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### Introduction to the Case Studies

Traffic use, hydrologic regime, available materials, channel type, stability, and aquatic species passage needs are all critical variables affecting the choice of structure type at a site and its success. Each crossing situation involves a unique combination of these variables, so each site is an individual engineering challenge. The following case studies illustrate a variety of structure types in different hydrogeographic areas around the country. Studying examples like these is the best way to learn from other people's experience, and the case studies should help you generate ideas for fitting new structures to individual sites.

Most of the structures described here are compromises, because the fit of the structure to the road, landform, or stream is rarely perfect. The structures are of very different ages, representing the development of low-water crossing design over the past few decades. Some demonstrate popular designs that have worked well in the past from a transportation or road-use perspective but which caused channel erosion and blocked aquatic species. Many have required repairs or improvements to make the structure functional today. Few achieve all the goals we would set for new structures. However, both their flaws and their successes demonstrate important points about locating, designing, and constructing low-water crossings. Use them as a resource to help you learn from, rather than repeat, the experiences of others.

About the case studies:

- The “Crossing Description” section, at the beginning of each case study, highlights the key points about the structure and is intended as a summary for people browsing through the appendix.
- Ecological unit information, under the “Setting” heading in each case study, comes from McNab and Avers' (1994) descriptions of the ECOMAP sections, shown on the map “Ecoregions and Subregions of the United States.” In some instances, where forests have completed landtype mapping, the sections include more details.
- We frequently cite Rosgen's (1996) channel types. Because we identified the channels only visually, consider our classifications as estimates.
- Information was available in different levels of detail. We have attempted to be as consistent as possible in describing and evaluating the structures. However, in some cases, information supporting an informed judgment about performance was not available.

## Appendix A—Case Studies

Structures highlighted in **BLUE** in table A1 are similar to the numbered case study just above them. Their descriptions are included at the end of that case study under the heading Similar Structures in Other Locations.

Table A1—Case study index by structure type.

|                          | <b>Crossing Name</b>              | <b>Forest</b>       | <b>State</b>     | <b>Structure Type</b>                |
|--------------------------|-----------------------------------|---------------------|------------------|--------------------------------------|
| <b>Unvented Fords</b>    |                                   |                     |                  |                                      |
| 1                        | Red Clover                        | Plumas              | California       | Rock dip                             |
| 2                        | 20-mile Cr                        | Okanagan            | Washington       | Rock dip                             |
| 3                        | Nurse Cr                          | Umpqua              | Oregon           | Large-rock fill                      |
|                          |                                   | Idaho Panhandle     | Idaho            | Vented rock fill structure           |
| 4                        | FR 732                            | Prescott            | Arizona          | Jersey barriers/riprap               |
|                          | FR 136                            | Prescott            | Arizona          | Jersey barriers/riprap               |
|                          | 7-Springs Rd                      | Tonto               | Arizona          | Jersey barriers/gabions              |
| 5                        | Willow Cr                         | Plumas              | California       | Concrete planks                      |
| 6                        | Fitzpatrick Cr                    | Coos Bay BLM        | Oregon           | Concrete blocks                      |
|                          | E. Fk. So. Tongue R;<br>Copper Cr | Bighorn             | Wyoming          | Concrete blocks                      |
| 7                        | Woodrock                          | Bighorn             | Wyoming          | Geoweb                               |
|                          | Little Brush Cr                   | Ashley              | Utah             | Geoweb                               |
| 8                        | Agua Fria R                       | Tonto               | Arizona          | Concrete slab                        |
|                          | Ashdale Admin Site                | Tonto               | Arizona          | Concrete slab                        |
| 9                        | Messman                           | Fremont             | Oregon           | Concrete slab with slot              |
| <b>Vented Fords</b>      |                                   |                     |                  |                                      |
| 10                       | Black Canyon                      | Clearwater          | Idaho            | Concrete planks with culvert         |
| 11                       | Babcock                           | Plumas              | California       | Concrete with culverts               |
|                          | Harris Creek                      | Ouachita            | Arkansas         | Concrete with culverts               |
| 12                       | Grubbs                            | Plumas              | California       | Concrete slab with grated top vent   |
| 13                       | N Fk Consumnes R                  | Eldorado            | California       | Concrete box with grated top         |
| 14                       | Rocky Cr                          | Ouachita            | Arkansas         | Concrete box with curbs              |
|                          | FR 512                            | Ouachita            | Arkansas         | Embedded concrete boxes              |
| 15                       | Moonlight                         | Plumas              | California       | Concrete box with fish ladder        |
| 16                       | Sibley Cr                         | Mt Baker Snoqualmie | Washington       | Concrete box-removable top           |
|                          | Catherine Cr                      | Industrial land     | British Columbia | Large-rock fill                      |
| 17                       | Stoney R                          | Superior            | Minnesota        | Embedded timber boxes                |
| 18                       | French Cr                         | Plumas              | California       | Embedded concrete boxes              |
| 19                       | Mill Cr                           | Mark Twain          | Missouri         | Embedded concrete boxes              |
|                          | Kincaid                           | Shawnee             | Illinois         | Embedded concrete boxes              |
| <b>Low-water Bridges</b> |                                   |                     |                  |                                      |
| 20                       | Deep Cr                           | Osceola             | Florida          | Double T-sections with concrete deck |
| 21                       | Capps                             | Eldorado            | California       | Concrete piers; cattleguard          |
|                          | Jones Wreckum                     | Eldorado            | California       | Concrete piers; cattleguard          |

## Appendix A—Case Studies

The case study index (table A1) is arranged by structure type. Table A2 lists the case studies by channel characteristic, so that users confronted by a certain channel type can see which structures have or have not worked in a similar channel. We also list flow regime (perennial, intermittent, ephemeral) and special site considerations that pertain to each case study.

Table A2. Case studies indexed by channel characteristics and streamflow regime.

| Channel Characteristic       | Flow Regime  | Fishery | Structure Type          | Name            | Case Study Number | Special Design Considerations                          |
|------------------------------|--------------|---------|-------------------------|-----------------|-------------------|--|
| <b>Unentrenched</b>          | Intermittent | Y       | Unvented ford           | 20-mile         | 2                 | Spring trout spawning; seasonally closed road          |
|                              | Perennial    | Y       | Unvented ford with slot | Messman         | 9                 | Juvenile trout passage in summer; headcut control      |
|                              | Perennial    | Y       | Vented ford             | Mill            | 19                | Debris-jamming hazard (wood)                           |
|                              | Perennial    | Y       | Vented ford             | French          | 18                | Wide flood plain; high stream power; debris            |
|                              | Perennial    | Y       | Low-water bridge        | Deep            | 20                | Very low gradient; wide flood plain; soft soils        |
|                              | Ephemeral    | N       | Unvented ford           | Red Clover      | 1                 | Discontinuous, poorly defined channel                  |
| <b>Moderately Entrenched</b> | Ephemeral    | N       | Unvented ford           | 732 Road        | 4                 | Flow diversion down riparian road; channel downcutting |
|                              | Perennial    | Y       | Unvented ford           | Woodrock        | 7                 | Compressible stream-bank soils; RVs and ATVs           |
|                              | Perennial    | Y       | Vented ford             | Stoney          | 17                | Damming (ice); scenic values                           |
|                              | Perennial    | Y       | Vented ford             | Rocky           | 14                | Summer passage for weak-swimming fish; debris          |
|                              | Perennial    | Y       | Vented ford             | Babcock         | 11                | Trout passage; reservoir releases                      |
|                              | Perennial    | Y       | Vented ford             | Grubbs          | 12                | Trout passage; very high stream power; coarse sediment |
|                              | Perennial    | Y       | Vented ford             | North Consumnes | 13                | Juvenile trout passage; debris flow deposition zone    |
|                              | Perennial    | Y       | Low-water bridge        | Capps           | 21                | Preexisting channel damage—widened channel             |
|                              | Intermittent | Y       | Unvented ford           | AguaFria        | 8                 | very high stream power during floods; steep approaches |

## Appendix A—Case Studies

Table A2. *Continued.*

| Channel Characteristic     | Flow Regime  | Fishery | Structure Type   | Name            | Case Study Number | Special Design Considerations                                   |
|----------------------------|--------------|---------|------------------|-----------------|-------------------|---|
| <b>Entrenched</b>          | Perennial    | N       | Unvented         | Nurse           | 3                 | Steep, high energy stream                                       |
|                            | Perennial    | Y       | Unvented         | Willow          | 5                 | Trout passage; channel incision at tributary junction           |
|                            | Perennial    | Y       | Vented           | Fitzpatrick     | 6                 | Aquatic organism passage; large woody debris                    |
|                            | Perennial    | N       | Vented           | Black Cyn       | 10                | Snow avalanches   |
|                            | Perennial    | N       | Vented           | Sibley Cr       | 16                | Debris torrents   |
| <b>Laterally Unstable</b>  | Intermittent | Y       | Unvented         | 20-mile Cr      | 2                 | Spring-spawning steelhead, seasonally closed road; alluvial fan |
|                            | Perennial    | Y       | Vented           | French          | 18                | Potential for channel shift if blocked during flood             |
|                            | Perennial    | Y       | Low-water bridge | Capps           | 21                | Preexisting channel and flood plain damage                      |
| <b>Vertically Unstable</b> | Perennial    | Y       | Unvented         | Mesman          | 9                 | Grade control, fish passage                                     |
|                            | Perennial    | Y       | Vented           | Moonlight       | 15                | Grade control, fish ladder                                      |
|                            | Perennial    | Y       | Vented           | North Consumnes | 13                | In depositional zone  |