CHAPTER 4

NMFS ACTIVE CHANNEL DESIGN OPTION OR LOW-SLOPE CA FISH & GAME DESIGN OPTION

LIST OF FIGURES

LIST OF TABLES

4 ACTIVE CHANNEL DESIGN OPTION OR LOW SLOPE DESIGN OPTION

4.1 Design Method Applicability

As defined by NMFS in their *Guidelines for Salmonoid Passage at Stream Crossings* document, an active channel is “a waterway of perceptive extent that periodically or continuously contains moving water. It has definite bed and banks which serve to confine the water and includes stream channels, secondary channels, and braided channels. It is often determined by the ordinary high water mark which means that line on the shore established by the fluctuations of water and indicated by physical characteristics such as clear, natural line impressed on the bank, shelving, changes in the character of soil, destruction of terrestrial vegetation, the presence of litter and debris, or the appropriate means that consider the characteristics of the surrounding areas.” See Figure 3-2 from Chapter 3 for a graphical identification of active channel.

An active channel design employs a culvert placed at a level grade, sized sufficiently large enough to encourage the natural movement of bedload and the formation of a stable bed inside the culvert. The culvert width at the streambed elevation equals 1.5 times the active channel width. The active channel design method originally was developed with the intent of providing a simplified stream simulation design for private landowners with short crossings under driveways and similar sites. For those limited projects satisfying specific criteria regarding channel slope and culvert length, the active channel design method can greatly reduce the engineering effort necessary to develop a culvert design approved by State and Federal fisheries agencies. The tradeoff for the reduced engineering effort is that it provides a road crossing culvert that is commonly larger than would be required under more rigorous hydraulic design approaches. On a long-term basis, the larger culvert size is likely to enhance the effectiveness of passing storm flow, debris and fish.

The active channel design option will be allowed only if the following conditions apply:

- The natural slope of the stream is 3% or less.
- The culvert length is less than l00 feet.
- The design will be applied to a new culvert installation or to replacement of an existing culvert.

Sites having a natural streambed slope greater than 3%, or sites that require a culvert length greater than 100 feet, must have culvert designs based on the streambed simulation design option or the hydraulic design option. The active channel design option is not appropriate for the design of culvert retrofits.

In April 2009, CDFG developed Part XII: Fish Passage Design And Implementation of the *California Salmonid Stream Habitat Restoration Manual.* This new section modified the **old** Active Channel Option design criteria from the CDFG *Culvert Criteria For Fish Passage (2002)*, and has been renamed Low-Slope. CDFG has not officially updated their criteria document, but they have verbally stated that the design criteria for Low-Slope in Part XII will supersede the Active Channel Option.

The NMFS Active Channel criteria presented above has not changed, as of the date of this chapter update, and remains consistent with the CDFG *Culvert Criteria For Fish Passage (2002)*, which is the reason both options are shown and discussed. Most likely, the Low-Slope

Option will control because it is more conservative, but this final decision will be made on a project-by-project basis between NMFS, US Fish & Wildlife Service, and CDFG.

The changes in design criteria are displayed in Table 4-1.

	Active Channel	**Low-Slope**
Culvert Width	Minimum of 1.5 Times Active Channel Width	Minimum of 1.25 Times *Bankfull Width
Culvert Length	100 Feet or Less	75 Feet or Less
Culvert Slope	0% (Flat)	Match Natural Stream Slope
Channel Slope	3% or Less	1% or Less
Culvert Embedment	Equal or <40% (Upstream) 20%-40% (Downstream)	20%-40% Throughout
Bed Material (Backfill) Inside Culvert	Natural Recruitment	Natural Recruitment (Length<50 feet) OR Backfill With Native (Length 50-75 feet)
**Development of Long Profile	Not Required	Required
* See Figure 3-2 for presentation of bankfull width.		
** See Figure 5.2 for Long Profile Example.		

Table 4-1. Active Channel vs. Low-Slope

4.2 Active Channel or Low-Slope Design Process Overview

Step 1: Create a long profile drawing to show the upstream and downstream conditions of the culvert. Evaluate stability surrounding the culvert structure for both existing and proposed culvert conditions using the created long profile.

Step 2: Create HEC-RAS model of the existing culvert geometry design to identify capacity issues and create a water surface profile for later comparison to proposed conditions.

Step 3: Determine proposed culvert size by calculating Average Active Channel Width (Active Channel Design Option) or Bankfull Width (Low-Slope Design Option) to obtain Culvert Width. When using the Low-Slope Option for culverts 50 feet to 75 feet in length, calculate the largest immobile particle in natural streambed and multiply by 1.5 (minimum) to determine bed material (backfill) inside culvert.

Step 4: Calculate upstream and downstream embedment depth to determine culvert invert.

Step 5: Select remaining proposed culvert dimensions and physical characteristics to satisfy future culvert design needs.

Step 6: Model culvert geometry in Proposed Conditions HEC-RAS Plan. Note: HEC-RAS is limited to one constant embedment depth through the entire culvert. For the Active Channel Option, two embedment depths are required so the 0% slope criteria are satisfied. To account for the difference in depth between the inlet and outlet embedment depths, average embedment depth and enter into Proposed Conditions HEC-RAS Plan.

Step 7: View Proposed Condition HEC-RAS Plan results to identify possible proposed culvert design issues. Check culvert capacity based on proposed design conditions for the 100-Yr event. Summarize results in Form 6A (Appendix D) sections Maximum Allowable Inlet Water Surface Elevation, Allowable Hydraulic Impacts, and Velocity Summary.

4.2.1 Engineering Analysis and Reporting

The collected data will be used to perform an engineering analysis and complete the active channel or low-slope culvert design. Summary information from the analysis and design will be recorded in a report that shall include the following:

1. Data as described in Section 4.2.1.
2. Culvert design calculations as described in Section 4.3.
3. Roadway stationing of the culvert location.
4. Culvert length and size.
5. Culvert material.
6. Culvert profile, plus additional profile of the stream channel if required by Section 4.4.
7. Roadway cross-section and roadway profile, demonstrating the maximum height of fill over the culvert.
8. Calculations for flood capacity check.
9. Description of culvert end treatment and any additional culvert appurtenances.

4.3 Culvert Design

The active channel or low-slope method for culvert design uses a simplified approach to determine the size of the culvert, based generally on the dimensions of the stream in the vicinity of the road crossing. Although this reduces much of the hydraulic engineering effort required for the design, it is nonetheless necessary to conduct hydrologic, hydraulic and structural analyses to complete the design effort.

4.3.1 Culvert Shape

Any culvert shape can be used with the active channel design option. At this stage of the design, a preferred culvert shape should be selected. If the selected culvert shape is not circular, establish preliminary values for the culvert span and rise based on the minimum culvert diameter previously calculated, taking into account the standard dimensions of culvert products commonly used in the project area.

4.3.2 Culvert Invert

The active channel and the low-slope design options provide for the culvert to be installed with the culvert invert placed below the natural streambed elevation, allowing the natural movement of bedload to form a stable bed inside the culvert. Criteria established by CDFG (Appendix B) and NOAA Fisheries (Appendix C) require the invert at the culvert outlet to be embedded no less than 20 percent of the culvert diameter or rise. Additionally, the invert at the culvert inlet must be embedded no more than 40 percent of the culvert diameter or rise. Figure 4-1 illustrates the criteria requirements for an active channel design, while Figure 4-2 presents criteria for low-slope.

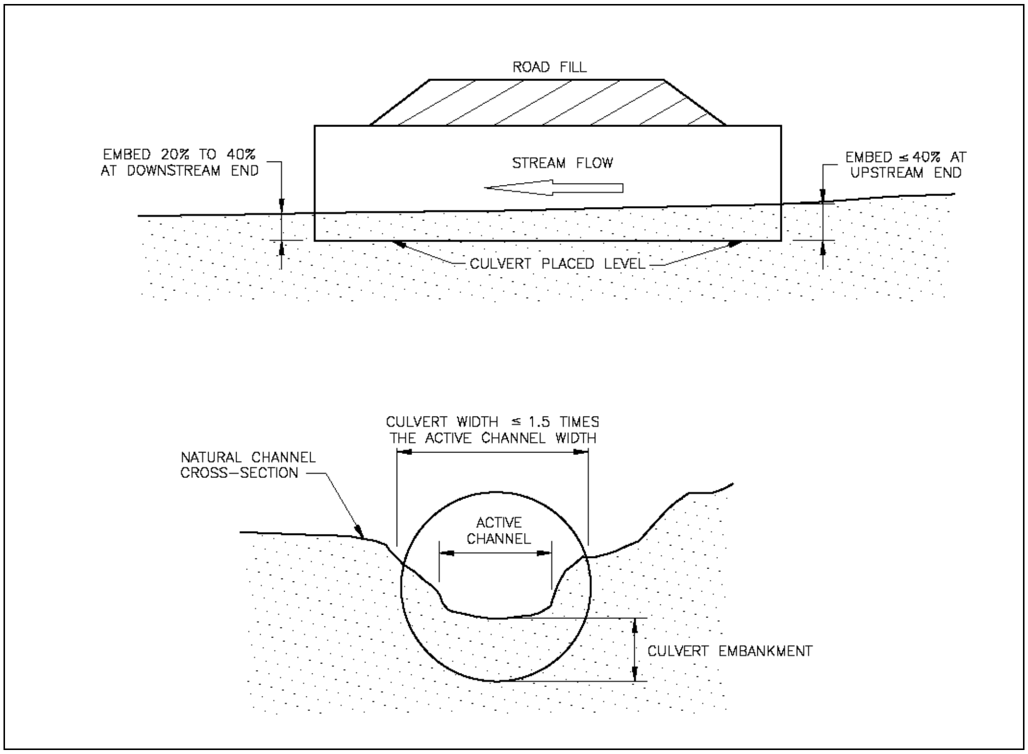

Figure 4-1. Active channel criteria diagram

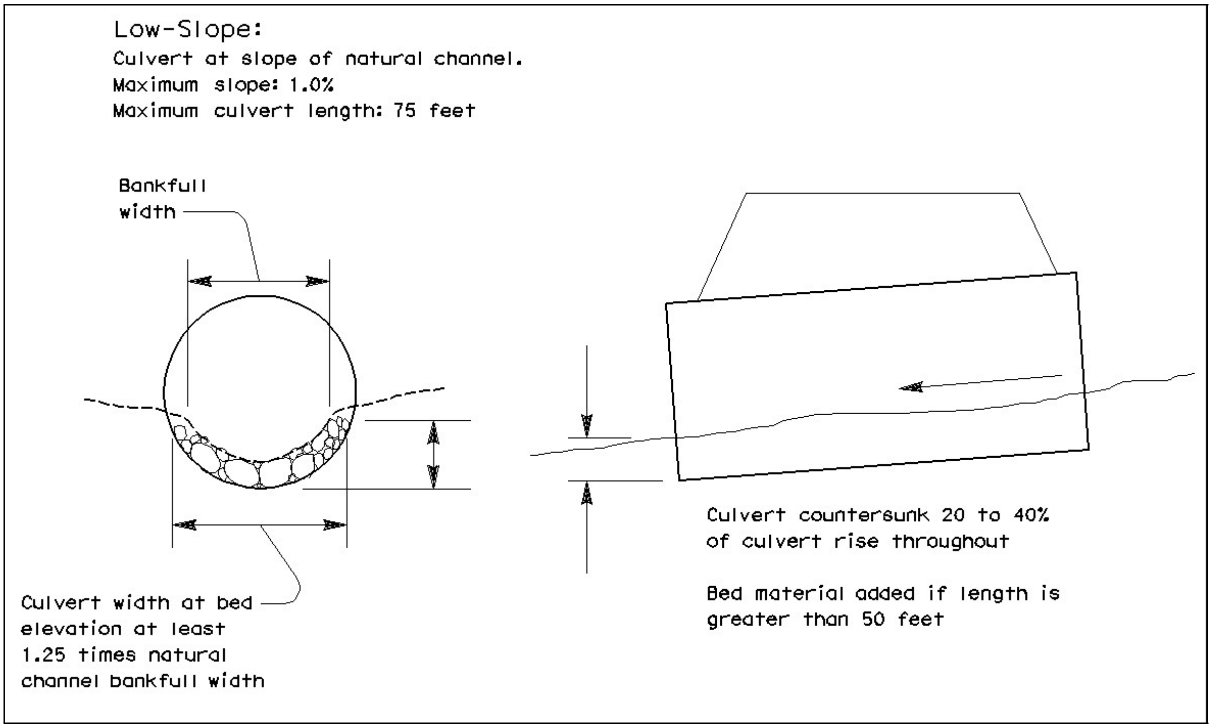

Figure 4-2. Low-slope criteria diagram

4.3.3 Flood Flow Capacity Check

At this stage of the active channel design, the preliminary size, shape and embedment characteristics of the culvert are analyzed to estimate water surface elevations that occur during discharges associated with a 100-year peak flood. In the CDFG (2002) Culvert Criteria document, for the 100-year peak flood, the upstream water surface elevation shall not be greater than 50 percent of the culvert height or diameter above the top (ceiling)of the culvert inlet.

The open area of an embedded circular or elliptical pipe can be estimated from basic geometric properties of the radius (or pipe rise), corner radius (where applicable), and depth of embedment. The open area of the pipe is then used in the determination of the water surface elevation under the peak flood discharge conditions. If either of the flood capacity criteria noted above are not satisfied with the selected pipe size, then the design process should be repeated with a larger pipe size until the flood capacity criteria are met. Section 3.5 provides equations and nomographs that facilitate the hydraulic analysis of the pipe flow capacity.

4.3.4 Culvert Appurtenances

The design of culvert end treatments may vary depending on site specific issues such as retention of roadway embankment, hydraulic efficiency, and debris control. In general, fisheries agencies encourage end treatments that provide a smooth hydraulic transition between the upstream channel and the culvert inlet, as a means to facilitate the passage of flood borne debris.