, Reuse and Recycle Materials

Chapter 3, 5, & 8
Slides, Spoils and Revegetation

Chapter 5
Spoils Management

- Permanent, Temporary or Emergency
- Location, Location, Location



Chapter 7 Maintaining Bridges

7-A Bridge Maintenance

- 7-A-1 Bridge Cleaning and Maintenance
- 7-A-2 Bridge Vegetation Management

7-B Bridge Repair & Drift Removal

- 7-B-1 Bridge Repair
- 7-B-2 Drift Removal

Chapter 7 Maintaining Bridges

7-B-2 **Drift Removal**

Chapter 9 Snow and Ice

9-B-1 Sanding

9-B-2 De-icing and Anti-icing Chemicals

Chapter 9 Snow and Ice

Best Management Practices:

1. Minimize the application rates of sand where sand could wash off into the streamcourse.
2. Use anti-icing products on bridges and roads where permitted and during freezing fog in lieu of sanding, when optimum conditions exist, where adjacent water bodies support a 100:1 dilution factor, or where there is a vegetative buffer between the road and water body and there is no standing, shallow water.
3. Seek use of alternative de-icing agents that are environmentally friendly.
4. Calibrate spreaders routinely. Do not over-apply de-icing agents.
5. Maintain accurate records of the locations for salt application and quantities of salt used. Follow recommended salt application rates.
6. Wash equipment used in the application of de-icing agents at a wash area that discharges to a sanitary sewer system or water recovery system using detergents.
   [See: 6-C-3 Maintenance Yard: Pressure Washing]
7. Store de-icing agents in covered areas, bunkers, or storage buildings. Do not store de-icing chemical where they will come in contact with storm water runoff. [See: 6-D Maintenance Yard: Material Use & Storage]

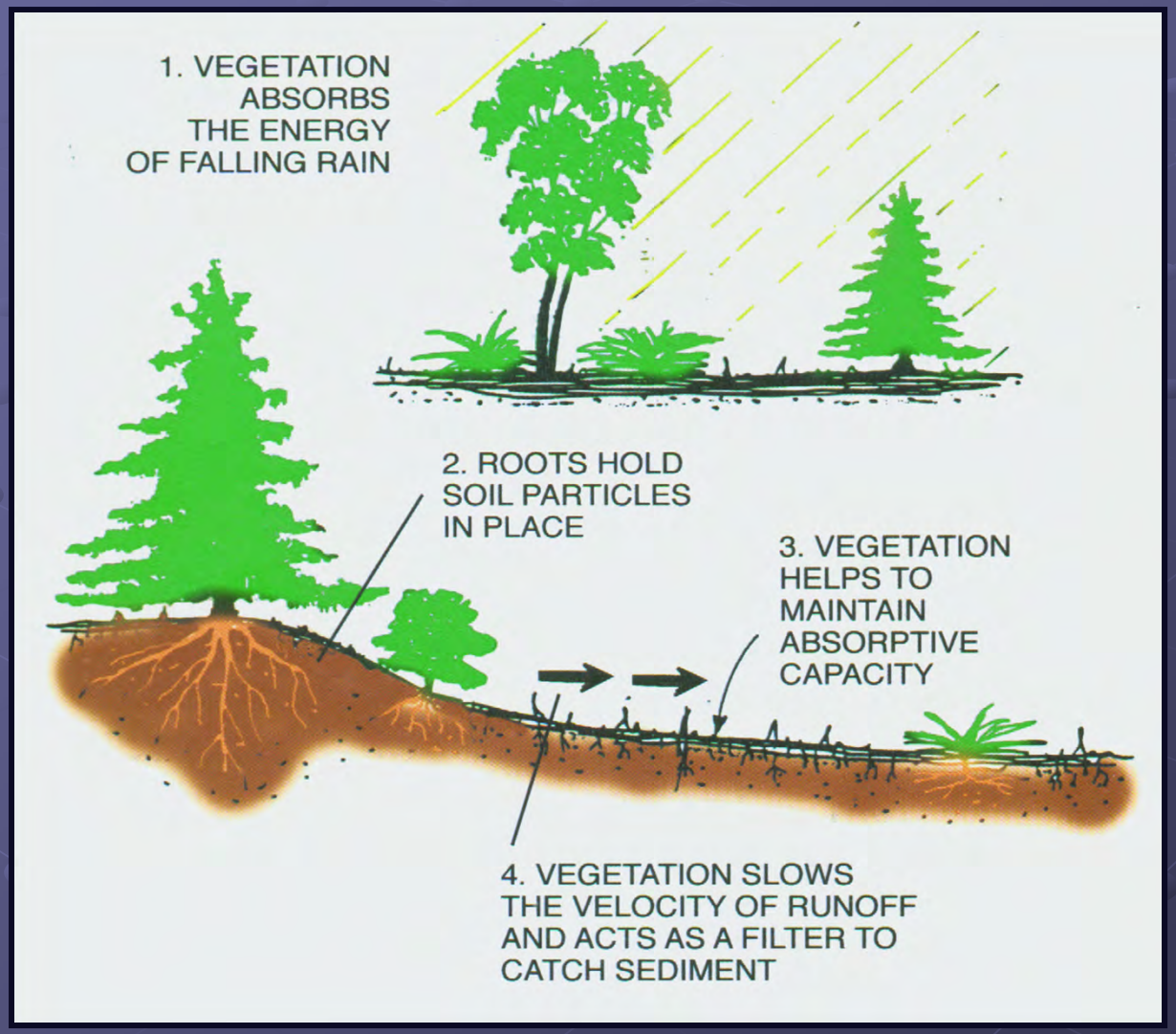
8. See ODOT video, “CMA: A Valuable Tool for Winter Operations” (18 min.).

General Vegetation Management BMPs

Do not remove plants more than 20 feet off the road on either side of a bridge

Do not remove plants from 10 feet upstream/downstream of a culvert that is 6-feet in diameter or larger

Primary Goal:
Preserve Vegetation to Extent Feasible



- Slope Stabilization
- Sediment & road runoff filtration
- Shade
- LWD

Bioengineering techniques as effective streambank stabilization, riparian function & weed management BMP

Bank Stabilization & Bio-Engineering