

**Case Study 8. Agua Fria River Concrete Slab Ford**

**Location**

North Central Arizona. U.S. Department of the Interior Bureau of Land Management Agua Fria National Monument, near Horseshoe Ranch. Approximately 15 miles North of Black Canyon City, AZ, and 3.1 miles south of Cordes Junction, Bloody Basin Road, east of I-17. Forest Road 269.

**Crossing Description**

This ford was constructed in 1994 on a perennial to intermittent fish-bearing stream. It is a reinforced-concrete slab with concrete approaches. The surface is slightly raised above the streambed surface, but it allows fish passage when the structure is submerged.



Figure A42. Agua Fria River ford.

**Setting**

Colorado Plateau, Tonto Transition Section (313-C). Short, steep, highly dissected mountain slopes with thin, very rocky soils. Narrow alluvial valleys with schist bedrock not far below the surface. Vegetation is fire-adapted interior chaparral. Willow, sycamore, and juniper grow in drainages.

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### Why Was This Structure Selected?

Traffic interruptions are acceptable on this road, road use is moderately low, normal flows are very low (occasionally the channel is dry), and peak flows are very large in this drainage. Thus a low-water crossing is the logical choice of structure. A bridge span would have to be about 150 feet long to avoid constricting the flood channel. The solid concrete slab was chosen to provide enough strength and resistance to movement to survive a major storm event.

### Crossing Site History

The previous structure at this location, a ford constructed of concrete planks, jersey barriers, and riprap, was damaged by flooding in 1993. The flood moved many of the planks and riprap boulders downstream from the crossing. Thus the site had to be reconstructed in 1994 and a more durable type of crossing was chosen.

### Road Management Objectives

Although located on land managed by the U.S. Department of the Interior Bureau of Land Management, the ford was designed and constructed by the Tonto National Forest as an Emergency Relief for Federally Owned Roads (ERFO) project. The road has an annual average daily traffic count of 75 vehicles, and provides access to popular hunting areas, archeological sites, and to the newly created Agua Fria National Monument. Currently, it receives most use during hunting season but recreational traffic to the monument is expected to increase in future. The road is maintained for passenger vehicles, although road signs at I-17 recommend high-clearance vehicles. Traffic interruptions due to flooding are estimated to occur up to six times each year and last from several days (winter) to a half day (summer) (Gibson, personal communication).

### Stream Environment

**Hydrology:** This is a desert landscape with an annual precipitation in the range of 10 to 25 inches. Most falls as rain during the winter and again during the summer monsoon season (July through September). The drainage basin area above this point on the Agua Fria River is several hundred square miles. The crossing reach is usually perennial but can become intermittent during droughts (Loomis, 2002 personal communication). Floods can be extreme. Flood debris deposited among the trees on the highest natural levee (about 6.5 feet above the low-flow channel) suggests that the 100-year flood in 1993 inundated that surface (figure A45). After the very large flood in January 2005, a tire rim was found embedded in a tree 20 feet above the low-flow channel (Skordinsky, personal communication).

**Channel Description:** The crossing reach is moderately confined between valley and terrace walls and is controlled by bedrock outcrops in the channel and along one bank a few hundred yards above the ford. Banks are stable and vegetated with trees, shrubs, and grasses. Channel width is about 30 feet, depth about 1 to 2 feet, and slope was estimated at 1 percent (figure A45). Just upstream of the ford, three terraces are distinguishable adjacent to the channel, each one rising about 2 to 4 feet above the previous one, and each bordered by 1- to 2-foot-high vegetated levees. Bed material in transport is primarily sand and gravel, and woody debris trapped on trees shows that debris loads during floods are high. The slightly elevated ford surface has caused the active channel to aggrade somewhat upstream of the crossing.

**Aquatic Organisms:** Fish biologists have recently identified fish passage as an issue of concern at this type of site (Calamusso, personal communication). As flow decreases, fish need to be able to follow the water to springs, deep pools, or other refuges. At this site, fish were observed moving downstream over the ford in less than an inch of water after a thunderstorm runoff event in May 2003. Later, in August, they were isolated in pools both upstream and downstream from the ford (figure A43). Needs for passage for other aquatic species in this area are unknown.



Figure A43a and A43b. Agua Fria River A43a. Pool several hundred feet upstream of ford in August 2003. A43b. Fish are in isolated pools both upstream and downstream of the dry ford.

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### Structure Details

**Water Quality:** Even in this landscape of naturally high erosion rates, sediment delivery from roads is a water quality concern. Protecting water quality and aquatic habitats is an objective of all crossings in the area.

**Structure:** The ford is an 8-inch thick reinforced concrete slab raised slightly above the bed of the active channel. The driving surface is 15 feet wide and has no curbs. The slab is 65 feet long and flat across the active channel and the lowest flood terrace (figures A44 and A45). Including approaches, the structure extends a total of 170 feet across the channel and flood terraces.



Figure A44. Oblique view of ford and aggraded upstream channel.

**Bank stabilization and approaches:** Fifty- to 55-foot-long concrete approach slabs slope steeply into the drainage at 15 percent. The road fill obstructs flow on the upper terraces during very high flows, and riprap has been placed along the upstream fillslope to control gully erosion there.

**Cost:** \$95,000, plus 10-percent design cost and 10-percent construction inspection and control. Funding was through U.S. Department of Transportation Federal Highway Administration as EFRO Storm Damage Repair funds.

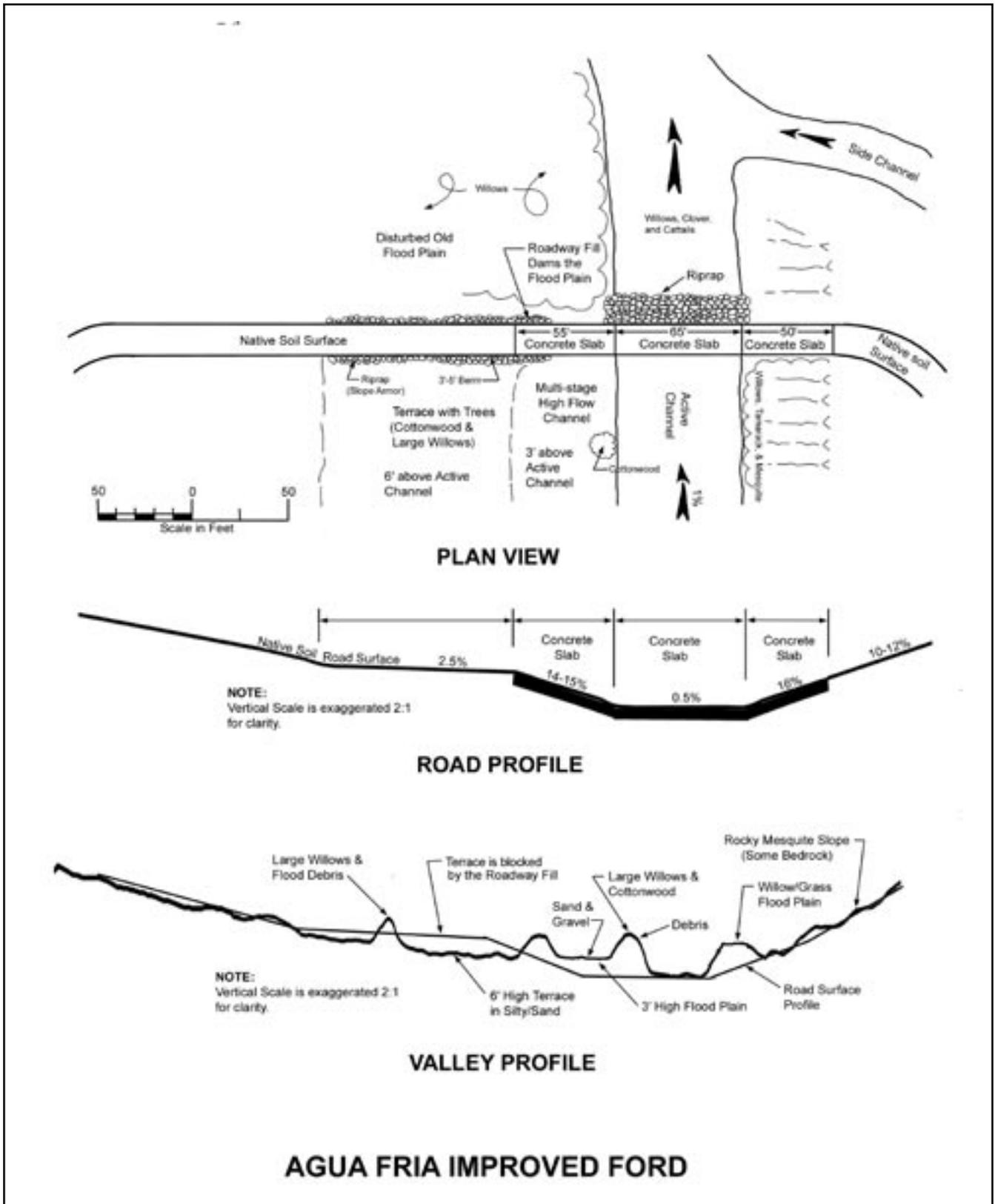


Figure A45. Site plan view and road and valley cross section sketches.

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**Safety:** The crossing is signed before both approaches with “Dip - 5 MPH” and “DO NOT ENTER WHEN FLOODED” signs (figure A46). The road itself is signed as being maintained for high-clearance vehicles only at the junction with the freeway. When water flows over the ford for long times, slippery algae can sometimes be a road hazard.



Figure A46. Warning sign at Agua Fria River ford.

### Flood and Maintenance History

Since construction in 1994, this ford required no maintenance until January 2005, when the area received 8 inches of rain in one month. The resulting flood exceeded the structure’s capacity and eroded large volumes of soil from above the armored approach on one side, requiring repairs.

### Summary and Recommendations

The structure fits the site, with its infrequent floods and moderate road use. It also fits the stream fairly well, except for the fact that it obstructs aquatic organism movement as flow decreases to zero after a runoff event. Since the approach roadfill slightly constricts the flood channel, some gullying and scour are expected along the edge of the road fill.

The downstream edge of the flat slab is about 1-foot above the streambed. Riprap has been placed there to control scour but minor undermining has already occurred in the fine, easily erodible streambed materials. A several-foot-deep downstream cutoff wall would be recommended here.



Figure A47. Looking upstream at ford and Agua Fria channel. Fish can move across the ford only when it is submerged.

Gordon Cates, forest engineer (retired); Grant Loomis, forest hydrologist; Bob Calamusso, forest fish biologist; and Marivel Linares, road operations engineer from the Tonto National Forest, and Mary Skordinsky, director of the Agua Fria National Monument provided information for this case study.

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### Similar Structures in Other Locations

The Ashdale administrative site ford on the Tonto National Forest is another example of an unvented, improved ford with a concrete slab. It is on a very short road (FR24B) that accesses a defunct administrative site, and has primarily light recreational traffic (figure A48). The ford crosses Cave Creek, a moderately entrenched ephemeral to intermittent stream that is closely confined between the valley side walls (figure A49). Channel slope is approximately 3 percent, and much of the bed material is small boulders that are mobile during floods. Annual precipitation in this region is 10 to 25 inches, falling either during the winter or summer monsoon season. Fish or other aquatic organism passage is not a concern on this ephemeral stream.



Figure A48. Ashdale concrete slab ford (downstream is to left).

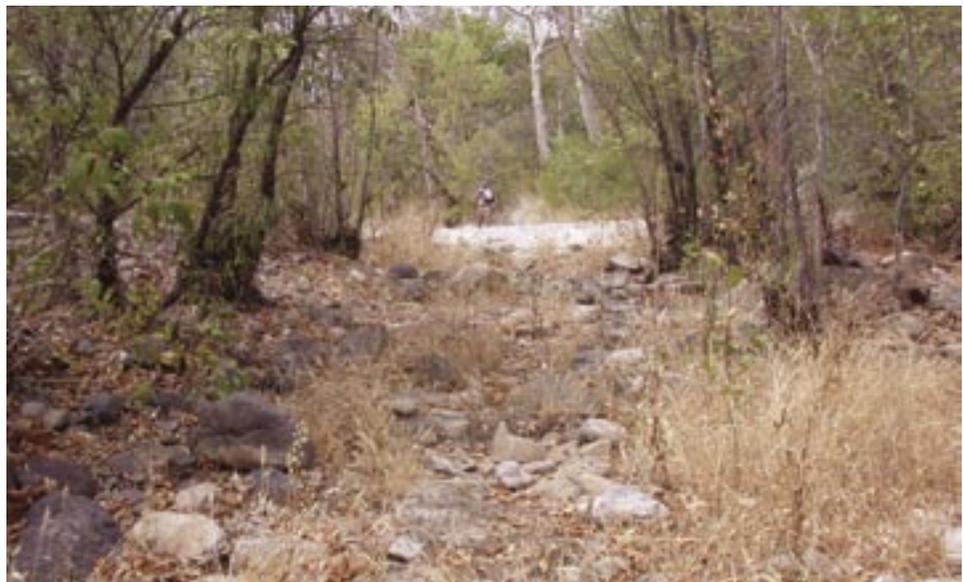


Figure A49. Cave Creek looking downstream toward the ford.

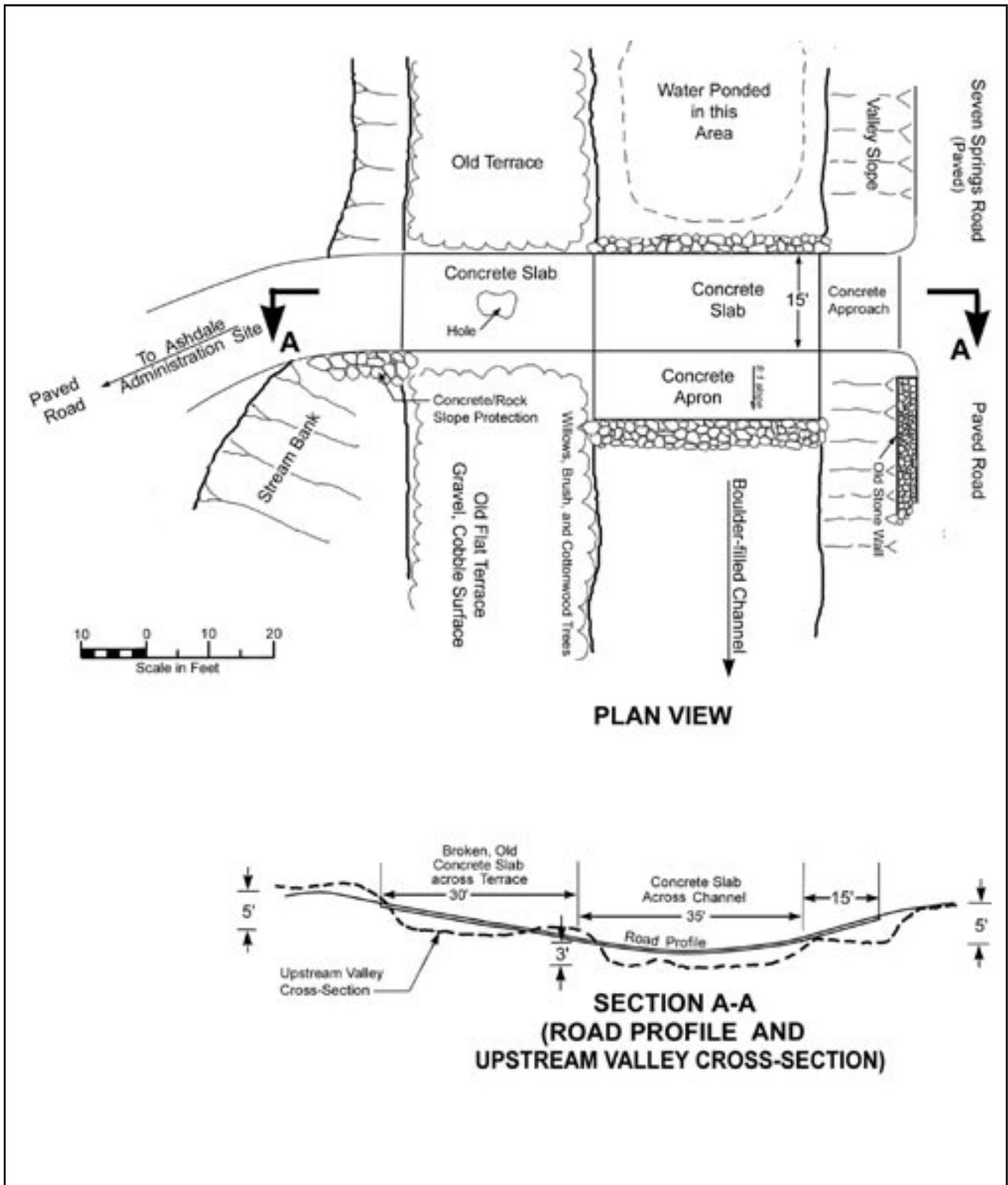


Figure A50. Ashdale ford plan view sketch and valley cross section with road profile.

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The ford is 15 feet wide and 35 feet long across the active channel (figure A50), and a total of 80 feet is armored. An 8 to 1 sloping concrete apron transitions to a riprap and boulder cascade reach downstream of the crossing. The structure has a moderate vertical curve with steep, short approaches.

The ford is 50-years old. It has been through many desert floods, including the major 100-year-flood event of 1993. Its concrete surface is battered and has been repaired or extended on both ends. Flows have partially outflanked it at some times in the past, so grouted riprap and pieces of concrete and rock have been placed along the approaches to control scour (figure A51). Downstream scour occurred at some point in its history, leading to the construction of the concrete apron, which currently provides adequate protection against scour. The ford has not received any maintenance since the late 1980s. The structure is appropriate to this high-energy site since it provides for free passage of debris and rock during high flows and there are no aquatic animal issues.



Figure A51. Concrete apron and grouted riprap prevent downstream scour and scour around edges of the ford.