

**Case Study 5. Willow Creek Concrete Plank Ford**

**Location**

Northeastern California. Plumas National Forest. Willow Creek. 5 miles northwest of Portola, CA, on Spur Road 23N97Y off Forest Road 24N12, (Smith Peak Lookout Road).

**Crossing Description**

This unvented ford, constructed in the mid 1980s, is on a perennial fisheries stream. Concrete planks form the driving surface. The structure is 31 feet long and the driving surface across the planks is 14 feet wide. There are 21 concrete planks, which are each 12 inches wide, with a 6-inch space between planks. The spaces allow passage of low flows. The planks are set into the streambed 2 inches and rest upon a bed of coarse streambed material and Class IV riprap. The outlet of the structure spills onto Class X riprap. Grades into the ford vary from 7 to 9 percent on both approaches, and the middle of the ford is flat.



Figure A22. Willow Creek concrete plank ford.

**Setting**

Sierra Nevada Section (M261-E). Elevation 5,130 feet. Variably weathered granitic mountains capped with tertiary volcanic (pyroclastic) flows. Vegetation is mixed conifer.

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### Why Was This Structure Selected?

This structure was chosen for its ability to pass large rocks without damage, and for its easy maintenance and low cost. The large concrete planks are large enough to resist movement if properly bedded.

### Crossing Site History

This site was originally a native rock ford. The concrete plank structure was built by the Plumas National Forest in 1985 to improve the road for a timber sale.

### Road Management Objectives

This is a native-surface road maintained for high-clearance vehicles (maintenance level 2). It provides access only to the local area, and average daily traffic is about 10 vehicles. The road is closed during the winter. Occasional interruptions are acceptable as traffic volume is low. Traffic interruptions occur several times each year, particularly during the springtime, and last approximately 12 to 24 hours each time. Road use is a mix of occasional logging traffic during a timber sale, Forest Service administrative traffic, and occasionally the general public.

### Stream Environment

**Hydrology:** The Willow Creek watershed drains approximately 7 square miles on the south side of Smith Peak. It is a perennial stream fed with snowmelt, and both rain-on-snow and summer thunderstorms cause occasional floods. Annual precipitation in this location is 40 inches. Summer low flows are less than 1 cubic foot per second. The 2-year flow is 110 cubic feet per second, and the estimated 100-year flood is 1,500 cubic feet per second. Flood flows inundate the entire structure 1 to 2 feet deep. Maximum flood flow velocities of 10 to 12 feet per second are expected.

**Channel Description:** Channel slope is about 3 to 5 percent at the crossing. There is a drop in the channel bottom elevation of 3.5 feet just downstream of the crossing. This is partially due to scour, but also to an old wooden diversion structure that failed and caused channel cutting. A tributary also enters the stream immediately downstream of the road-crossing (figure A23—upper right). Sloping streambanks are 1 to 2 feet high and quite stable with boulders and riparian vegetation including willow and fir trees. Bankfull width is approximately 15 feet, with a bankfull depth of 2.5 feet. The substrate is a mixture of cobbles, some gravels, and large boulders.



Figure A23. Looking downstream: ford is just above a tributary junction where an old diversion structure blew out and caused streambed to degrade.

**Aquatic Organisms:** Several species of trout are resident in this stream, including rainbow and brown trout. Fish have been observed moving across the structure at high flows. However, at low flows, the riprap cascade immediately downstream of the structure prevents fish from accessing it. Passage for other aquatic species is unknown, but it seems likely that some crawling species could negotiate the gravel-floored spaces between the planks.

**Water Quality:** Water quality in this drainage is relatively high. Thus, the armored surface was selected to prevent driving directly through the creek most of the time. However sediment is added to the channel from the unsurfaced approaches.

### Structure Details

**Structure:** The driving surface of the ford is made of steel reinforced concrete planks 12 inches wide by 12 inches high and 15 feet long. They are spaced 6 inches apart and held in place with metal brackets between the planks (figure A24). Each plank is tapered at each end. Twenty-one planks form the 31-foot-long reinforced driving surface. The planks are set onto a smooth bed of small riprap. Additional large riprap was placed along the downstream edge of the structure for scour protection.

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Protection of the planks against scour and movement of the material beneath the planks is a key design detail. The bed must be carefully prepared to be smooth, yet made of coarse enough material to resist movement during storm flows.



Figure A24. Detail of planks and metal brackets.

**Bank stabilization and approaches:** Large riprap was added to stabilize the downstream area from the effects of the drop downstream (figure A22). Road approaches dip down into the crossing at 7- to 9-percent slope (see site sketch, figure A25).

**Cost:** Initial construction cost in 1985 was \$10,000. Repair costs in 1998 were \$21,500, including replacing several planks. Most of the cost in 1998 was in casting new concrete planks for two sites (\$17,000).

**Safety:** This structure is not signed. The entire structure has a very low profile, and it is on a low velocity road. Also the site is on a relatively straight part of the road with good sight distance. Thus safety issues are minimal.

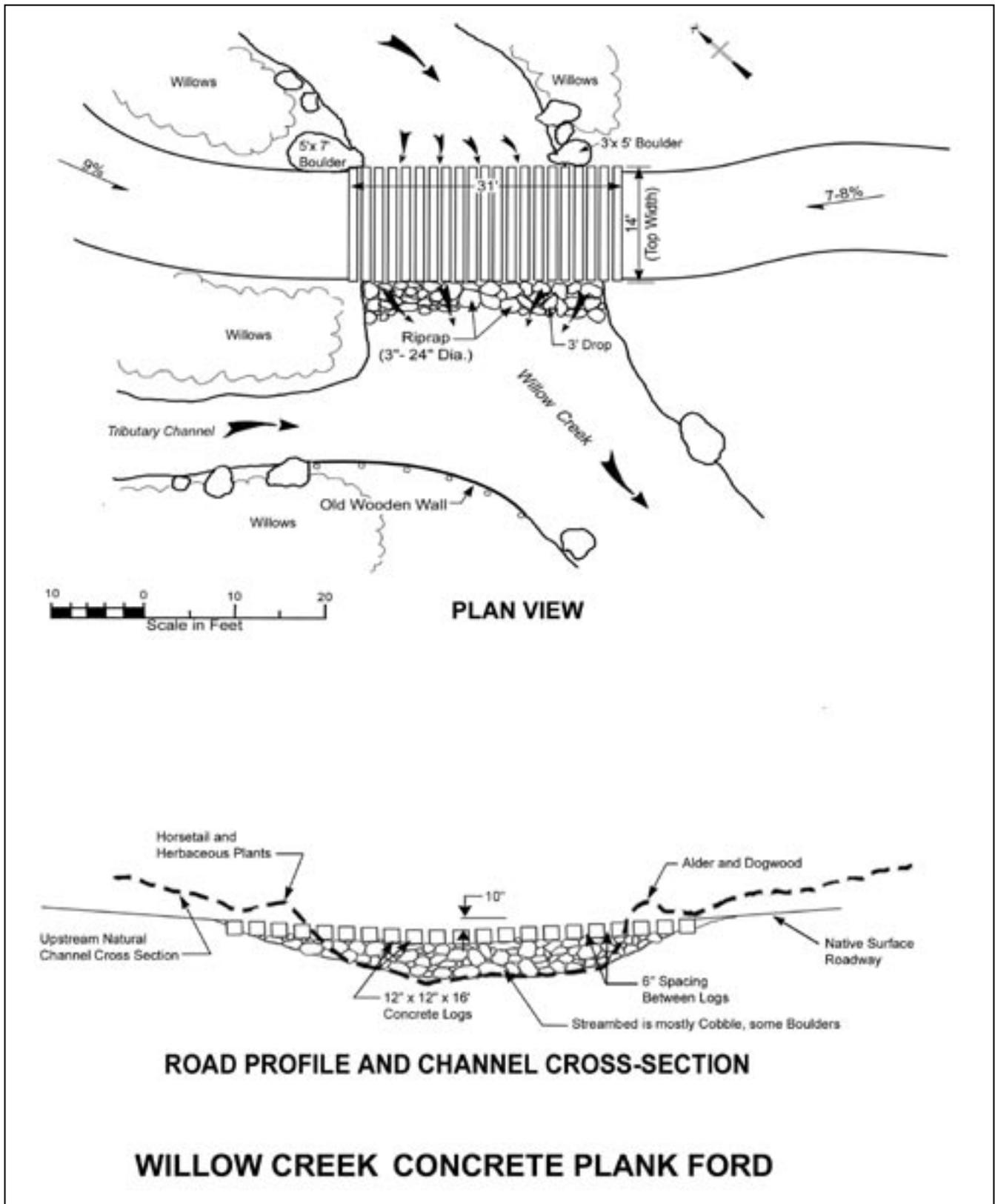


Figure A25. Site plan view and cross-section sketch.

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### Flood and Maintenance History

The structure received only minor damage in the large storms of 1986 and 1995. However, during the major 1997 flood (local storm of record), some of the concrete planks were undermined, cracked, and steel was exposed (figure A26). Repairs included replacing some concrete planks, rebedding most of those in the middle of the channel, and adding riprap scour protection at the downstream outlet of the structure.



Figure A26. The crossing was damaged in the 1997 flood by scour of fine bedding materials under the planks. The planks had to be reset into coarser materials and the downstream edge protected with riprap.

### Summary and Recommendations

The Willow Creek concrete plank ford has the advantage of forming a stable road surface that is resistant to damage from boulders moving in the stream. Its open cross section permits free transport of rock and debris. The stream is fairly small and streambed material is coarse enough that the concrete planks can be well-bedded and resist movement. Large boulders placed under the downstream toe of the planks help resist scour and movement in this area. Careful preparation of the bedding for the planks is likely the most important construction detail. The large, heavy individual concrete blocks have the ability to resist fast stream velocities, so long as the material beneath the planks does not move.

Two disadvantages of this design are that, during large floods, it is susceptible to scouring underneath the structure, and it allows only partial aquatic organism passage. If the structure were slightly backwatered at lower flows, fish passage would be improved.

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Possible changes to improve fish passage include: lower the structure or build step pools downstream; increase the outslope of the structure to no more than 5 percent; extend structure approaches; reconstruct the approaches to create a more defined dip, and armor the steeper approaches with gravel or pavement to minimize sediment movement.

Charlie Carter, design team leader on the Plumas National Forest (now retired), designed the structure repairs after the flood, and provided information for this case study.

