

State of California
Office of Administrative Law

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BOARD OF FORESTRY AND FIRE PROTECTION

In re:
Board of Forestry and Fire Protection

NOTICE OF APPROVAL OF REGULATORY ACTION

Regulatory Action:

Government Code Section 11349.3

Title 14, California Code of Regulations

OAL File No. 2014-0429-02 SR

Adopt sections: 923, 923.1, 923.2, 923.3,
923.4, 923.5, 923.6, 923.7,
923.8, 923.9, 923.9.1, 943,
943.1, 943.2, 943.3, 943.4,
943.5, 943.6, 943.7, 943.8,
943.9, 943.9.1, 963, 963.1,
963.2, 963.3, 963.4, 963.5,
963.6, 963.7, 963.8, 963.9,
963.9.1

Amend sections: 895.1, 914.7, 914.8, 915.1,
916.3, 916.4, 916.9, 934.7,
934.8, 935.1, 936.3, 936.4,
936.9, 954.7, 954.8, 955.1,
956.3, 956.4, 956.9, 1034,
1051.1, 1090.5, 1090.7,
1092.09, 1093.2, 1104.1

Repeal sections: 918.3, 923, 923.1, 923.2,
923.3, 923.4, 923.5, 923.6,
923.7, 923.8, 923.9,
923.9.1, 938.3, 943, 943.1,
943.2, 943.3, 943.4, 943.5,
943.6, 943.7, 943.8, 943.9,
943.9.1, 958.3, 963, 963.1,
963.2, 963.3, 963.4, 963.5,
963.6, 963.7, 963.8, 963.9

This regulatory action by the Board of Forestry and Fire Protection (Board) represents a comprehensive overhaul of the Board's "Road Rules," located within title 14 of the California Code of Regulations. The purpose of this action is to ensure that all road-related Forest Practice Rules adequately prevent individual and cumulative adverse impacts to beneficial uses of water. In addition to making substantive revisions, the Board reorganized all rules related to logging roads, landings, and watercourse crossings into a clear, concise, and logical order.

OAL approves this regulatory action pursuant to section 11349.3 of the Government Code. This regulatory action becomes effective on 1/1/2015.

Date: 6/11/2014


Eric Parjington
Attorney

For: DEBRA M. CORNEZ
Director

Original: George Gentry
Copy: George Gentry

NOTICE PUBLICATION/REGULATIONS SUBMISSION

STD. 400 (REV. 01-2013)

RESUBMITTAL See Instructions on reverse)

For use by Secretary of State only

OAL FILE NUMBERS	NOTICE FILE NUMBER Z-2013-0813-08	REGULATORY ACTION NUMBER 2014-0429-023R	EMERGENCY NUMBER
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2014 APR 29 PM 12:03

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ADMINISTRATIVE LAW

 DEBRA BOWEN
 SECRETARY OF STATE

NOTICE

REGULATIONS

AGENCY WITH RULEMAKING AUTHORITY

California Board of Forestry and Fire Protection

AGENCY FILE NUMBER (if any)

A. PUBLICATION OF NOTICE (Complete for publication in Notice Register)

1. SUBJECT OF NOTICE	TITLE(S)	FIRST SECTION AFFECTED	2. REQUESTED PUBLICATION DATE
3. NOTICE TYPE <input type="checkbox"/> Notice re Proposed Regulatory Action <input type="checkbox"/> Other	4. AGENCY CONTACT PERSON	TELEPHONE NUMBER	FAX NUMBER (Optional)
OAL USE ONLY <input type="checkbox"/> Approved as Submitted <input type="checkbox"/> Approved as Modified <input type="checkbox"/> Disapproved/Withdrawn	ACTION ON PROPOSED NOTICE	NOTICE REGISTER NUMBER 2013, 342	PUBLICATION DATE 8/23/2013

B. SUBMISSION OF REGULATIONS (Complete when submitting regulations)

1a. SUBJECT OF REGULATION(S) Road Rules, 2013	1b. ALL PREVIOUS RELATED OAL REGULATORY ACTION NUMBER(S) Z-2011-1213-11, 2013-1118-015
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2. SPECIFY CALIFORNIA CODE OF REGULATIONS TITLE(S) AND SECTION(S) (Including title 26, if toxics related)

SECTION(S) AFFECTED (List all section number(s) individually. Attach additional sheet if needed.)	ADOPT Please refer to attached additional sheet.
	AMEND Please refer to attached additional sheet.
	REPEAL Please refer to attached additional sheet.
TITLE(S) 14	

3. TYPE OF FILING

<input type="checkbox"/> Regular Rulemaking (Gov. Code §11346)	<input type="checkbox"/> Certificate of Compliance: The agency officer named below certifies that this agency complied with the provisions of Gov. Code §§11346.2-11347.3 either before the emergency regulation was adopted or within the time period required by statute.	<input type="checkbox"/> Emergency Readopt (Gov. Code, §11346.1(h))	<input type="checkbox"/> Changes Without Regulatory Effect (Cal. Code Regs., title 1, §100)
<input checked="" type="checkbox"/> Resubmittal of disapproved or withdrawn nonemergency filing (Gov. Code §511349.3, 11349.4)	<input type="checkbox"/> Resubmittal of disapproved or withdrawn emergency filing (Gov. Code, §11346.1)	<input type="checkbox"/> File & Print	<input type="checkbox"/> Print Only
<input type="checkbox"/> Emergency (Gov. Code, §11346.1(b))		<input type="checkbox"/> Other (Specify) _____	

4. ALL BEGINNING AND ENDING DATES OF AVAILABILITY OF MODIFIED REGULATIONS AND/OR MATERIAL ADDED TO THE RULEMAKING FILE (Cal. Code Regs. title 1, §44 and Gov. Code §11347.1)

1/3/2014 - 1/20/2014	request
5. EFFECTIVE DATE OF CHANGES (Gov. Code, §§ 11343.4, 11346.1(d); Cal. Code Regs., title 1, §100)	
<input type="checkbox"/> Effective January 1, April 1, July 1, or October 1 (Gov. Code §11343.4(a))	<input type="checkbox"/> Effective on filing with Secretary of State
<input type="checkbox"/> \$100 Changes Without Regulatory Effect	<input checked="" type="checkbox"/> Effective other (Specify) January 1, 2015 per PRC § 4554.5

6. CHECK IF THESE REGULATIONS REQUIRE NOTICE TO, OR REVIEW, CONSULTATION, APPROVAL OR CONCURRENCE BY, ANOTHER AGENCY OR ENTITY

<input type="checkbox"/> Department of Finance (Form STD. 399) (SAM §6660)	<input type="checkbox"/> Fair Political Practices Commission	<input type="checkbox"/> State Fire Marshal
<input type="checkbox"/> Other (Specify) _____		

7. CONTACT PERSON

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8. I certify that the attached copy of the regulation(s) is a true and correct copy of the regulation(s) identified on this form, that the information specified on this form is true and correct, and that I am the head of the agency taking this action, or a designee of the head of the agency, and am authorized to make this certification.

SIGNATURE OF AGENCY HEAD OR DESIGNEE

DATE

March 13, 2014

TYPED NAME AND TITLE OF SIGNATORY

George Gentry, Executive Officer

For use by Office of Administrative Law (OAL) only

ENDORSED APPROVED

JUN 11 2014

Office of Administrative Law

1 **BOARD OF FORESTRY TECHNICAL RULE ADDENDUM NO. 5:**
2 **GUIDANCE ON HYDROLOGIC DISCONNECTION, ROAD DRAINAGE,**
3 **MINIMIZATION OF DIVERSION POTENTIAL, AND HIGH RISK CROSSINGS (1st**
4 **EDITION)**

5
6 **Purpose**

7 The purpose of this technical rule addendum is to provide guidance to Registered
8 Professional Foresters (RPFs), Licensed Timber Operators (LTOs), Timberland
9 Owners, and agency personnel on hydrologic disconnection of road segments and
10 logging road drainage, as required by the Forest Practice Rules pursuant to 14 CCR §
11 923 et seq. [943 et seq., 963 et seq.]. Logging roads cannot be completely
12 disconnected from watercourses in all locations. This addendum provides assistance in
13 understanding where disconnection is necessary and where site-specific field
14 observations indicate that key areas and problem indicators combine to result in
15 significant existing or potential erosion sites. The information contained herein is
16 designed to be integrated with site-specific evaluation of logging road conditions in the
17 field.

18
19 Part I of this addendum presents an introduction to the concept of hydrologic
20 disconnection, a method to evaluate existing hydrologic connectivity, and treatment
21 measures available to achieve hydrologic disconnection. Part II contains guidance on
22 the appropriate location of drainage facilities and structures, installation of energy
23 dissipaters, road surface outsloping, and placement of rolling dips. Part III describes
24 diversion potential at watercourse crossings and the importance of critical dip
25 installation. Part IV describes crossings with higher risk of failure and potential

1 approaches that can be used to reduce the risk of catastrophic failure. Part V concludes
2 with a table and several figures that illustrate the concepts discussed in the text of the
3 addendum.

4 5 **I. Hydrologic Disconnection**

6 As defined in 14 CCR § 895.1, hydrologic disconnection means the removal of
7 direct routes of drainage or overland flow of road runoff to a watercourse or lake. The
8 goal of hydrologic disconnection is to minimize sediment delivery and hydrologic change
9 derived from road runoff being routed to a watercourse (Refer to Figure 1). Hydrologic
10 disconnection is achieved by creating a road surface and drainage configuration that
11 directs water to discharge from the road in a location where it is unlikely to directly flow
12 into a watercourse. Hydrologic disconnection can be accomplished by directing road
13 runoff onto effective filter strips. Filter strips should have high infiltration capacity and
14 dense vegetation and/or obstructions (e.g., woody debris, slash) to dissipate energy,
15 facilitate percolation, and resist or prevent erosion and channelization. Hydrologic
16 connectivity increases the potential for the road segment to deliver road-derived
17 sediment and road chemicals, including spills, to a watercourse. When roads are
18 connected to watercourses, this effectively increases the drainage density of the
19 watershed, producing hydrologic changes that can alter the magnitude and frequency of
20 runoff delivery to watercourses. The proportion of road prisms that are hydrologically
21 connected is strongly controlled by road location, road design, road maintenance, local
22 topography, geology, and factors that control the amount of road runoff (e.g., the
23 amount of annual precipitation).

1 Hydrologically connected roads can deliver water and sediment via inside ditches that
2 drain to a watercourse crossing; by a connected road drainage structure or facility (i.e.,
3 ditch drain culvert, rolling dip, waterbreak, or lead-off inside ditch that delivers runoff to a
4 watercourse channel); or by direct runoff from the road running surface to a watercourse
5 at road crossings (Refer to Figure 1). **In the western U.S., road-watercourse**
6 **crossings account for the majority of the connected road length,** followed by
7 gullies formed by concentrated runoff at drainage structure or facility outlets. Evidence
8 of connection below a road drainage structure or facility is provided by: (1) indication of
9 surface flow between the drainage structure outlet and a defined channel or a flood
10 prone area; (2) a channel that extends from a road drainage structure outlet to the high
11 water line of a defined channel or a flood prone area; (3) a sediment deposit that
12 reaches the high water line of a defined channel or a flood prone area; (4) observation
13 of turbid water reaching the watercourse during runoff events; or (5) indications of
14 channel widening and/or incision below a drainage structure resulting from increases in
15 flow.

16
17 Primary mechanisms for decreasing hydrologic connectivity are: (1) installation of a
18 “disconnecting” drainage facility or structure close to the watercourse crossing; (2)
19 increasing the frequency of ditch drain (relief) culvert spacing for roads with inside
20 ditches; (3) converting crowned or insloped roads with inside ditches to outsloped roads
21 with rolling dips; (4) removing or breaching outside berms on crowned or outsloped
22 roads to facilitate effective drainage; (5) applying treatments to dissipate energy,
23 disperse flows, and minimize erosion at road drainage outlets not connected to
24 watercourses; and (6) avoiding concentration of flows onto unstable areas. In
25 particular, the distance between a watercourse crossing and the first upslope

1 adequately functioning and sized road drainage facility or structure is of high importance
2 because this distance has a large influence on the volume of water and sediment
3 delivered to a watercourse.

4
5 Not all road segments are hydrologically connected and complete hydrologic
6 disconnection is not possible for most roads. For example, insloped road segments
7 with an inside ditch will generally include a segment that is connected between the
8 watercourse and first road drainage facility or structure located up-grade from the
9 watercourse crossing (Refer to Figure 2). The likelihood of connectivity generally
10 decreases rapidly as the distance between the road and the watercourse increases.

11 Low delivery potential roads also include road segments on flat terrain that do not
12 intersect watercourse channels. For all existing road segments where hydrologic
13 connection may be present, 14 CCR § 923.1(e) [943.1(e), 963.1(e)] requires that an
14 evaluation be conducted to identify which segments need to be disconnected and how
15 the disconnection will occur.

16 17 **A. Key Areas to Evaluate for Hydrologic Connectivity**

18 When evaluating the hydrologic connectivity of logging roads, particular attention should
19 be devoted to identifying road segments with a high number of watercourse crossings
20 and those located close to watercourses (e.g., <200 feet). Key areas to consider in this
21 context include, but are not limited to:

- 22
- 23 • Road segments with road drainage structure or facility outlets near watercourses.
- 24 • Insloped or crowned road segments with inside ditches.
- 25 • Crowned or outsloped road segments with outside berms.

- 1 • Steep road or ditch grades (e.g., > 7 percent).
- 2 • Roads on steep hillslope gradients (e.g., > 40 percent).
- 3 • Roads located on lower hillslope positions (as opposed to mid-slope and upper
- 4 hillslope positions).
- 5 • Throughcut and incised road segments that are difficult to adequately drain.
- 6 • Areas with relatively high hillslope instability (e.g., Franciscan mélange terrain).
- 7 • Areas with high precipitation amounts and intensity, and/or high levels of
- 8 snowmelt runoff (e.g., transient and seasonal rain-on-snow zone).
- 9 • Road segments with surfaces prone to erosion (e.g., non-cohesive soils such as
- 10 decomposed granitic soils) and/or significant rutting from intensive use.
- 11 • Road segments with wet weather use.
- 12 • Areas with little surface roughness or vegetative cover (e.g., areas recently
- 13 burned), or compacted soils with low infiltration capacities.
- 14 • Unsurfaced roads that are graded on a regular basis.
- 15 • Inside ditches that are graded on a regular basis.
- 16 • Roads with high traffic volumes (e.g., primary roads in a road network, as
- 17 opposed to secondary, low-use roads).
- 18 • Roads with maintenance issues (e.g., road segments with damaged or plugged
- 19 drainage structures) and/or limitations regarding ownership or control (e.g., public
- 20 roads, private non-appurtenant roads, roads with unauthorized use).

21 **B. Indicators of Significant Existing or Potential Problems**

22 Indicators of significant existing or potential problems with the existing road drainage
23 conditions include, but are not limited to:
24

- 1 • Evidence of direct sediment entry into a watercourse or a flood prone area from
2 road surfaces or drainage structures and facilities (e.g., ponded sediment,
3 sediment deposits, delivery of turbid runoff from drainage structures during
4 rainfall events).
- 5 • Ditch scour or downcutting resulting from excessively long undrained ditches with
6 infrequent ditch drain (relief) culverts or other outlet structures or facilities. This
7 condition can also result from design inadequacies (e.g., spacing not altered for
8 steep ditch gradient), inadequate erosion prevention practices (e.g., lack of
9 armoring), or ditches located in areas of erodible soils.
- 10 • Gullies or other evidence of erosion on road surfaces or below the outlets of road
11 drainage facilities or structures, including ditch drain (relief) culverts, with
12 transport or a high likelihood of transport to a watercourse.

13
14 Additionally, if a road and/or ditch runoff is hydrologically connected to a watercourse,
15 the following factors elevate the risk of sediment delivery to a watercourse:
16

- 17 • Existing or high potential for cutbank sloughing or erosion into inside ditches.
- 18 • Native-surfaced road exhibiting erosion.
- 19 • Native-surfaced road composed of erodible soil types (e.g., granitic soils).
- 20 • Rilled, gullied, or rutted road approaches to crossings.
- 21 • Existing ditch drain (relief) culverts or other road drainage structures with
22 significant plugging from sediment and/or small woody debris.
- 23 • Existing ditch drain (relief) culverts or other road drainage structures with
24 decreased capacity due to damage or impairment (e.g., crushed or bent inlets,
25 flattened dips due to road grading).

- Decreased structural integrity of ditch drain (relief) culverts, waterbreaks, or other road drainage structures (e.g., excessive culvert corrosion, breached waterbreaks, or rutted road segments).

C. Design and Treatment Measures to Achieve Hydrologic Disconnection

Treatment measures for existing logging roads are necessary where site-specific field observations indicate that key areas and problem indicators combine to result in significant existing or potential erosion sites. Proposed and reconstructed roads should be designed to achieve hydrologic disconnection to the extent feasible. Additional restrictions and requirements specified under 14 CCR § 923.4(a) [943.4(a), 963.4(a)] apply for new or reconstructed roads, while 14 CCR §§ 923.5(a) [943.5(a), 963.5(a)], and 923.6(g) and (h)(3) [943.6(g) and (h)(3), 963.6(g) and (h)(3)] apply to existing roads.

Measures to hydrologically disconnect logging road segments include, but are not limited to:

- Installation of a road drainage facility or structure as close as possible to the watercourse crossing. Typically, this distance is 30 to 100 feet above the crossing (Refer to Figure 2), but may be up to 200 feet or more based on road drainage design and site-specific conditions. For example, the distance from the watercourse crossing to the road drainage facility or structure might be based on the location of where the buffering capacity of the filter strip is the greatest (i.e., densest vegetation and ground cover). Note that this spacing may be closer than the maximum distance specified under 14 CCR § 923.5(f) [943.5(f), 963.5(f)], or

1 as needed for conformance with 14 CCR § 923.5(g) [943.5(g), 963.5(g)].
2 Depending on the road drainage design, the road drainage facility or structure
3 can be a ditch drain (relief) culvert, rolling dip, waterbreak, or other effective
4 facility or structure. Surface drainage designs or facilities that concentrate runoff
5 (e.g., crowned or insloped road surfaces) require more buffering distance
6 between the drainage outlet and the watercourse than those that disperse runoff
7 (e.g., outsloped road surfaces).

- 8
9 • Installation of additional road drainage facilities or structures above (upgrade of)
10 the closest road drainage facility or structure to the watercourse crossing that are
11 appropriately sized and located in conformance with 14 CCR § 923.5(b) and (c)
12 [943.5(b) and (c), 963.5(b) and (c)]. Maximum waterbreak spacing for roads is
13 specified under 14 CCR § 923.5(f) [943.5(f), 963.5(f)]. Appropriate spacing for
14 rolling dips is considered in Section II.C. of this Technical Rule Addendum.
- 15
16 • Installation of ditch drains that are sufficiently spaced to: minimize ditch scour,
17 prevent exceedance of ditch drain hydraulic capacity, and minimize erosion at
18 drain outlets. Local experience, knowledge and site-specific conditions (e.g.,
19 hydrology, soil and geologic material present) should be considered by the RPF
20 in the location and spacing of ditch drains. Spacing of ditch drains should be
21 adjusted in response to: (1) poor filtering capacity or potentially unstable areas at
22 the outlet (additional factors are listed in the following section), and (2) proximity
23 to a watercourse. Near a watercourse, the ditch drain spacing should be closer
24 so that smaller amounts of flow are routed down the ditchline, thus providing an
25 added factor of safety for high flow conditions and potential failure of drainage

1 facilities. An example of ditch drain (relief) spacing guidelines is displayed in
2 Table 1 (see Section IV of this addendum). In the preparation of THPs, NTMPs,
3 and PTHPs, RPFs may develop and use other spacing guidelines that better
4 match the field conditions where their plans are proposed. For example, the RPF
5 can observe the length of road necessary to initiate significant fill erosion and use
6 these observations to adjust spacing guidelines to local conditions.

- 7
- 8 • In general, if ditch drain (relief) culverts are used, they are recommended to be at
9 least 18 inches in diameter to lower the potential for plugging from soil and small
10 woody debris.
- 11
- 12 • Elevation of the crossing slightly above the road grade to ensure that the
13 crossing (e.g., bridges or relatively flat road approaches) does not serve as the
14 low point for road surface runoff (Refer to Figures 2 and 7). Where applicable,
15 this does not alleviate the necessity for installation of a critical dip to mitigate
16 diversion potential.
- 17
- 18 • Installation of outside berms to decrease hydrologic connectivity where they
19 direct flow to a more suitable discharge area.
- 20

21 Many road segments will have a small portion of their length still connected, even
22 following implementation of 14 CCR §§ 923.2(a)(5) [943.2(a)(5), 963.2(a)(5)], 923.5(a)
23 [943.5(a), 963.5(a)], and 923.6(g) and (h)(3) [943.6(g) and (h)(3), 963.6(g) and (h)(3)].
24 Additionally, treatment of road approaches for connected road segments next to
25 watercourses may be necessary pursuant to 14 CCR § 923.5(i) [943.5(i), 963.5(i)].

1
2 **II. Road Drainage, Energy Dissipation, Outsloping and Rolling Dips**

3
4 **A. Location of Drainage Facilities and Structures**

5 In addition to drainage structures and facilities being located: (1) to disconnect road
6 drainage upslope of watercourses, and (2) at a sufficient interval (spacing) to avoid
7 volume concentrations and associated erosion, as discussed above, there are
8 additional factors that should be considered prior to placing drainage structures and
9 facilities in the field. To assist in identifying sites best suited for a drainage structure or
10 facility, the following criteria should be considered. These criteria should be evaluated
11 and appropriately weighted based on site-specific conditions, so that the effectiveness
12 of the drainage structure or facility is maximized and potential problems are avoided or
13 minimized. RPFs should maintain or restore natural drainage patterns as much as
14 possible, while considering the factors listed below. Drainage structures and facilities
15 should be placed:

- 16
17
- 18 • To avoid the concentration of flow onto unstable or potentially unstable areas,
19 such as known active landslides, hummocky ground, concave headwalls, or
20 steep fillslopes.
 - 21 • To discharge onto divergent (convex) to planar slopes where possible, to allow
22 for better dispersion and infiltration (Refer to Figure 3).
 - 23 • Before hydrologic divides to prevent water from one hydrologic basin mixing with,
24 and potentially impacting, another hydrologic basin not conditioned to receiving
25 the additional flows.

- Above breaks in the road grade that transition from low-gradient to high-gradient to remove the water off of the road before it gains velocity and erosive power on the downslope steep road segment.
- To drain localized or emergent groundwater, springs, and wet areas present in the road prism.

B. Installation of Energy Dissipaters for Drainage Structures and Facilities

Where the natural topography, soil surface texture, and vegetation is inadequate to dissipate the energy of flowing water, energy dissipaters (e.g., slash, rock armor, flow diverters, downspouts, etc.) should be placed at outfalls of drainage structures and facilities to disperse flows and promote infiltration, consistent with the requirements stated in 14 CCR § 923.5(h) [943.5(h), 963.5(h)]. The use and selection of an appropriate energy dissipater should be based on field conditions and is a function of flow, erosion characteristics of the soils, slope gradient, slope roughness and cover, and distance to a receiving watercourse. Effective energy dissipaters commonly used in the forest setting, include, but are not limited to:

- Dense vegetative ground cover.
- Wood slash that is “packed” into place with heavy equipment (ideally) or by hand.
- Pit-run rock. Generally composed of competent local rock that has a range of rock sizes and is of sufficient size to resist movement from road runoff.
- Properly located, sized, and maintained stilling basins.

1 **C. Logging Road Outsloping and Installation of Rolling Dips**

2 Outsloped roads are built with a slight angle of the road surface towards the outside
3 edge (Refer to Figure 4). This configuration allows road surface runoff to drain in a
4 dispersed manner over the fillslope onto undisturbed forest soils. As defined in 14 CCR
5 § 895.1, outsloping means shaping the road surface to drain toward the outside edge of
6 the logging road or landing.

7
8 Rolling dips are typically constructed on outsloped roads to ensure adequate drainage
9 of the road surface. As defined in 14 CCR § 895.1, a rolling dip means a drainage
10 facility that is constructed to remain effective while allowing passage of motor vehicles
11 at reduced road speeds.

12
13 An outsloped road's running surface is considered hydrologically disconnected as long
14 as runoff is effectively transported across rather than down the road surface, outside
15 berms do not restrict runoff, and the road prism does not encroach upon the
16 watercourse. Rolling dips should be installed on outsloped roads to ensure that surface
17 flow is routed off the road surface in situations where outsloping alone may not be
18 effective to prevent concentrating flow or eroding the fill (Refer to Figure 5). Outsloped
19 roads with rolling dips are typically not appropriate for roads with a gradient in excess of
20 ten percent (10%) because of the steepness of the dip approach grades that would be
21 required and the added difficulty to effectively drain the road surface. The maximum
22 amount of outsloping achievable depends on the type of traffic that will use the road
23 (e.g., lowboys, log trucks, pickup trucks) and the road surfacing. Outsloped roads are
24 not appropriate in all situations due to safety concerns, timing of use, or expected traffic
25 (e.g., winter use in snow zones).

1 The spacing of rolling dips must be in conformance with 14 CCR § 923.5(g) [943.5(g),
2 963.5(g)]. As with ditch drain (relief) culvert location, the location of rolling dips is to be
3 modified based on the site buffering capacity at proposed installation locations and
4 avoidance of concentrated flow onto unstable areas. Spacing of rolling dips is a
5 function of: (1) road grade, soil erodibility, and road surface area draining to the dip, and
6 (2) proximity to a watercourse. Near a watercourse, the rolling dip spacing should be
7 closer so that smaller amounts of flow are routed towards each dip, thus providing an
8 added factor of safety for high flow conditions and potential failure of drainage facilities.
9 Local experience and knowledge of soil and geologic material present should be
10 considered by the RPF in the location and spacing of rolling dips. An example of
11 general rolling dip spacing guidelines is displayed in Table 1. In the preparation of
12 THPs, NTMPs, and PTHPs, RPFs may develop and use other spacing guidelines that
13 better match the field conditions where their plans are proposed.

14

15 **III. Diversion Potential at Watercourse Crossings and Critical Dip Installation**

16 Diversion potential at watercourse crossings is typically associated with large storm
17 events, and can be a significant source of erosion and sediment. Watercourse
18 crossings have diversion potential if overflow at a plugged culvert inlet diverts the
19 watercourse down the road rather than over the crossing and back into the natural
20 watercourse channel. Diverted flows can create excessive erosion where the flows
21 erode non-channeled surfaces and where they exceed the channel capacity of non-
22 original channels. Diversion potential exists on roads that have a continuous climbing
23 grade across the crossing or where the road slopes downward away from the crossing
24 in at least one direction (Refer to Figure 6). Forest Practice Rules 14 CCR § 923.10(k)
25 [943.10(k), 963.10(k)] requires diversion potential on constructed (new) and existing

1 logging roads to be addressed; similar requirements have existed since 1990. As
2 specified in 14 CCR § 923.10(i) [943.10(i), 963.10(i)], critical dips are incorporated into
3 the construction or reconstruction of logging road watercourse crossings utilizing
4 culverts, except where diversion of overflow is addressed by other methods stated in
5 the plan. The critical dip should be constructed at the point where the potential for
6 erosion and the loss of fill is minimized (Refer to Figure 7).

7

8 **IV. Crossings with Higher Risk of Failure and Higher Risk to the Environment**

9 Some watercourse crossings have a higher relative risk of failure due to the landscape
10 in which they are installed (e.g., areas prone to debris flows or landsliding); or due to
11 seasonal lack of access or remoteness, both of which limit effective emergency
12 maintenance. Additionally, crossings that employ larger than typical fills to achieve
13 running surface elevations often present a higher risk to the environment if they fail due
14 to the large volumes of fill that could be introduced to downstream watercourses. In
15 these cases, it is recommended and/or required (Forest Practice Rule 14 CCR §
16 923.11(i) [943.11(i), 953.11 (i)]) that such crossings be oversized, designed for low
17 maintenance, reinforced, or removed before the completion of timber operations. As
18 discussed in *Designing Watercourse Crossings for 100-year Flood Flows, Wood and*
19 *Sediment* (Cafferata et al., 2004), where temporary crossings are not used, rock ford or
20 rock armored fill crossings are often a better alternative to culverts on small to medium
21 sized watercourses in areas where winter maintenance is difficult or debris flows are
22 more likely; the same holds true in areas prone to earthflows or other types of
23 landsliding. Overall, fords (including native surface, rock, armored fill, and vented) are
24 more apt to effectively transport flows, sediment, and debris in unstable landscapes and
25 areas with poor access for emergency monitoring and repairs than culvert crossings.

Where culverts are used, and fills are large, Cafferata recommends that the diameter of the culvert be increased by 6 inches for every 5 feet of fill above the culvert on the discharge side of the crossing. The additional culvert diameter reduces the risk of failure by allowing more room for transport of flow, sediment and debris, and is relatively inexpensive compared to the cost of replacement of a failed crossing. Crossings may also be reinforced by utilizing large rock designed to resist movement during high flows to line fill faces and by incorporating large critical dips to allow flow passage if the culvert becomes plugged. Temporary crossings typically provide the least environmental risk since flow is unimpeded after the crossings are removed.

V. Table and Figures

The following table and figures are provided as examples to illustrate design concepts. These are not intended to serve as default performance standards.

Table 1. An example of ditch-relief culvert and rolling dip spacing guidelines is found in the University of California's Publication 8262, *Rural Roads: A Construction and Maintenance Guide for California Landowners* (Kocher et al. 2006, adopted from Keller and Sherar 2003). Note that spacing of rolling dips and ditch relief culverts should be a function of proximity to a watercourse, with closer spacing near the channel.

Road Grade (percent)	Soil Erodibility	
	Low to Non-erosive soils	Erosive soils
0-3%	400'	250'
4-6%	300'	160'
7-9%	250'	130'
10-12%	200'	115'
12+	160'	100'

Note: (1) **Low Erosion Soils** = Coarse Rocky Soils, Gravel, and Some Clay
 (2) **High Erosion Soils** = Fine, Friable Soils, Silt, Fine Sands

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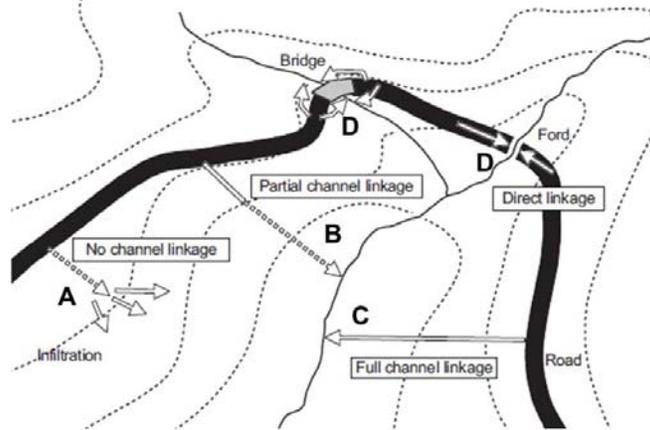
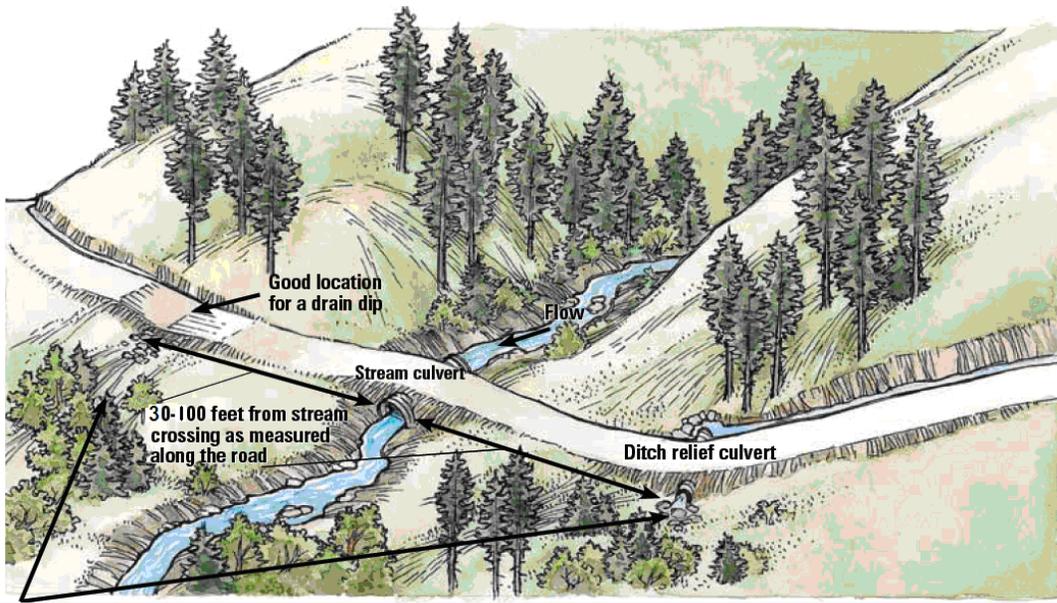


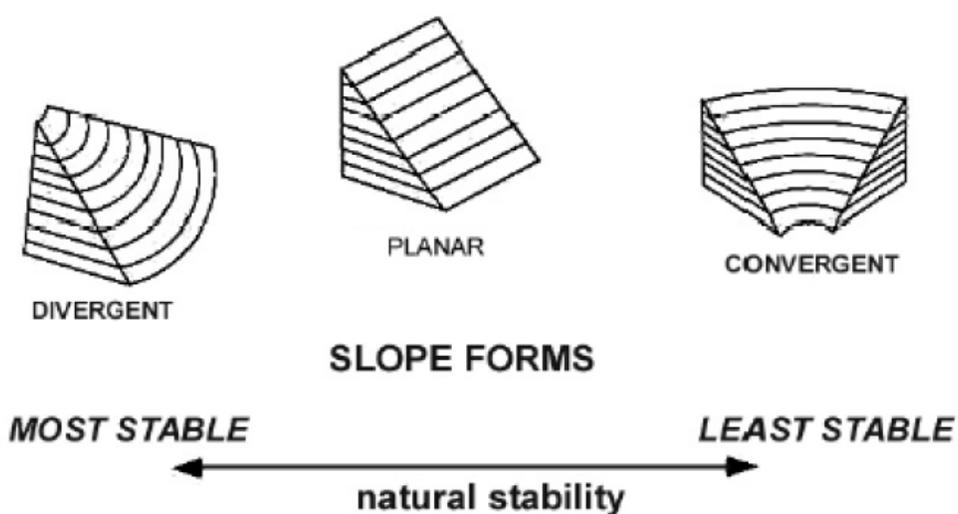
Figure 1. The range of hydrologic connectivity (i.e., linkage) for a road. Ideally, road runoff is drained to an effective filter strip where runoff and sediment is dispersed onto the forest floor (A). Roads can be partially connected when a portion of runoff and sediment reaches the watercourse (B). Full hydrologic connectivity can occur when road runoff initiates channels or gullies (C), or is drained directly into watercourses at road crossings (D). Figure adapted from Croke and Hairsine, 2006.



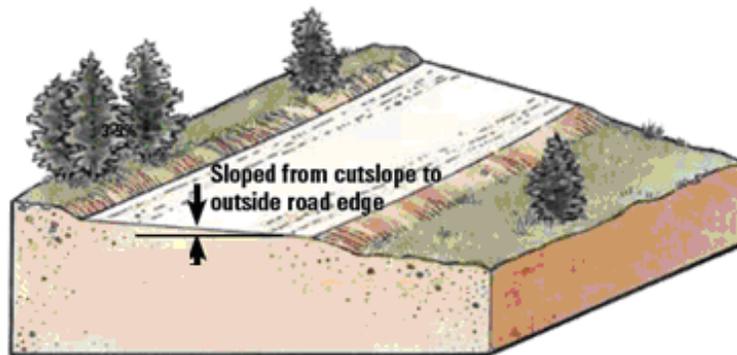
Ditch drainage should be directed into vegetation and undisturbed soil filter, and not allowed to continue flowing down the ditch and into the stream.

Figure 2. Diagram showing implementation of road drainage disconnection facilities/structures to limit sediment delivery into a watercourse. Note the absence of an apparent critical dip at the

1 crossing. (modified from Oregon Forest Resources Institute 2011, 2nd Ed., used with
2 permission).



12 Figure 3. Three major slope forms; water should be discharged onto divergent (convex) to
13 planar slopes where possible (from WFPB 2004).



22 Figure 4. Diagram displaying a typical outsloped road (modified from Oregon Forest Resources
23 Institute 2011, 2nd Ed., used with permission.

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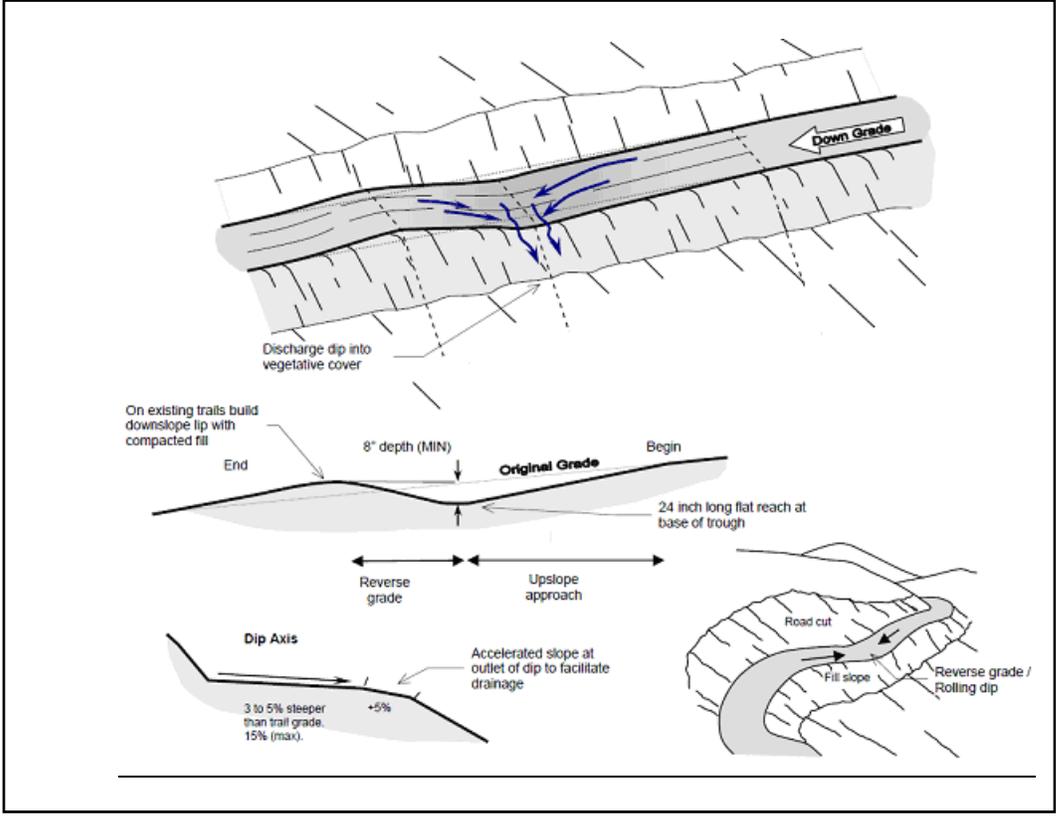


Figure 5. Example of rolling dip specifications (modified diagram provided by Tim Best, CEG).

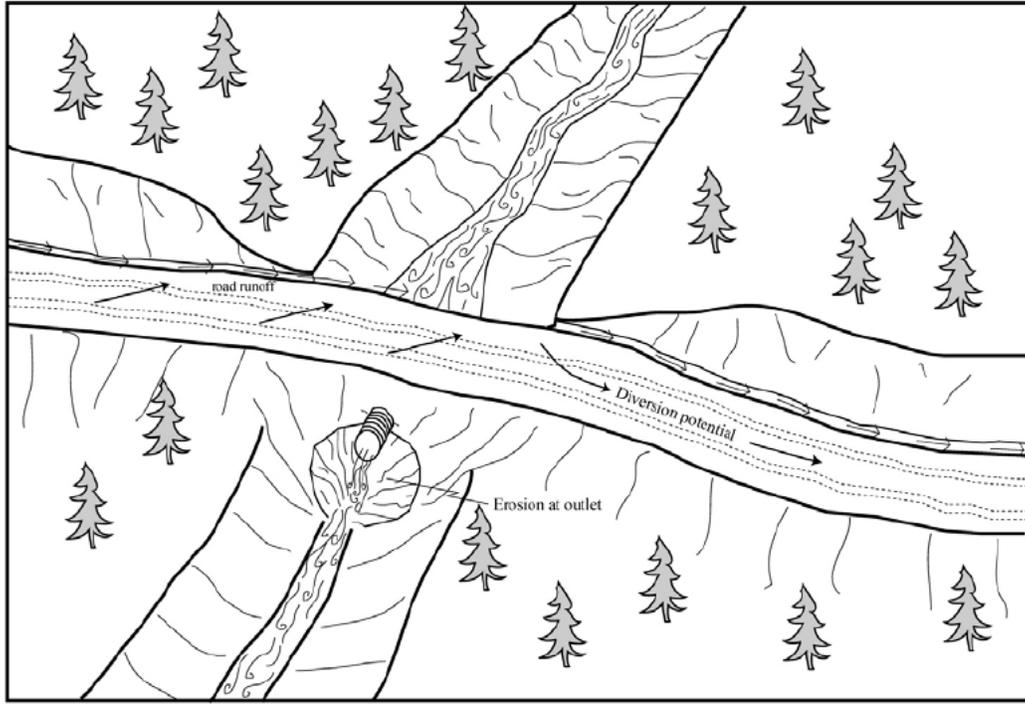


Figure 6. Diagram illustrating diversion potential at a watercourse crossing (from DFG 2006).

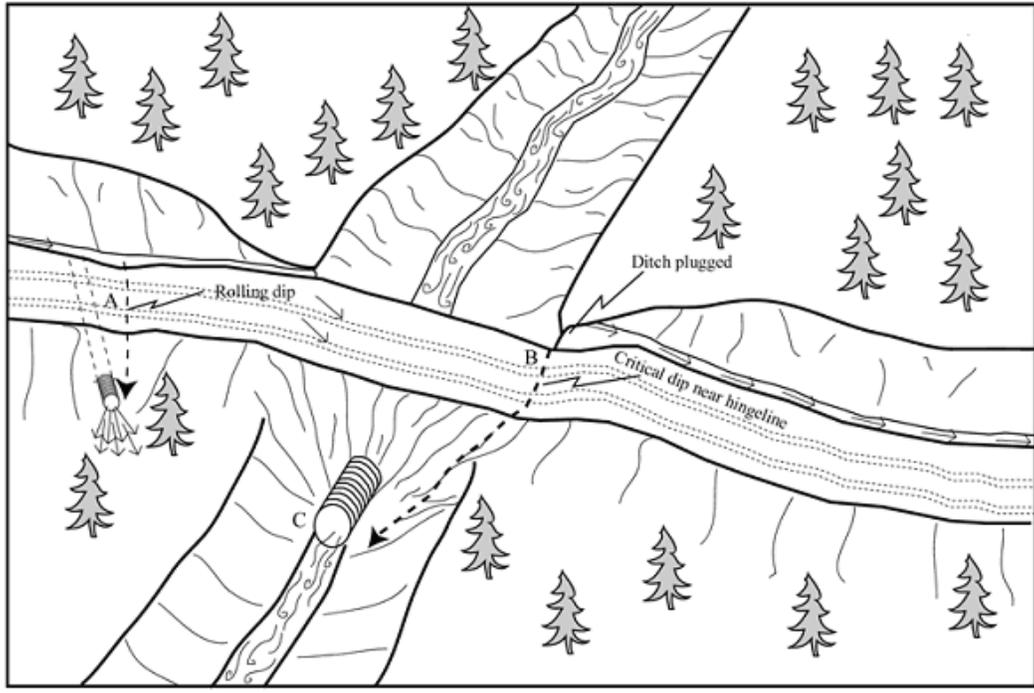


Figure 7. Illustration of a critical dip installed at a watercourse crossing to remove diversion potential (from DFG 2006). The critical dip should be constructed at the point where the potential for erosion and the loss of fill is minimized.