When flows from several different gauging stations are available, use knowledge of the local hydrology and rainfall patterns to decide which one offers the best estimate. For inventory and assessment purposes, the method described above is often sufficient. More detailed or accurate flow measurement techniques may be necessary in the design of new or replacement stream crossings.

FishXing Analysis

The subset of stream crossings identified as GRAY will require additional analysis to determine the extent to which they are barriers. At these stream crossings, water depths, velocities and outlet conditions should be calculated between the lower and upper passage flows to ascertain whether fish passage requirements are being met. Fish passage conditions can be analyzed using *FishXing*, a computer software program developed by the Six Rivers National Forest Watershed Interactions Team (USDA Forest Service 1999). *FishXing* models culvert hydraulics (including open-bottom structures) and compares the predicted values with data regarding swimming and leaping abilities and minimum water depth requirements for numerous fish species. *FishXing* is available on-line at: http://www.stream.fs.fed.us/fishxing/.

FishXing inputs are divided into two categories:

1. Swimming capabilities and requirements for the fish species of concern

2. Site-specific information about the stream crossing.

The following are general instructions for using *FishXing* to analyze passage conditions at a stream crossing. For detailed instructions and background information about using the software, consult the "Help Files" contained within *FishXing* and available from the home-page in a user manual format.

Fisheries Inputs

For each stream crossing that was placed in the GRAY category, conduct a separate passage analysis for all salmonids and their life stages. At many sites this may include different life stages of anadromous salmonids and resident trout. For each lifestage, a prolonged and burst swim speeds must be entered into the software. Prolonged swim speeds can be sustained for extended periods of time, ranging from one to sixty minutes. Fish often swim in this mode when passing through the barrel of a culvert. Burst swim speeds are higher than prolonged but can only be sustained for a few seconds. Fish swim in burst mode when faced with challenging situations, such as the inlet and outlet regions of a typical culvert. "Minimum water depth requirements and swimming and leaping ability inputs for *FishXing*." lists swimming and leaping speeds along with corresponding endurance times for several salmonid life stages.

Species or Lifestage	Minimum Water Depth	Prolonged Swimming Mode		Burst Swimming Mode		
		Maximum Swim Speed	Time to Exhaustion	Maximum Swim Speed	Time to Exhaustion	Maximum Leap Speed
Adult anadromous salmonids	0.8 feet	6.0 ft/sec	30 minutes	10.0 ft/sec	5.0 sec	15.0 ft/sec
Resident trout and juvenile steelhead trout >6"	0.5 feet	4.0 ft/se	30 minutes	5.0 ft/sec	5.0 sec	6.0 ft/sec
Juvenile salmonids <6"	0.3 feet	1.5 ft/sec	30 minutes	3.0 ft/sec	5.0 sec	4.0 ft/sec

(These values are used to assist in prioritizing stream crossing for treatment and do not represent whether or not a stream crossing currently meets DFG or NOAA passage criteria).

Table IX-6. Minimum water depth requirements and swimming and leaping ability inputs for *FishXing*.

FishXing and other hydraulic models report the average cross-sectional water velocity, not accounting for spatial variations. Stream crossings with natural substrate or deep corrugations will have regions of reduced velocities that can be utilized by migrating fish (Figure IX-20). These areas are often too small for larger fish to use, but can enhance juvenile passage success. *FishXing* allows the use of reduction factors that decrease the calculated water velocities proportionally. Accounting for areas of reduced velocities may be appropriate for the analysis of juvenile passage through certain types of stream crossing structures. *FishXing* also requires a lower and upper fish passage flow. To calculate these flows refer to the previous "Hydrology and Flow Requirements" section.

Stream Crossing Inputs

During the site visit, all required stream crossing information will have been collected for the passage analysis. Input the appropriate stream crossing type, material and length, whether it's embedded, corresponding roughness values, and the bottom elevations of the inlet and outlet.

Next, define the tailwater elevation with respect to the stream crossing outlet. The tailwater elevation often determines whether the culvert is a barrier. A high tailwater can backwater the culvert for easy passage. Too low of a tailwater elevation will leave the outlet perched above the downstream channel. There are three different methods to choose from, depending on the type of information collected during the field survey (Table IX-7).